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Unexplored Rock art of Bairagi Village (Manendragarh District)

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Abstract

This research paper is related to the study of rock paintings located in Bairagi village. The village is geographically rich as it is surrounded by mountains and forests. Caves are naturally formed in these hills and various types of vegetation are found in these forests, which appear to be a suitable place for primitive man to live. The river flowing in this village plays an important role in fulfilling the daily tasks of the primitive man. Apart from this, humans also get food from these rivers. In this research paper, the rock paintings located in Bairagi village have been studied in depth and described. This rock painting mainly depicts wild animals, human figures, anthropomorphic figures and geometric shapes. Primitive humans have used red and yellow colors to make the paintings here.

Key words - Anthropomorphic figures, Primitive, Petroglyphs, Geoglyphs, Pictographs, Paleolithic Age, Mesolithic Age, Neolithic Age, Pectiform, Naturalistic style, Geometrical style

Introduction

Rock painting is an ancient art style; it is a type of impression of man-made paintings on natural stones. Rock paintings include engravings, stencils, printing of pictures, drawings on boulders and platforms, carvings on dwelling sites, figures in rock shelters and caves, etc. It is generally divided into three forms: Petroglyphs are carved on the rock surface. Pictographs are painted on the surface with colors. Geoglyphs are made on the ground. Rock painting is an ancient art style; it is a type of impression of man-made paintings on natural stones. Rock paintings reflect the rich spiritual and cultural heritage of mankind and these rock paintings have great significance for their creators and descendants. Prehistoric rock paintings were the oldest art form to express mankind and humans used cave walls as their canvas. This made their houses more beautiful and colorful. The prehistoric period is divided into three types on the basis of geological age, types of stone tools and technology and subsistence basis: Paleolithic Age, Mesolithic Age and Neolithic Age.¹ Traditionally, individual marks are called motifs and groups of motifs are known as panels. The sequences of panels are considered archaeological sites. However, this method of classifying rock art has become less popular because the imposed structure is unlikely to have any relevance to the creators of the art. Even the word 'art' carries with it many modern prejudices about the purpose of features. Prehistoric rock paintings were not purely descriptive. Each motif and design had a "deeper significance" that is not always understandable to modern scholars.² They are of great importance for humanity in general. Their beauty, symbolism and rich narrative means that they are widely appreciated and treasured at international, regional and local levels. Their continued presence allows global communities to recognize diverse cultural traditions, their origins and the landscapes they created. The people of tribal community follow their customs by imitating the pictures engraved on rocks. The paintings reflect the rich spiritual and cultural heritage of mankind and these rock paintings have great significance for their creators and descendants. They have great significance for humanity in general. Their beauty, symbolism and rich narrative means that they are widely appreciated and treasured at international, regional and local levels. Their

Ethno archaeological study of rock paintings of Bastar region

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Abstract: This research paper mainly describes the main features of rock paintings of Bastar, southern part of Chhattisgarh. The specialty of the rock paintings found in the Bastar division is that the feet and palms are mainly depicted in these paintings. The tradition of worshipping rock paintings by the tribes of Bastar region has been there for centuries. This research paper also describes the rock paintings and associated material scattered around the rock paintings. In this research paper, there is also a detailed description of the worship and festival related to the rock paintings by the tribes, such as the worships like Bagha Veda, Kollam and Pitar paksha, in which the pictures related to the rock paintings are still alive in the paintings of the tribes.
Keywords - Prehistory, Bagh Veda, Kolang, Pitar Paksha, Chitkul, Marka Pandurn, Beeja Pandum, Harhi, Naval, Pola, Nawakhai, Charu, Dharni

Literary Review

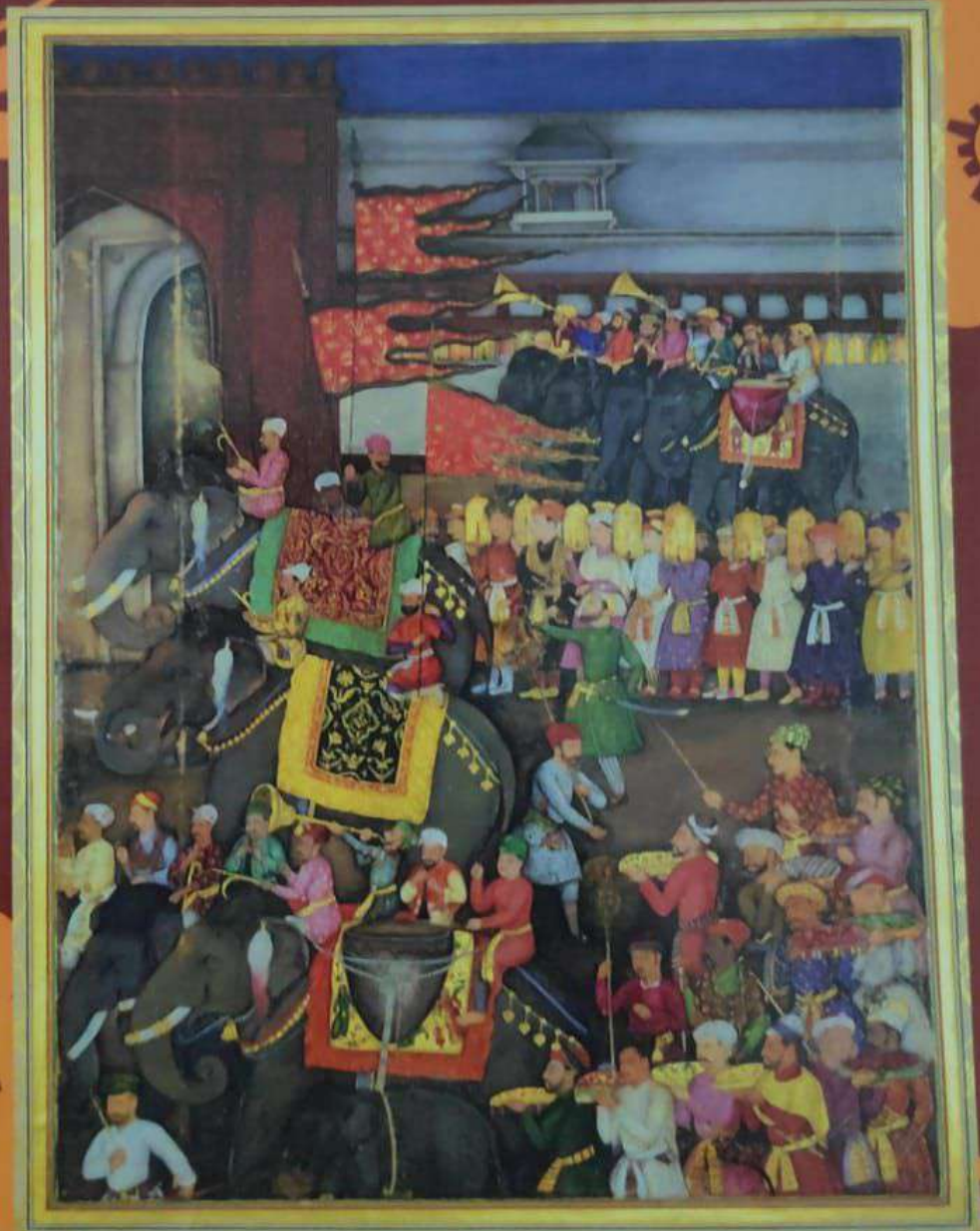
Apart from being full of natural resources, Chhattisgarh has been the centre of human activities since time immemorial and their evidences are scattered all over the region. Chhattisgarh is the tribal dominated area. That's why a specific type of customs, culture, art, belief, food and lifestyle of tribes are found here. In the specific cultural activities, the forest, mountains, rivers and wildlife found in these area beautify its natural beauty. Attracted by these evidences many research scholars and experts have published their findings in the reports. The various research works of the scholars and experts are as follows – "Madhya Pradesh Avam Chhattisgarh Ka Puratava Ka Sandarbh Granth" (1974) had written by Rajkumar Sharma gives some rock shelter cave names of Bastar. The archaeology of Bastar region is a thesis written by Vivek Dutt Jha submitted to the University of Saugar in 1980. Michel Postel and Zanne Cooper, provide a good ethnic data or folk art data of tribes in the book of "Bastar folk art, shirnes, figures and memorials" 1999. He gave a data of tribal life and people in Bastar and their art form but they did not said about rock art in that area. Dutt sir did excellent work. He tries to give the whole archaeological information about Bastar. He covered Prehistoric to the historical period. Only he did not mention the rock art sites. In the book "Madhya Bharat ka Shell Chitra" 2009 having lot of contain about rock art of Chhattisgarh, unfortunately most of paper talk about Raigarh district and only to give information about rock art of Kanher. In 2010, Dr. Rajkumar Sharma has written a book title of Madhya Pradesh Evam Chhattisgarh ke Puratav ka Sandarbh Granth. This book writes in the Hindi language. It's a bibliography of both present-day states, Madhya Pradesh and Chhattisgarh. From page 198 to 222, Sharma mentioned name of the rock painting site with references. In this some sites belong to the Bastar region. Meenakshi Dubey Pathak and Jean Cloues", "Powerful Images of Chhattisgarh Rock Art and Tribal Art", (2017), this book describes the detailed study of rock art of Chhattisgarh, which includes photography, analysis and comparative study with the tribal art.



इतिहास दृष्टि

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संपादक : सैयद नजमुल रज़ा रिज़वी

Investigation of Pictographs – Special Reference to the Amajhola, Kanker District (C.G.)

Nitesh Kumar Mishra, Bhenu

Abstract

Early man was very artistic; they had deep knowledge about art since the lower Paleolithic age. The origin of art, thus, could be seen from the primitive time. The early manufactured stone tools for multifaceted uses, rock paintings and engraving on the caves' walls and roofs are evidence of specific leisure activities that early men carried out. These man-made paintings are considered to be rock art. The rock arts are basically found on the walls and ceilings of shelters, big boulders and hill slopes. It is one of the most incredible creativity and cultural activities of mankind, which was preserved by our ancestors and can be seen on the walls of the caves today. This research paper mainly consists of the unreported rock art sites of Amajhola, Kanker district Chhatisgarh. It will document and describe the various facts and figures related to the rock art sites discovered in the region. The paper will also discuss the rituals and other performative traditions developed around these sites. It will study the correlation between the social dimensions of primitive rock art forms and the active cultural traditions practised among local tribal communities.

Keywords: Rock art, tribes, tradition, ancestors, Amajhola, Prehistoric, pictograph
cross

Introduction

It is challenging to understand the human behaviour of early man. To make life easier, early man used organic and inorganic materials for their daily uses. The organic materials were degradable and erased over time, so it is difficult to search the shreds of evidence of those materials. However, inorganic material like stone tools is still scattered all over the surface. Stone tools are one of the significant materials used by prehistoric man, which have been discovered in various prehistoric sites in India.

Rock art is one of the magnificent arts of early man, which expresses the views of various aspects of human society like social, cultural, emotional, economic and human behaviour.

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IGNCA GANDHI NATIONAL CENTRE FOR THE ARTS

**Newly discovered rock art site of Virendranagar village
(Balrampur district)**

Dr. Nitesh Kumar Mishra

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Abstract

This research paper is related to the rock paintings of Virendranagar village. This village is located in Wadrafagar block of Balrampur, which from geographical point of view was a center of habitation place of primitive man. This village is surrounded by mountains and forests and the river flowing through the village plays an important role in the survival of mankind. Through this research paper, the rock paintings located in Virendranagar village have been analyzed and documented. In this rock art site, mainly geometric designs and human figures have been depicted. The human figure depicted in this rock art is believed to be a depiction of the main deity of the Gond tribe. According to the people of Gond tribe, their ancestors used to reside here, they believe that the human figure is a depiction of their ancestral deity. In this research paper, a comparative study of the deities of Gond community has been done.

Keywords: expression, engraving, prehistoric, Deccan Trap, Gaurlatia, Neolithic period, animal figurine, hunting scene, ritualistic scenes, Pashupati, Velakkanaar, Gond tribe and bullock cart

Introduction

Rock painting is one of the oldest arts of man. Man has painted rock paintings on rocks, cave walls and roofs to express his expression. To make rock paintings, humans used two methods, first by painting with natural colors and by engraving on stones.¹ These arts have preserved their existence even in the present times. Even in today's scientific age, these ancient rock paintings force us to wonder that in today's era, the paint we apply on our houses lasts only for a maximum of 5 years whereas these rock paintings have been around for thousands of years. The chemicals that were used in that period are still shining today. These rock paintings also give a glimpse of the daily activities of that period, like hunting, dance, wild animals, human clothing, human musical instruments, their rituals etc.² Rock paintings are the only evidence of the prehistoric period which enables us to clearly understand the differences in different periods. If humans are hunting wild animals in the pictures, it reflects the period before animals were

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Introduction

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Lead biosorption profiling of endophytic *Aspergillus flavus* SGE34 isolated from *Cleome viscosa* Linn.

Samiksha Sharma , Kishan Lal Tiwari & Shailesh Kumar Jadhav

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ABSTRACT

Lead is an environmental pollutant that causes remarkable damage to various organs in the human body, especially the nervous system. Removal of lead by conventional methods is costly, and therefore, in the current scenario, biosorption using fungi is extensively explored as they provide good metal uptake systems. The present study evaluated the Pb (II) biosorption potential of endophytic fungi *Aspergillus flavus* SGE34. The fungal isolate was obtained from the root of an indigenous medicinal plant of the Chhattisgarh region named *Cleome viscosa* Linn. The biosorption potential of dead fungal biomass was optimized at different operating parameters like contact time, pH, and temperature. The maximum biosorption values were found at pH 6.0 with an equilibrium time of 150 minutes at 35°C. The Fourier transform infrared spectroscopy study revealed that the pattern of new absorption bands, altered absorption intensity, and shift in wavenumber of functional groups was deduced, due to

that *A. flavus* SGE34 has high metal tolerance and biosorption capacity; it could effectively remove lead from industrial effluents.

Q KEYWORDS: *Aspergillus flavus* biosorption dead biomass endophytic fungi FTIR lead

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Disclosure statement

No potential conflict of interest was reported by the author(s).

Additional information

Notes on contributors

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Dr. Samiksha Sharma (Corresponding Author)- Currently working as scientist (Virology) at Chhattisgarh Institute of Medical Sciences. She has more than 8 years of research experience. She was awarded with budding scientist award and best paper award in "Metal Toxicity".

Dr. Kishan Lal Tiwari- He has expertise in field of environmental biotechnology and botany. He has more than 150 research papers, book chapters and review in this area. He has more than 40 years of research experience. He is a member in board of advisor of flora and Fauna (An International Journal on Biological Sciences, Jhansi). He has occupied many renowned positions in different R&D field.

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Dr. Shailesh Kumar Jadhav- He is a renowned professor in field of botany and biotechnology. His area of specialization is Botany, Biotechnology and Microbiology. He has more than 32 years of research and academic experience. He has published more than 165 research articles, reviews in national and international journals. He is a member of many academics as well as executive council of Chhattisgarh, India.

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Zn Fortification Influential Impact on the Productivity of *Calocybe indica* Mycelium

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Abstract: *Calocybe indica* is an edible medicinal mushroom, preferably eaten for its culinary value. It was cultivated for its higher nutritional value, medicinal properties, and high polysaccharide content, especially glucan. Some particular minerals were enriched in food substitutes, an alternative to fighting against some targeted human ailments. Thus, mineral fortification is accessible in the submerged cultivation of mushrooms to produce bioactive compounds and fortified mushrooms. In this study, the submerged cultivation of *C. indica* was performed to make exopolysaccharides (EPS) using a supplemented medium of Zinc with varying concentrations. Thus, research revealed that the Zn fortification enhances the production of EPS and mycelial biomass after 21 days of incubation. The maximum mycelial biomass was 7.7133 ± 0.30 g/L (dry weight), and the highest 0.3853 ± 0.006 EPS was produced in the 175mg/L mineral concentration, respectively. The present study revealed that the Zn supplementation gradually increased the mineral concentration and directly influenced the yield of mycelial biomass and EPS production. These EPS have various biological activities and can be helpful for fortified food or pharmaceutical product development in the medicinal and pharmaceutical sectors.

Keywords: Antioxidant, Fortification, Mycelial biomass, Submerged culture and Exopolysaccharides.

Introduction

C. indica, commonly known as a Milky mushroom, was first described by Purkayastha and Chandra in 1974. It belongs to the phylum Basidiomycetes and is a medicinal mushroom primarily consumed in West Bengal, India. Worldwide, it is recognized for the richness of its bioactive compounds (Balouiri et al., 2015; Ghosh et al., 2020). It is an umbrella-like mushroom and requires a hot, humid climate for its cultivation; the temperature is about 25°C-35°C, and the stem is cylindrical and has no rings (Purkayastha et al., 1974; Subbiah et al., 2015). The cultivation of *C. indica* generally takes place on wheat straw and paddy straw as the substrate, such as sorghum stalks, groundnut hulls, soybean straw, and coconut coir, which are also used for cultivation (Rathore et al., 2020; Kosre et al., 2021; Chouhan et al. 2022). Milky mushroom consists of carbohydrates up to 6.8%, proteins 2.75%, lipids 0.6%, fibres 1.67%, water 87% and minerals 0.5-1 %, respectively (Gupta et al., 2012). The essential amino acids of *C.indica* consist of arginine, lysine, histidine, tryptophan, leucine, threonine, valine, isoleucine and methionine (Sumathy et al., 2015; Thejaswini et al., 2015). Therefore, it is used for cures or alternative food materials and combats many diseases like cardiovascular cancer and diabetes as it is rich in fibre, proteins and antioxidants (Balouiri et al., 2015). The polysaccharides of *C.indica* generally consist of rhamnase, arabinose, galactose, glucose xylose and mannose. However, β - glucan is known to present a massive amount in *C.indica*



Assessing the genetic diversity of *Buchanania lanzan* Spreng. (Chironji) using inter simple sequence repeat markers

Tripti Agrawal · Afaque Quraishi

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Abstract *Buchanania lanzan* Spreng, a member of the Anacardiaceae family, is a valuable tropical fruit tree native to India. This tree species possesses enormous pharmacological properties and socio-economic significance but is underutilised due to inadequate genetic diversity and germplasm wealth resources data. The present investigation attempted to evaluate the diversity of nine accessions of *B. lanzan* obtained from three distinct geographical locations in the Chhattisgarh state of India using inter simple sequence repeat (ISSR) markers. Ten ISSR primers were used, of which eight ISSR primers produced remarkable bands selected for genetic diversity analysis. The ISSR primers produced a total of 127 loci, of which 63 loci exhibited polymorphism. On average, each primer yielded 7.87 loci. The maximum polymorphism was observed for primer BLA4 (77.77%), while primer BLA10 exhibited the lowest polymorphism (25%). An average 49.87% polymorphism was detected amongst nine accessions using eight ISSR primers. The Jaccard's similarity coefficient exhibited a range of values between 0.63 and 0.98. Genetic variability in *B. lanzan* accessions is low owing to low polymorphism percentage, although they belong to different agroclimatic regions of the Chhattisgarh state.

Keywords Chironji · Genetic variability · ISSR marker · Primer · Tropical

Introduction

Buchanania lanzan Spreng is a valuable tree species known for its fruit and nut production, primarily found in the tropical forests of Asia. It is commonly known as the Almondette tree, and its vernacular name is Chironji in Hindi. The tree is often growing in the Sal dominating tropical deciduous forest areas inhabiting *Shorea robusta*, *Madhuca latifolia*, and *Diospyros melanoxylon* trees (Malik et al. 2012; Raj and Jhariya 2021). The tree is significant for its highly nutritious and valuable seeds enclosed in a hard fruit nut. Seeds have a sweet almond-like flavour and high nutraceutical, medicinal values. Parts of the tree, viz., root, bark, gum, leaf, fruit, and seed, bear various phytoconstituents having pharmacological and are used to treat blood disorders, fever, ulcers, burning sensations in body parts, diarrhoea, dysentery, asthma, and snake bite (Malik et al. 2012). The kernel and bark extracts are used as a tonic, to treat an intrinsic haemorrhage, and bloody diarrhoea. Kernel powder mixed with milk is an aphrodisiac that is also used to treat fever and burning sensations. The bark decoction of this plant species has been employed in the treatment of stomach pain, cough, and bronchitis, as documented by Mehmood et al. (2016). The fruit is a laxative, aphrodisiac, cures fever, ulcers,

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Enhanced epicurzerenone production *via in vitro* elicitation of microrhizomes of *Curcuma caesia* Roxb.

Afreen Anjum¹ · Afaque Quraishi¹

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Abstract

Curcuma caesia Roxb. is a critically endangered herb belonging to the Zingiberaceae family with economic and medicinal importance associated with its rhizomes. The prime function of epicurzerenone (a sesquiterpene) is to eliminate reactive oxygen species and is, therefore, known to have antitumor properties. In the present investigation, *in vitro* elicitation of terpenes was carried out on microrhizomes of *C. caesia* using salicylic acid and jasmonic acid at 25.0 μM and 50.0 μM each for 30 and 60 d. The jasmonic acid treatment did not affect morphology of the cultures compared to the un-elicited cultures. The jasmonic acid treated had similar or less epicurzerenone area% than the un-elicited cultures (23.48%). Even the total terpenoids content was less in the jasmonic acid treated ones than the un-elicited cultures. However, phenolic content was higher than the un-elicited cultures in jasmonic acid treated. Among all the tested elicitations, cultures with 25.0 μM salicylic acid on the 60th day had the least fresh weight of microrhizomes. Gas chromatography–mass spectrometry analysis revealed epicurzerenone as the dominant sesquiterpene in all the elicited and un-elicited cultures on the 60th day. Salicylic acid at 25.0 μM level could elicit the highest accumulation of epicurzerenone (32.11%) compared to the other treatments, un-elicited culture (23.48%), and field-grown mother plant (12.43%). Biochemical studies during *in vitro* elicitation revealed that the protein, ascorbate, glutathione, and thiobarbituric acid reactive substances content increased significantly on the 60th day; similarly, the superoxide dismutase, ascorbate peroxidase, and guaiacol peroxidase activity also increased at the 30th day and then decreased at the 60th day in the 25.0 μM salicylic acid elicited cultures. These alterations in the biochemical parameters showed that treatment with 25.0 μM salicylic acid could induce a significant stress in the microrhizomes of *C. caesia*, which led to enhanced production of secondary metabolites, including terpenes (0.1649 mg abscisic acid equivalents g^{-1} dry weight) and phenols (0.1382 mg gallic acid equivalents g^{-1} dry weight).

Keywords Epicurzerenone · GC–MS · Glutathione · Jasmonic acid · Salicylic acid

Introduction

Elicitation is a process in which plants synthesized secondary metabolites by trace amounts of elicitors that help them survive, persist, and compete (Thakur *et al.* 2019). Elicitors stimulate the biosynthetic pathways leading to the enhanced production of commercially important secondary metabolites (Jaiswal *et al.* 2022). This method is simple, effective, and inexpensive for increasing the secondary metabolites of cultured plant cells. The composition and percentage of secondary metabolites vary widely depending on various

factors, such as the plant's health, growth stage, parts used, soil, climate, and harvest time (Biesalski *et al.* 2009).


Salicylic acid and jasmonic acid are essential endogenous signal molecules in the plant signal transduction network that control physiological processes like growth, differentiation, and metabolism (Liu *et al.* 2018). Salicylic acid plays a significant role in plant growth and development and helps plants tolerate abiotic stresses, such as metals, drought, and salinity (Zhang *et al.* 2015). Jasmonic acid is a natural growth regulator in higher plants and is involved in plant-pathogen interactions and abiotic stress tolerance. Salicylic acid and jasmonic acid are the commonly used elicitors. Stressors induce the production of reactive oxygen species (ROS), which accumulate in plant cells and cause oxidative stress. This oxidative stress, in turn, enhances the production of secondary metabolites and increases the antioxidant activity of the plant (Dumanovic *et al.* 2021).

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Review

Allantoin: A Potential Compound for the Mitigation of Adverse Effects of Abiotic Stresses in Plants

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Abstract: Stress-induced alterations vary with the species of plants, the intensity and duration of the exposure, and stressors availability in nature or soil. Purine catabolism acts as an inherent defensive mechanism against various abiotic stresses and plays a pivotal role in the stress acclimatisation of plants. The intermediate metabolite of purine catabolism, allantoin, compensates for soil nitrogen deficiency due to the low carbon/nitrogen ratio, thereby maintaining nitrogen homeostasis and supporting plant growth and development. Allantoin accounts for 90% of the total nitrogenous compound in legumes, while it contributes only 15% in non-leguminous plants. Moreover, studies on a variety of plant species have reported the differential accumulation of allantoin in response to abiotic stresses, endowing allantoin as a stress modulator. Allantoin functions as signalling molecule to stimulate stress-responsive genes (*P5CS*; pyrroline-5-carboxylase synthase) and ROS (reactive oxygen species) scavenging enzymes (antioxidant). Moreover, it regulates cross-talk between the abscisic acid and jasmonic acid pathway, and maintains ion homeostasis by increasing the accumulation of putrescine and/or spermine, consequently enhancing the tolerance against stress conditions. Further, key enzymes of purine catabolism (xanthine dehydrogenase and allantoinase) have also been explored by constructing various knockdown/knockout mutant lines to decipher their impact on ROS-mediated oxidative injury in plants. Thus, it is established that allantoin serves as a regulatory signalling metabolite in stress protection, and therefore a lower accumulation of allantoin also reduces plant stress tolerance mechanisms. This review gives an account of metabolic regulation and the possible contribution of allantoin as a photo protectant, osmoprotectant, and nitrogen recycler to reduce abiotic-stress-induced impacts on plants.

Keywords: abscisic acid; allantoin; antioxidants; mutants; reactive oxygen species; ureide metabolism



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1. Introduction

Environmental stresses are unpredictable, irregular, and ever-changing. Plants are exposed to several complex environmental variables, including temperature, radiation, precipitation, humidity, wind, and soil factors. When a plant experiences less/more than optimum environmental conditions (stress), either through climatic change or human interference, this ultimately affects its survival [1]. Abiotic-stress-induced injuries result in stress-specific responses through distinct modes, and irrespective of the type of stress factor plants elicits a universal response mechanism [2]. Plants can evoke a myriad of responses (morphological, physiochemical, and molecular) to oscillating environmental (stress) conditions [3]. In general, stress conditions stimulate the generation of reactive oxygen species (ROS) such as hydrogen peroxide (H₂O₂), singlet oxygen (¹O₂), hydroxyl radical (•OH), superoxide (O₂^{•−}) anion, and cytotoxic compounds like methylglyoxal (MG), which disturbs cellular redox homeostasis [4]. The generation of ROS is unavoidable, even under optimal conditions. During normal cellular metabolism, plants can produce



Mechanistic prospective and pharmacological attributes of quercetin in attenuation of different types of arthritis

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Abstract

Arthritis is a frequent autoimmune disease with undefined etiology and pathogenesis. Scientific community constantly fascinating quercetin (QUR), as it is the best-known flavonoid among others for curative and preventive properties against a wide range of diseases. Due to its multifaceted activities, the implementation of QUR against various types of arthritis namely, rheumatoid arthritis (RA), osteoarthritis (OA), gouty arthritis (GA) and psoriatic arthritis (PsA) has greatly increased in recent years. Many research evidenced that QUR regulates a wide range of pathways for instance NF- κ B, MAK, Wnt/ β -catenine, Notch, etc., that are majorly associated with the inflammatory mechanisms. Besides, the bioavailability of QUR is a major constrain to its therapeutic potential, and drug delivery techniques have experienced significant development to overcome the problem of its limited application. Hence, this review compiled the cutting-edge experiments on versatile effects of QUR on inflammatory diseases like RA, OA, GA and PsA, sources and bioavailability, therapeutic challenges, pharmacokinetics, clinical studies as well as toxicological impacts. The use of QUR in a health context would offer a tearing and potential therapeutic method, supporting the advancement of public health, particularly, of arthritic patients worldwide.

Keywords Inflammation · Gout arthritis · Osteoarthritis · Psoriatic arthritis · Rheumatoid arthritis · Quercetin

Abbreviations

AIM2	Absent in melanoma 2	COX	Cyclooxygenase
ADME	Absorption, distribution, metabolism, and excretion	E-ADA	Ectoadenosine deaminase
ADA	Adenosine deaminase	ENM	Electrospun nanofiber membrane
AIA	Adjuvant-induced arthritic	ECM	Extracellular matrix
ALP	Alkaline phosphatase	FLS	Fibroblast like synovium
ASC	Apoptosis-associated speck-like protein containing CARD	GATA6	GATA transcription factor 6
CaC ₂ O ₄	Calcium oxalate	GO	Gene ontology
CCL	C-C motif chemokine ligand	GA	Gout arthritis
JNK	C-Jun N-terminal kinase	HO	Heme oxygenase
CD14	Cluster of differentiation 14	H	Hydrogen
CoPP	Cobalt protoporphyrin IX	HIF-1	Hypoxia-inducible factor-1
CIA	Collagen-induced arthritic	iNOS	Inducible nitric oxide synthase
C3	Complement protein 3	IL	Interleukin
CFA	Complete Freund adjuvant	KOA	Knee-OA
		KEGG	Kyoto Encyclopedia of Genes and Genomes
		LII	Limb idleness index
		LOX	Lipoxygenase
		LPS	Lipopolysaccharides
		M1	Secretes pro-inflammatory cytokines
		M2	Secretes anti-inflammatory cytokines
		MMPs	Matrix metalloproteinases
		MTX	Methotrexate
		mPEG-PA	Methyl-poly(ethylene glycol)-l-poly(alanine)
		MIA	Monoiodoacetate

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Antibacterial Activity of CdTe/ZnS Quantum Dot- β Lactum Antibiotic Conjugates

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Abstract

β -Lactum antibiotics are broad class of antibiotics which kills bacteria by inhibiting the formation of peptidoglycan that constitutes the bacterial cell wall. The resistance that develops in bacteria for antibiotics led the scientific world to think about the future aspects for modifying the way through which antibiotics are acted on the bacteria and become lethal for them. In this consequence, the potential of latest marketed antibiotics e.g. Amoxiciline (I), ceftazidim (II) have been evaluated after being conjugated with quantum dots. The surface of quantum dots has been conjugated with antibiotics by carbodiimide coupling with the help of 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) and N-hydroxysuccinimide (NHS) as conjugating agent between antibiotic and functionalized quantum dots. The antibacterial properties of QD-conjugated antibiotics have been determined by disc diffusion assay. The potency of QD-conjugated antibiotics has been estimated by determining their MIC₅₀ for the selected strain of Gram-negative (*Escherichia coli*) and Gram-positive (*Staphylococcus aureus*) bacteria. Minimum inhibitory concentration study, minimum bactericidal concentration and growth pattern analysis revealed that QD-antibiotic conjugates showed slightly more prospective than pure native antibiotics against both Gram-negative (*Escherichia coli*) and Gram-positive (*Staphylococcus aureus*) bacteria.

Keywords β -Lactum antibiotics · QD-antibiotics conjugates · MIC₅₀ · Antibacterial Activity

Introduction

Since the invention of penicillin, β -lactam antibiotics have developed as the most essential spectrum of antibacterial agents [1, 2]. However, the experimental treatment and wide utilization of these agents have made the bacteria to

generate various types of β -lactamases (β -Lases), which could prompt the spread of bacterial resistance [3–6]. Thus clinical viability of β -lactam antibiotics was negotiated. β -lactam antibiotics resistance has turned out to be a serious issue that encounters the human health [7–10]. Thus, progressively more demand has been put on pharmaceutical investigators and medical researchers to develop new antibiotics [11]. Some strategies have been accounted for disabling the bacterial resistance. One was to change the structure of β -lactam to reduce its sensitivity to the hydrolysis by β -Lases [12]. Another technique was to utilize double activity cepheems; if bacteria have resistance to one of them, the other antibacterial agent would destroy them in another way [13–16]. Vergauwe and coworkers utilized reagents, for example, 3 clavulanic acid to inactivate the β -Lases [17]. In all these techniques, reagents added to conquer the bacterial resistance were organic compounds. Inorganic components were occasionally utilized as a part of the antimicrobial industry. Though, it is notable that inorganic nanomaterials are great antimicrobial agents. Currently, there were some research work reported, which

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started to investigate the antimicrobial impacts of combination of β -lactam and inorganic nanomaterials. This investigation would be invaluable for designing novel antimicrobial agents.

Over the previous decades, nanoparticles with exclusive chemical and physical properties have demonstrated a growing significance in biological, biomedical, and pharmaceutical applications. Inorganic nanomaterials have large surface to volume ratio and pronounced bioactivity which made them great candidate to displace conventional organic antimicrobial agents that are enormously irritant and toxic. Currently, various nanoparticles have been appeared to have antimicrobial activities [18, 19] and among them the silver nanoparticles have been very much examined and reported to accrue in the *Escherichia coli* (*E. coli*) membrane to have efficaciously antibacterial effects [20]. Titanium dioxide (TiO_2), Silicon dioxide (SiO_2) and zinc oxide (ZnO) nanoparticles, also demonstrate encouraging biocidal properties against both Gram-positive and Gram-negative bacteria [21]. All these assemblies are observed to be photosensitive and can create reactive oxygen species (ROS) under high intensity light at a particular wavelength. TiO_2 can be utilized as an important antibacterial agent although when sunlight is applied as the excitation source. In contrast with different nanoparticles, quantum dots (QDs) have superior size-dependent optical properties. They are essentially nanoscale crystals fabricated from semiconducting materials [22, 23]. QDs have turned out to be more significant research subjects in present years [24] because of their exceptional physical properties including photostability, narrow emission, and wide excitation range, high photoluminescence and potential applications in recent biosensors [25], cell imaging [26] and in vivo tracking of living being [27]. QDs can indicate sizes and numbers of atoms between the molecular level and bulk solids with a band-gap relying upon different factors, for example, strength and type of bond with adjacent atoms. Usually, narrow fluorescent emission peaks are witnessed for separated atoms. It has been accounted for that a nanoparticle of roughly 100–10000 atoms indicates distinctive narrow optical line spectra. On the premise of this data, QDs can be characterized as artificial atoms [28].

It has been demonstrated that under UV illumination, QDs produce free radicals, of which the quality and type are controlled by their center core materials [29]. The high extent of free radicals is hurtful to microorganisms. The release of free metal ions from QDs could also be hazardous to microbes. There are only few reports on antimicrobial activity of QDs can be established [30, 31]. For instance, Kloepper et al. demonstrated that cadmium selenium (CdSe) QDs can prevent bacterial growth [32]. To diminish the lethality and toxicity of QDs, core/shell structure and core/

shell materials are commonly utilized. Scientists develop various types of center/shell QDs (CdTe/ZnSe , CdTe/ZnS , and CdSe/ZnS), core/shell/shell QDs (CdTe/CdS/ZnS , CdSe/CdTe/ZnSe), and condition cordial QDs (CuInSe , Ag_2S , and Si QDs) for different purposes [33–41].

In the present study, CdTe/ZnS core/shell QDs were selected as one of the most robust and highly fluorescent QDs which are synthesized through a green way or environment-friendly way using water as a solvent. The CdTe/ZnS core/shell QDs can be applied in various biological fields because the high Cd toxicity of CdTe QDs is supposed to be reduced by forming a shell of ZnS . In the present study, CdTe/ZnS core/shell QDs were conjugated with amoxicillin (Amox) and ceftazidime (CZ) and subsequently characterized with spectroscopic and microscopic techniques. The potency of antibacterial activities of these CdTe/ZnS -antibiotic conjugates was evaluated against *E. coli* and *S. aureus* which is commonly used as a model in microbiological research.

Experimental Section

Materials

Amoxicillin, ceftazidime, 1-ethyl-3-(3-dimethylaminopropyl) carbodiimide (EDC) and N-hydroxysuccinimide (NHS), cadmium acetate ($(\text{CH}_3\text{COO})_2\text{Cd}$), tellurium powder, sodium borohydride (NaBH_4), zinc acetate ($(\text{CH}_3\text{COO})_2\text{Zn}$), thiourea (NH_2CSNH_2), manganese acetate tetrahydrate ($(\text{CH}_3\text{COO})_2\text{Mn}\cdot 4\text{H}_2\text{O}$), glutathione (GSH), acetone (CH_3COCH_3) and all other chemicals were purchased from Sigma Aldrich, Bangaluru, India. All the chemicals used were of analytical grade and millipore water was used in all experiments.

The strains which were employed in this study are the Gram-negative bacterium *E. coli* (MTCC 1687) and the Gram-positive bacterium *S. aureus* (MTCC 3160), purchased from the Microbial Type Culture Collection, Institute of Microbial Technology (Chandigarh).

Synthesis of CdTe/ZnS Core/Shell Quantum Dots

Core-shell CdTe/ZnS quantum dots were synthesized by slight modification of reported method [42]. Briefly, a NaHTe solution was prepared by dissolving Te powder (1 mM) and NaBH_4 (4 mM) in 2 mL of nitrogen bubbled millipore water which was stirred for a few hours at 4 °C. The Cd^{2+} precursor solution was prepared by dissolving GSH (10 mM) and Cd ($(\text{CH}_3\text{COO})_2$ (4.0 mM) in 100 mL millipore water. Subsequently, the pH was adjusted to 10.5 by adding 0.1 M NaOH followed by the addition of NaHTe solution into N_2 saturated Cd^{2+} precursor solution. The colour of the solution immediately changed from colourless to yellow.

The molar ratio of Cd^{2+} : NaHTE: GSH was maintained at 4:1:10. Then, the reaction mixture was heated at 100 °C, and aliquots of the mixture (0.5 mL) were collected after every 10 minutes. After desired growth the reaction was quenched by rapidly cooling down to 0 °C in an ice-bath. The core nanocrystals were precipitated by adding acetone (1:1 v/v), followed by centrifugation at 5000 rpm for 2 h. For ZnS shell coating, a Zn^{2+} precursor solution was prepared by dissolving GSH (0.2 mM) and $\text{Zn}(\text{CH}_3\text{COO})_2$ (0.1 mM) in 25 mL of Millipore water with adjusting pH to 7.0. For the synthesis of CdTe/ZnS core/shell QDs, the purified CdTe nanocrystals (0.025 $\mu\text{mol/L}$) and thiourea (0.1 mM) were added to the Zn^{2+} precursor solution, and the pH was adjusted to 11.0. The molar ratio of Cd^{2+} /thiourea (TU)/GSH in the reaction mixture was 1:1:2. Afterwards, the reaction mixture was kept at 90 °C, and aliquots (0.5 mL) were collected in a glass vial at a series of different times. Each reaction was quenched by cooling to 0 °C in an ice bath. The core/shell QDs were precipitated by adding equal volume of acetone (1:1 v/v), followed by centrifugation at 4000 rpm for 1.5h. The precipitate was used for further studies.

Conjugation of Antibiotics with CdTe/ZnS Core/Shell Quantum Dots

One milligram of CdTe/ZnS QDs was dissolved in 10 mL of 50 mM PBS buffer (pH 7.40). Then 10 mg of NHS and 20 mg of EDC were added to the QD solution, and stirred for 30 min to activate the carboxylate groups on QDs. Then various amounts of antibiotics (amoxicillin/ ceftazidime) (1 $\mu\text{g/ml}$ –300 $\mu\text{g/ml}$) was dissolved in PBS buffer, and added to the activated QD solution. After reaction overnight, the antibiotic-conjugated QDs were separated from the solution by an ultracentrifugation.

Characterization

UV-Visible spectra were recorded by using ThermoScientific evolution-300spectrophotometer operated at a resolution of 2 nm. Fluorescence spectra were recorded using an Agilent fluorescence spectrophotometer (G9800AA). The fourier-transform infrared (FTIR) spectral analysis was performed within the wave number ranges from 4000–600 cm^{-1} were measured using FTIR spectrometer (DRS-FTIR) set with deuterated, L-alanine doped triglycine sulfate (DLaTGS) detector (Model: Nicolet iS10, Thermofisher Scientific Instrument, Madison, USA). The size of the CdTe/ZnS QDs were assessed by transmission electron microscopy (TEM) on a JEOL, JEM-2100F model instrument operated an accelerating voltage of 200kV. The samples were prepared by adding drops of sample solution on carbon-129 coated copper grids and allowed to dry in air. The resulting images

were analyzed by gatan micrograph software. X-Ray diffraction study has been performed on PANalytical 3 kW X'pert Powder XRD–Multifunctional.

Antibacterial Activity

The antibacterial activities of QD-antibiotics conjugates were investigated against Gram-negative bacteria *Escherichia coli* (*E. coli*) MTCC 1687 and Gram-positive bacteria *Staphylococcus aureus* (*S. aureus*) MTCC 3160 by two methods: well diffusion and broth dilution method. The strains were cultured in Nutrient agar medium (NAM) plates in an incubator overnight at 37 °C. A single colony was inoculated in 20 ml of NAM Broth (TSB) and grown statically overnight at 37 °C. Then, 100 μl of this bacterial suspension was transferred into 100ml of NAM in a conical flask and grown in a shaker incubator at 150 rpm at 37 °C.

Well Diffusion Method

The antibacterial activity of QD-antibiotics conjugates were assessed in vitro against two pathogenic bacterial strains using well diffusion method. NAM plates were prepared by pour plate method. For agar well diffusion, 100 μl of the bacterial suspension was inoculated on semi solidified NAM plates and spread properly. Small wells about 5 mm diameter of size were made into semisolid NAM plates. Different dosages (5–150 $\mu\text{g/ml}$) of QDs, 50–300 $\mu\text{g/ml}$ and 1–30 $\mu\text{g/ml}$ of amoxicillin and its corresponding QD-amox conjugates for *E.coli* and *S. aureus* were added in to each well. Similarly, 5–50 $\mu\text{g/ml}$ and 1–30 $\mu\text{g/ml}$ of ceftazidime and its corresponding QD-CZ conjugates for *E.coli* and *S. aureus* QD- were added in to each well. The plates were placed in a 37 °C incubator for 24 h. Test was done in triplicate, then inhibitory action of tested samples on the growth of the bacteria was determined by measuring diameter of inhibition zone in mm around each well. *Streptomycin* was used as a positive control while water is used as negative control to test the bioactivity of compounds.

Broth Dilution Method

Nutrient broth medium inoculated in different test tubes plugged with sterile cotton and autoclaved. The 100 μl bacterial suspensions were inoculated in two set of test tubes containing different dosages of different dosages (5–150 $\mu\text{g/ml}$) of QDs, 50–300 $\mu\text{g/ml}$ and 1–30 $\mu\text{g/ml}$ of amoxicillin and its corresponding QD-amox conjugates for *E.coli* and *S. aureus*. Similarly, 5–50 $\mu\text{g/ml}$ and 1–30 $\mu\text{g/ml}$ of ceftadizime and its corresponding QD-CZ conjugates for *E.coli* and *S. aureus* QD- were used. The final volume in the tubes was 10 ml. The tubes were incubated in a shaker incubator at 100 rpm at 37 °C for overnight. Growth of inoculums in the test tube was observed by determining the optical density (OD) at 600

nm by colorimeter. For standard comparison a control sample was prepared by a similar method exclusive of QD-antibiotic conjugates. The experiments were carried out in triplicate to confirm reproducibility. The percentage of growth inhibition was calculated using the following formula:

$$\% \text{ Growth Inhibition} = - \left[\frac{OD_c - OD_t}{OD_c} \right] \times 100 \quad (1)$$

where OD_c and OD_t correspond to the optical density of the control and test sample of nanocomposite, respectively.

Results and Discussion

Spectral Characterization of CdTe/ZnS QDs and CdTe/ZnS QDs Antibiotic Conjugates

Figure 1 represents usual evolution of both absorption and fluorescence spectra of GSH-topped CdTe/ZnS QDs synthesized in the aqueous phase. Although successfully synthesizing CdTe QDs with an inclusive range of sizes, current study emphases on CdTe core with emission maxima at 556 nm and study the evolvement of the optical, electronic and structural properties as a function of ZnS coating. The size and concentration of the CdTe core are 3.78 nm and 4.7×10^{-6} M, respectively, which is determined by utilizing the empirical formula (Eq. 2): [43]

$$A = \varepsilon cl, \varepsilon = 10043(D)^{2.12}$$

$$D = (9.8127 \times 10^{-7})\lambda^3 - (1.7147 \times 10^{-3})\lambda^2 + (1.0064)\lambda - (194.84) \quad (2)$$

Here A is the absorbance of the first excitonic absorption peak for CdTe QDs, c is the molar concentration (mol/L) of the CdTe QDs, l is the path length (cm) of the radiation beam, D is the

diameter of the QDs, ε is the molar absorptivity of CdTe QDs and λ (nm) is the wavelength of the first excitonic absorption peak of the CdTe QDs. Heating the solution containing glutathione, Zn^{2+} and core CdTe QDs results in gradual red shift in the absorption and fluorescence spectra (Fig 1a), which infers that a ZnS shell is gradually developing in situ on the CdTe core. With the refluxing, the excitonic absorption peak of QDs shifts toward longer wavelength from 565 nm to 620 nm as the QDs grow to bigger size. This phenomenon is observed due to quantum confinement effect. The corresponding fluorescence emission wavelengths and QYs of the CdTe/ZnS NCs are 585 nm 40%, 600 nm 48 %, 610 nm 42 %, 620 nm 39 %, and 635 nm 36 %, respectively. After the 15 min of refluxing, the best fluorescence QY (48 %) of the CdTe/ZnS QDs achieved is 1.4 times greater than that of the CdTe core QDs. At the same time, the diameter of the core-shell QDs rises to 4.7 nm (core CdTe = 3.8 nm), which displays that the thickness of ZnS shell is around 0.9 nm. After 30 min. of refluxing, the fluorescence wavelength increases with decrease in the QY of CdTe/ZnS to 42 %. Further refluxing to 50 min, the increasing rate fluorescence wavelength diminishes with the decrease in the QY to 39 %. Lastly, after 90 min. of refluxing, the fluorescence emission wavelength of the QDs shifts up to 635 nm, however the QY reduced to just 36 %. These results show that during refluxing, the QDs are grown to their final size, as well as the fluorescence emission of the core-shell CdTe/ZnS QDs can be tuned in color with the refluxing time.

As appeared in the Fig. 1a, the absorption band shifts towards longer wavelength with increase in the fluorescence intensity as the ZnS shell grows. The increased intensity is due to the *in situ* formation of ZnS shell causing in the considerable decrease in the surface deformities of core CdTe QDs and the dropping down of confinement energy of exciton after coating core QDs with greater band gap shells [43–49]. Interfacial strain play an essential role which emerges from the extensive lattice mismatch between the ZnS shell and CdTe core (cross section parameters for ZnS $c = 6.257 \text{ \AA}$ and for CdTe $c =$

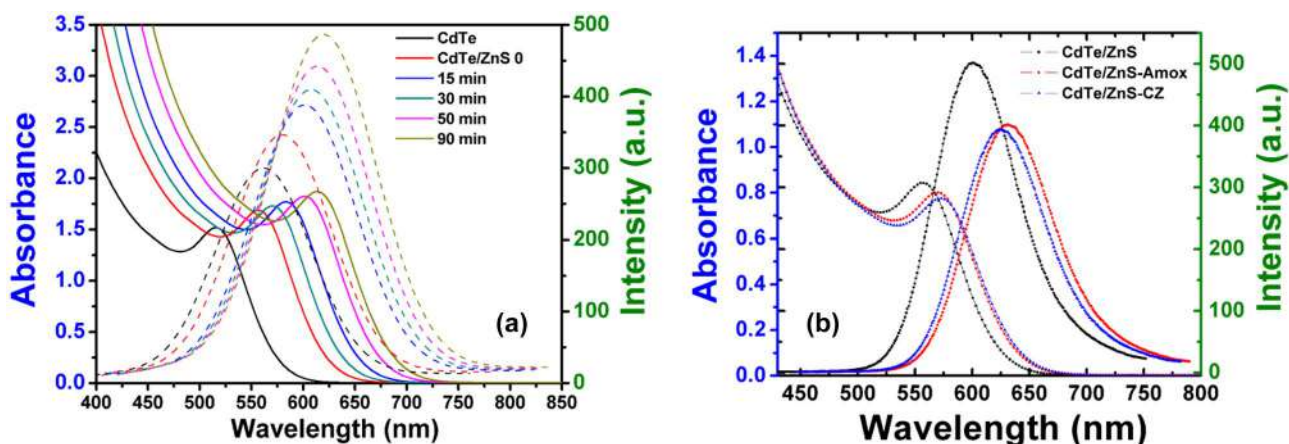


Fig. 1 Absorption and corresponding fluorescence spectra of CdTe and CdTe/ZnS QDs with refluxing time Absorption and corresponding FL spectra of CdTe/ZnS QDs and CdTe/ZnSamox and CdTe/ZnS CZ conjugates

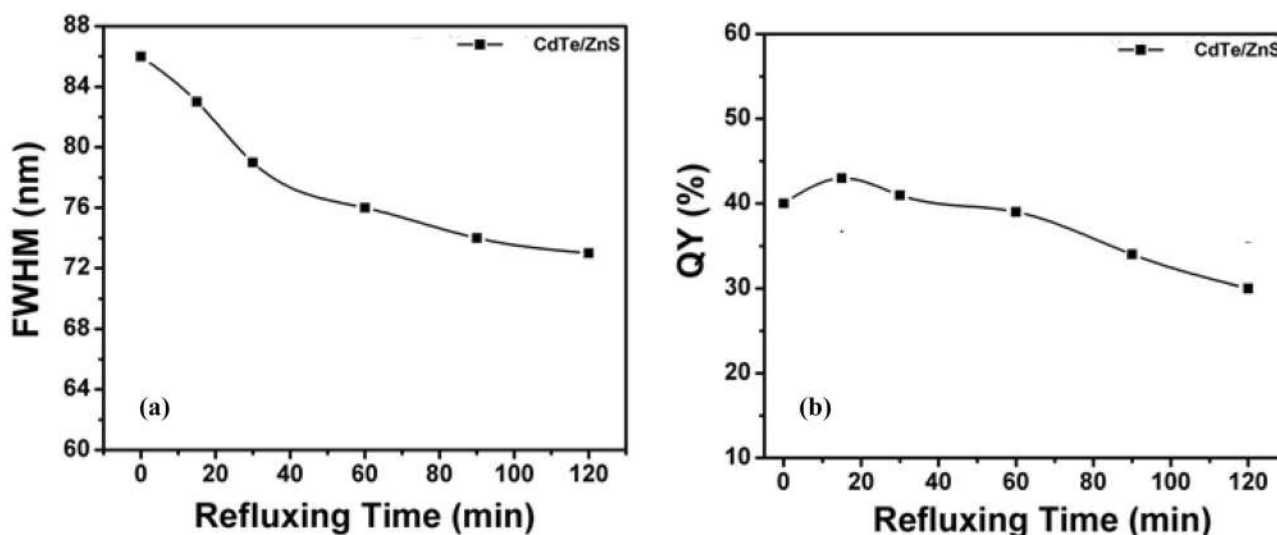


Fig. 2 Variation of FWHM (a) and Quantum Yield (b) of CdTe/ZnS QDs with refluxing time

6.477 Å) [50]. On the other hand, it can be found in Figs. 1a and 2 that the sizes of QDs grow in aqueous phase accomplished by the fluorescence full width at half most extreme (FWHM) decreasing. FWHM of the fluorescence emission peak rapidly changes from 86 nm to 76 nm during refluxing for 15–90 min. The narrow FWHM of the fluorescence emission peak reveals the narrow size distribution, which is a proficient way to explore the size focusing. Furthermore, the conjugation of CdTe/ZnS with Amox and CZ also monitored with absorption and fluorescence spectral measurements (Fig. 1b). The absorption and corresponding fluorescence spectra of amox and CZ CdTe/ZnS conjugates shifts towards longer wavelength with considerable decrease in intensity suggest the conjugation of CdTe/ZnS QDs with amox and CZ.

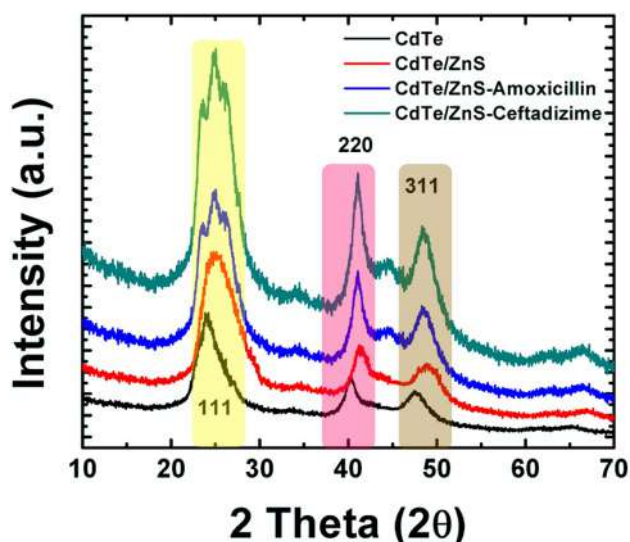


Fig. 3 XRD of CdTe/ZnS QDs and CdTe/ZnS -Amoxicillin and CdTe/ZnS CZ conjugate

The powder XRD diffractogram for the CdTe, CdTe/ZnS, CdTe/ZnS-Amox and CdTe/ZnS CZ conjugates are depicted in Fig. 3. The typical zinc blend planes of 111, 220, and 311 positioned at 24.40° , 41.60° , and 47.90° for CdTe and at 24.94° , 41.72° , and 48.76° for CdTe/ZnS in the range of $10\text{--}70^\circ$ have been observed. The position of the diffraction peaks of CdTe cores is well matched with those of the bulk CdTe cubic structure (JCPDSNO. 15-0770) [42]. After formation of ZnS shell on CdTe core, diffraction peak position shifted to greater angles towards the positions of bulk ZnS cubic structure (JCPDS NO. 05-0566) [42], which is confirmed the formation of CdTe/ZnS. Furthermore, the diffraction peaks of CdTe/ZnS Amox and CdTe/ZnS CZ conjugates also appears to be at 24.94° , 41.72° , and 48.76° , but the peaks at 24.95° shows a small splitting. The splitting of peaks might be due to slight loss in crystalline structure at 111 planes due to conjugation. The TEM and HRTEM images in Fig. 4 show that the CdTe/ZnS NCs possess a good dispersed crystalline structure, and have an average diameter of about 4.7 nm, consistent with the results calculated from the absorption spectrum. The structural characterizations show a

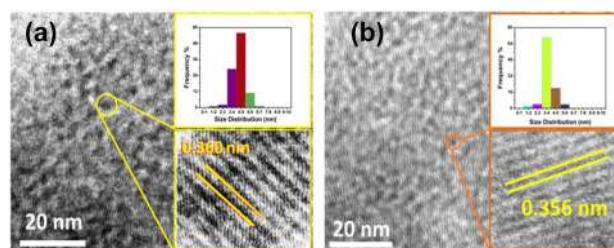


Fig. 4 TEM image of CdTe (a) and CdTe/ZnS QDs (b) Inset: Histogram of CdTe and CdTe/ZnS QDs and HRTEM showing interplaner distance

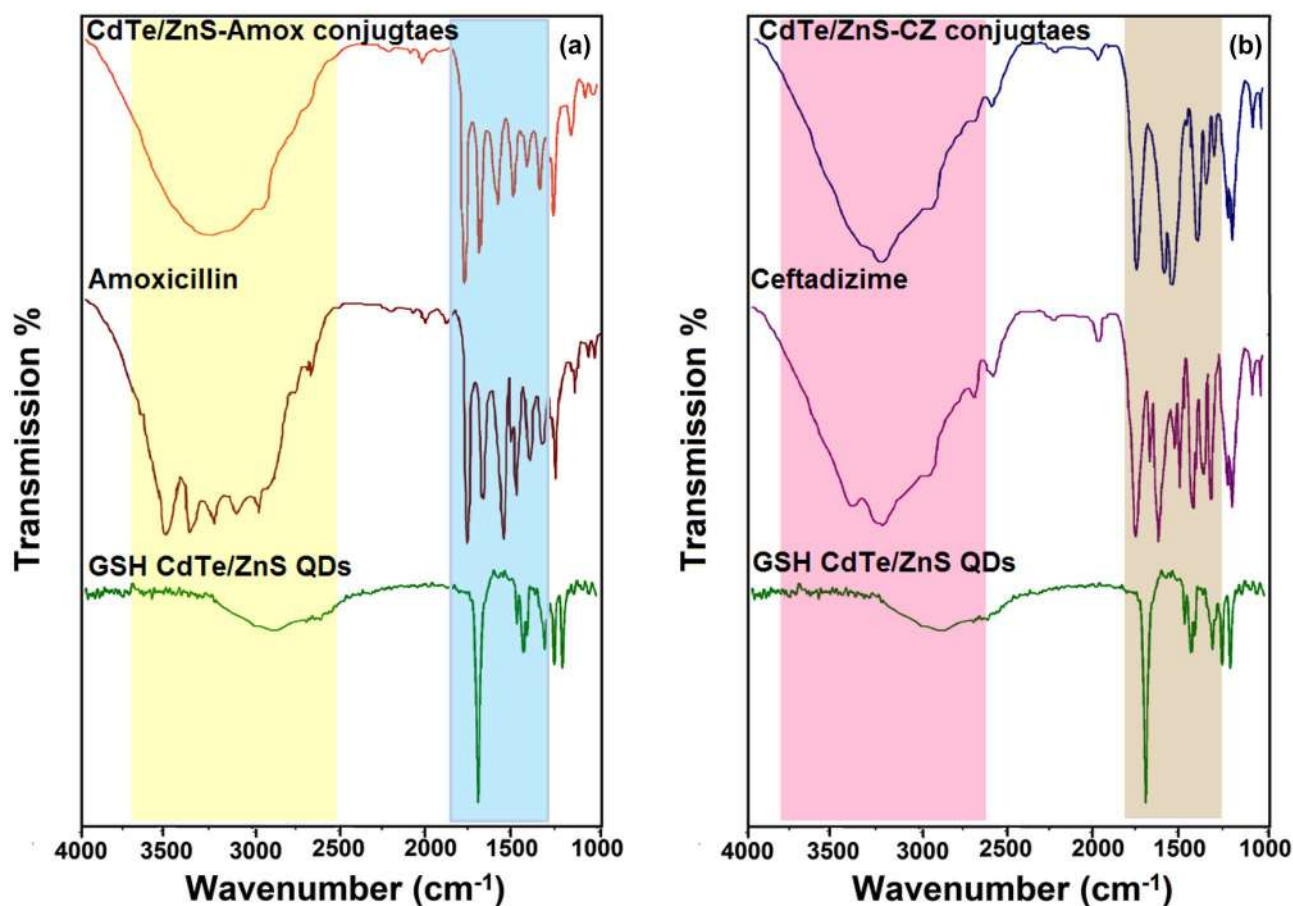


Fig. 5 FTIR spectra of (a) free Amox and Amox-CdTe/ZnS conjugate (b) CZ and CZ-CdTe/ZnS conjugates

continuous growth of the crystallographic planes without a distinct boundary at the core-shell interface. Energy-dispersive X-ray spectroscopy (EDS) was also used to examine the composition of CdTe/CdS/ZnS (Fig. S1). Zn and S were both clearly visible in the EDS pattern,

and the atomic ratio of S:Zn: Cd:Te was determined to be 1.38:1:1.64: 2.84. The FTIR spectrum of CdTe/ZnS antibiotics conjugates and free antibiotics (amox and CZ) reveals the conjugation of CdTe/ZnS with antibiotics as evident in the FTIR spectrum (Fig. 5) Curve 2 (Fig. 5a) represent

Table 1 List of some of the previously reported antibacterial activity studies of Quantum dots and corresponding bacterial strain

S. No.	Quantum Dot Nanaomaterial	Bacterial Strain	Reference
1	CdTe QDs CdS/Ag ₂ S QDs	Escherichia coli Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus	[51] [52]
2	CdTe–Rocephin QD complex	Escherichia coli	[53]
3	Thioglycolic acid (TGA) and mercapto-acetohydrazide (TGH) lysine-capped	Staphylococcus aureus	[54]
4			
5	Ciprofloxacin-Carbon dot conjugate	Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus Bacillus subtilis	[55]
6	CdTe/ZnS-Amoxicilline And Ceftadizime	Escherichia coli, Staphylococcus aureus	Current study

Table 2 MIC₅₀ values of pure antibiotics and antibiotics CdTe/ZnS conjugates for *E.coli* and *S. aureus*

Tested Sample	MIC ₅₀ (µg/ml)	
	<i>E.coli</i>	<i>S. aureus</i>
CdTe/ZnS	> 700	> 600
Amox	140±2.5	4.8±0.5
Amox-CdTe/ZnS	102 ±1.5	3.0±0.8
CZ	12.5 ±0.5	4.6±0.8
CZ-CdTe/ZnS	9.5±0.5	3.6±0.5

the free amox which show characteristic absorption bands of cephalosporin compounds, such as 3660-3250 cm⁻¹ (N-H group axial deformation), 1750-1725 cm⁻¹ and 1540 cm⁻¹ (carboxylic acid function C=O stretching), 1475-1600 cm⁻¹ (aromatic ring C=C axial deformation), 1350-1300 cm⁻¹ (C-N axial deformation) and 1680-1630 cm⁻¹ (amide group C=O axial deformation). Curve 3 (Fig. 5a) amox-CdTe/ZnS conjugates which shows quite characteristics changes in their amide stretching vibration such as splitting of 1680 cm⁻¹ (amide group C=O axial deformation) bands which suggest the formation of conjugates through amide bond formation. Similarly, Curve 2 (Fig. 5b) represent the free CZ which show broad absorption bands of N-H group axial deformation at 3660-3250 cm⁻¹, 1748 cm⁻¹ (carboxylic acid function C=O stretching), 1480 cm⁻¹ (aromatic ring C=C axial deformation), 1382 cm⁻¹ (C-N axial deformation) and 1678 cm⁻¹ (amide group C=O axial deformation). The stretching band at 1678 cm⁻¹ splits in to two peaks suggested the formation of new amide bond as well as the conjugation of CdTe/ZnS QDs with CZ.

Antibacterial Activity Tests

To evaluate the antibacterial efficacy of CdTe/ZnS antibiotics conjugates, the activity were tested at different concentrations against *E.coli* and *S. aureus*. The micro dilution method was employed to evaluate their antibacterial activity

and minimum inhibitory concentration (MIC₅₀). The evaluation included also the different concentrations of bare CdTe/ZnS, pure antibiotics and CdTe/ZnS-antibiotic conjugates to compare and analyze the antibacterial behavior contributed from each component of the conjugates. Moreover, the current study has been compared with that of previous reports and best of our literature survey we found that no such attempts have been made till now (Table 1)

Tables 2, 3 and 4 summarizes the percentage inhibition and MIC₅₀ values of bare CdTe/ZnS, pure antibiotics (Amox, CZ) and CdTe/ZnS-antibiotic conjugates, to inhibit both bacterial strains. The obtained data show that the percentage inhibition of bacterial growth increases with increasing concentration of CdTe/ZnS, Amox, CZ, and its conjugates. The percentage inhibition of Amox-CdTe/ZnS conjugates (50, 100, 150, 200 and 300µg/ml) against *E.coli* is found to be 32.06, 49.94, 69.01, 85.69 and 94.63% which is greater than the percentage inhibition of free Amox which shows 20.14, 40.40, 61.85, 79.73 and 89.27 % after 6h treatment at 37 °C (Fig. 6a). Similarly, the percentage inhibition of Amox-CdTe/ZnS conjugates (1, 3, 5, 10 and 20 µg/ml) against *S. aureus* found to be 33.25, 51.13, 71.39, 85.31 and 95.01 % which is greater than the percentage inhibition of free Amox Table (2 and 3) (Fig. 6c). Similar trends were observed for CZ-CdTe/ZnS conjugates and pure CZ against both the bacterial strain (Fig. 6b, d) (Tables 5 and 6). Furthermore, the MIC₅₀ of 102.0 and 3.0 µg/mL of Amox-CdTe/ZnS conjugates and 9.5 and 3.6 µg/mL of CZ-CdTe/ZnS conjugates are required to kill 50 % of *E. coli* and *S. aureus* bacteria, respectively (Table 2). On the other hand, the MIC₅₀ corresponding to bare CdTe/ZnS, CZ and Amox were found to be above the Amox-CdTe/ZnS and CZ-CdTe/ZnS conjugates for *E. coli* and *S. aureus* bacteria (i.e., 700 µg/ml and 500 µg/ml for CdTe/ZnS, 140 µg/mL and 4.8 µg/ml for Amox, 12.5 µg/ml and 4.8 µg/ml for CZ). It is clear that there is a significant enhancement and a strong antibacterial activity associated with CdTe/ZnS-antibiotic conjugates, as compared to bare CdTe/ZnS and pure antibiotics.

Table 3 Inhibition percentage of Amox, Amox-QD conjugates after 6 h treatment.

Tested Sample				Inhibition Percentage			
<i>E.coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180		<i>E.coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180	
Amox (µg/ml)	Amox-QD (µg/ml)	Amox (µg/ml)	Amox-QD (µg/ml)	Amox	Amox-QD	Amox	Amox-QD
50	50	1	1	20.14±1.93	32.06±1.83	27.29±1.97	33.25±1.82
100	100	3	3	40.40±1.84	49.94±1.89	42.78±2.33	51.13±2.16
150	150	5	5	61.85±2.23	69.01±2.13	64.24±1.91	71.39±1.85
200	200	10	10	79.73±1.94	85.69±1.69	80.12±1.74	85.31±1.78
300	300	20	20	89.27±1.86	94.63±1.79	90.70±1.96	95.01±1.91

Table 4 Inhibition percentage of CZ, CZ-QD conjugates after 6 h treatment.

Tested Sample				Inhibition Percentage			
<i>E. coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180		<i>E. coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180	
CZ (µg/ml)	CZ-QD (µg/ml)	CZ (µg/ml)	CZ-QD (µg/ml)	CZ	CZ-QD	CZ	CZ-QD
5	5	1	1	24.91±2.13	36.82±2.22	15.37±1.85	22.52±1.98
10	10	3	3	48.15±1.84	52.32±1.87	39.21±1.54	43.98±1.86
15	15	5	5	64.97±2.23	76.73±2.12	55.89±2.11	64.24±1.92
20	20	10	10	85.08±1.94	89.46±1.69	73.77±1.74	77.35±2.41
30	30	20	20	93.82±1.86	96.30±1.81	89.27±1.96	95.23±1.92

The antimicrobial effectiveness of CdTe/ZnS-Amox and CdTe/ZnS-CZ conjugates, dose-dependent growth kinetics curves of *E. coli* and *S. aureus* were used to assess the relative rate and extent of antibacterial activity of CdTe/ZnS-Amox and CdTe/ZnS-CZ conjugates. Figure 7 display the growth profiles of *E. coli* treated with various concentrations of pure antibiotics and CdTe/ZnS-antibiotic conjugates. Figure 7a, b shows a strong inhibition of *E. coli* and

S. aureus when treated with Amox and CZ. The interaction between CdTe/ZnS-antibiotics conjugates (Amox and CZ) and *E. coli* was stronger than pure antibiotics (Amox and CZ), and the inhibition was significantly high (Fig. 7a, b). The lowest concentration of 50 µg/mL of Amox exerts a delay of 4 h in the growth rate of *E. coli* and 5 µg/mL of CZ exerts a delay of 6 h in the growth rate of *E. coli*. On the other hand, CdTe/ZnS-antibiotic conjugates displayed a slightly

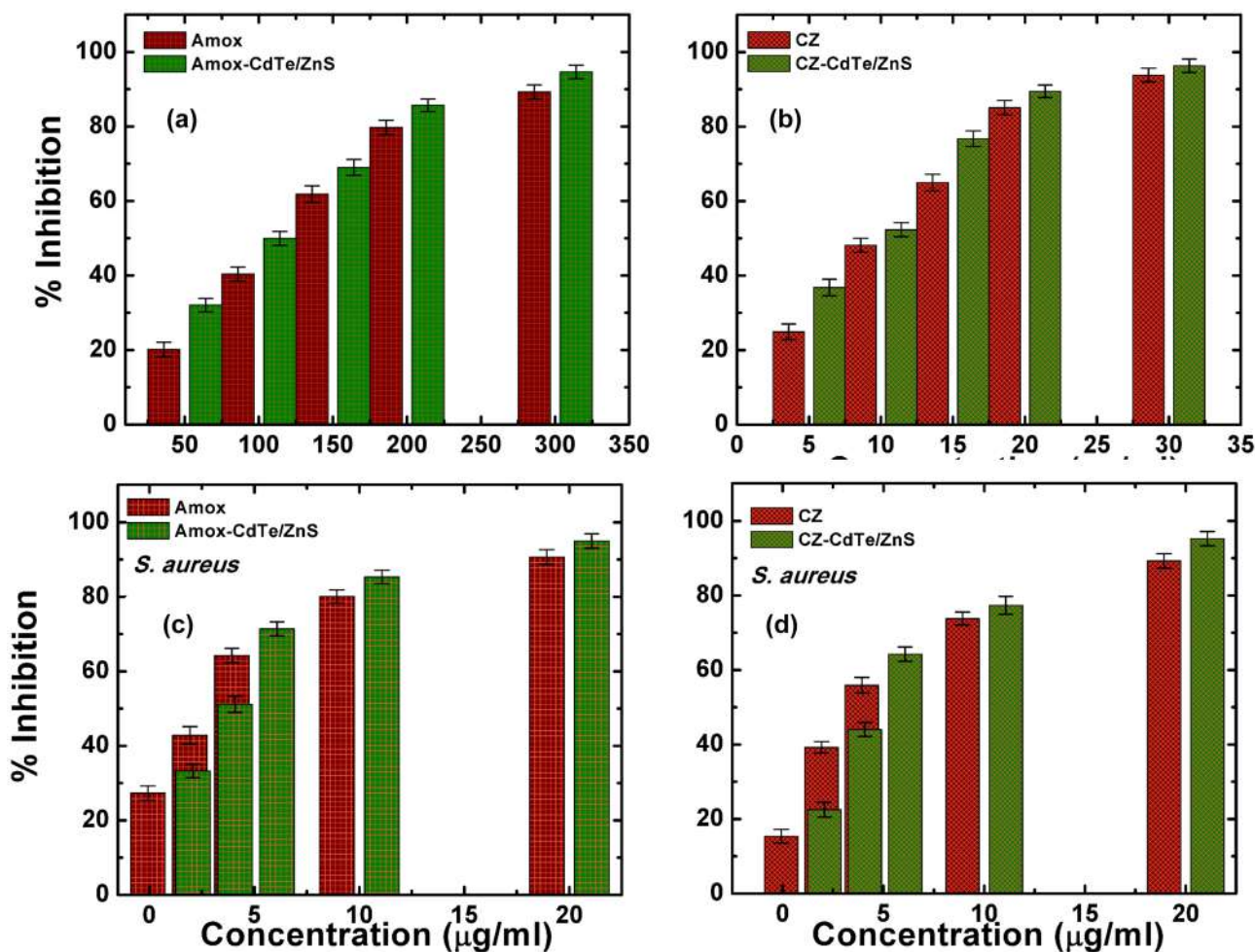
**Fig. 6** Inhibition percentage profile of Amox, Amox-CdTe/ZnS CZ and CZ-CdTe/ZnS conjugates against *E. coli* and *S. aureus*

Table 5 Inhibition zone of Amox, Amox-QD conjugates after 24 h treatment

Tested Sample				Inhibition Zone (mm)			
<i>E. coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180		<i>E. coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180	
Amox (μg/ml)	Amox-QD (μg/ml)	Amox (μg/ml)	Amox-QD (μg/ml)	Amox	Amox-QD	Amox	Amox-QD
50	50	1	1	14.0±1.93	18.0±1.93	13.0±1.93	18.0±1.93
100	100	3	3	25.0±1.93	29.0±1.93	20.0±1.93	24.0±1.93
150	150	5	5	30.0±1.93	34.0±1.93	26.0±1.93	29.0±1.93
200	200	10	10	36.0±1.93	44.0±1.93	32.0±1.93	35.0±1.93
300	300	20	20	45.0±1.93	56.0±1.93	35.0±1.93	41.0±1.93

Table 6 Inhibition zone of CZ, CZ-QD conjugates after 24 h treatment.

Tested Sample				Inhibition Zone (mm)			
<i>E. coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180		<i>E. coli</i> MTCC1687		<i>S. aureus</i> MTCC 3180	
CZ (μg/ml)	CZ-QD (μg/ml)	CZ (μg/ml)	CZ-QD (μg/ml)	CZ	CZ-QD	CZ	CZ-QD
5	5	1	1	16.0±1.93	17.0±1.93	15.0±1.93	18.0±1.93
10	10	3	3	23.0±1.93	28.0±1.93	21.0±1.93	24.0±1.93
15	15	5	5	27.0±1.93	32.0±1.93	26.0±1.93	29.0±1.93
20	20	10	10	31.0±1.93	37.0±1.93	31.0±1.93	35.0±1.93
30	30	20	20	41.0±1.93	46.0±1.93	38.0±1.93	43.0±1.93

strong antibacterial behavior at lower concentrations than pure antibiotics. Similar bacterial population growth kinetics experiments have been carried out for pure antibiotics and QD-antibiotic conjugates with *S. aureus* (Fig. 7a, b). Similar to the *E. coli*, pure Amox and CZ displayed strong antibacterial activity against *S. aureus*, where the bacterial growth rate becomes slower when increasing the antibiotic

(Amox and CZ) concentrations. Nonetheless, an increase in the antibacterial effect of CdTe/ZnS-antibiotic conjugates was observed.

Furthermore, we used the well diffusion method to evaluate the ability of QDs-antibiotic conjugate to inhibit the formation of bacterial biofilms (Figs. 8 and 9). Tables 5 and 6 summarizes the diameter of the inhibition zones exhibited by

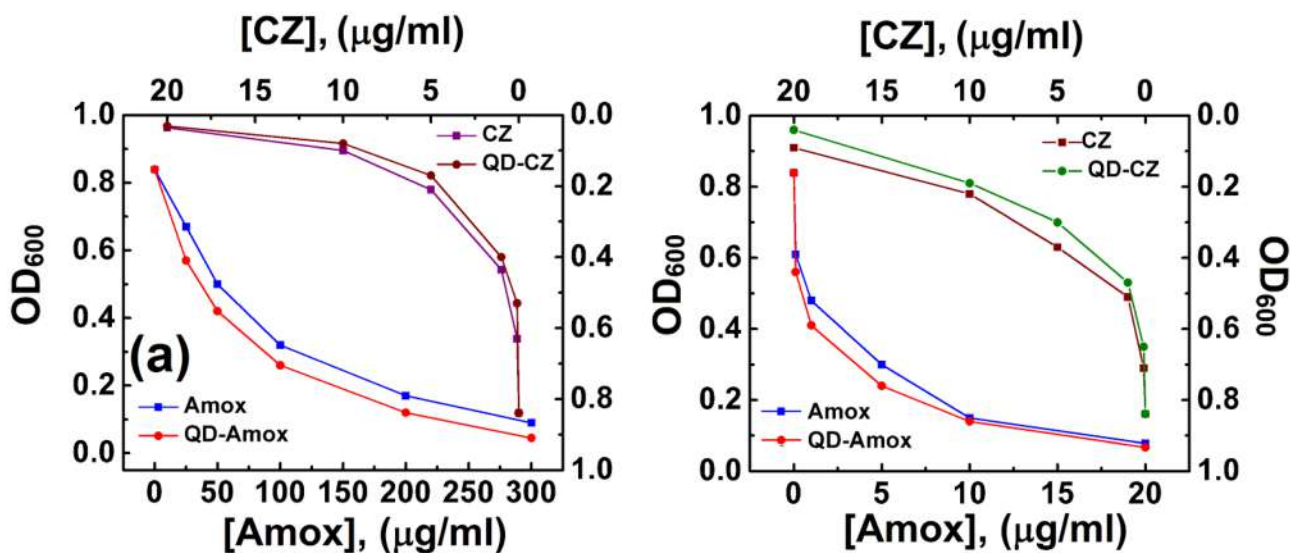


Fig. 7 Bacterial growth inhibition curve of (*E. coli* and *S. aureus*) at different concentration of pure antibiotics and its corresponding QD-conjugates

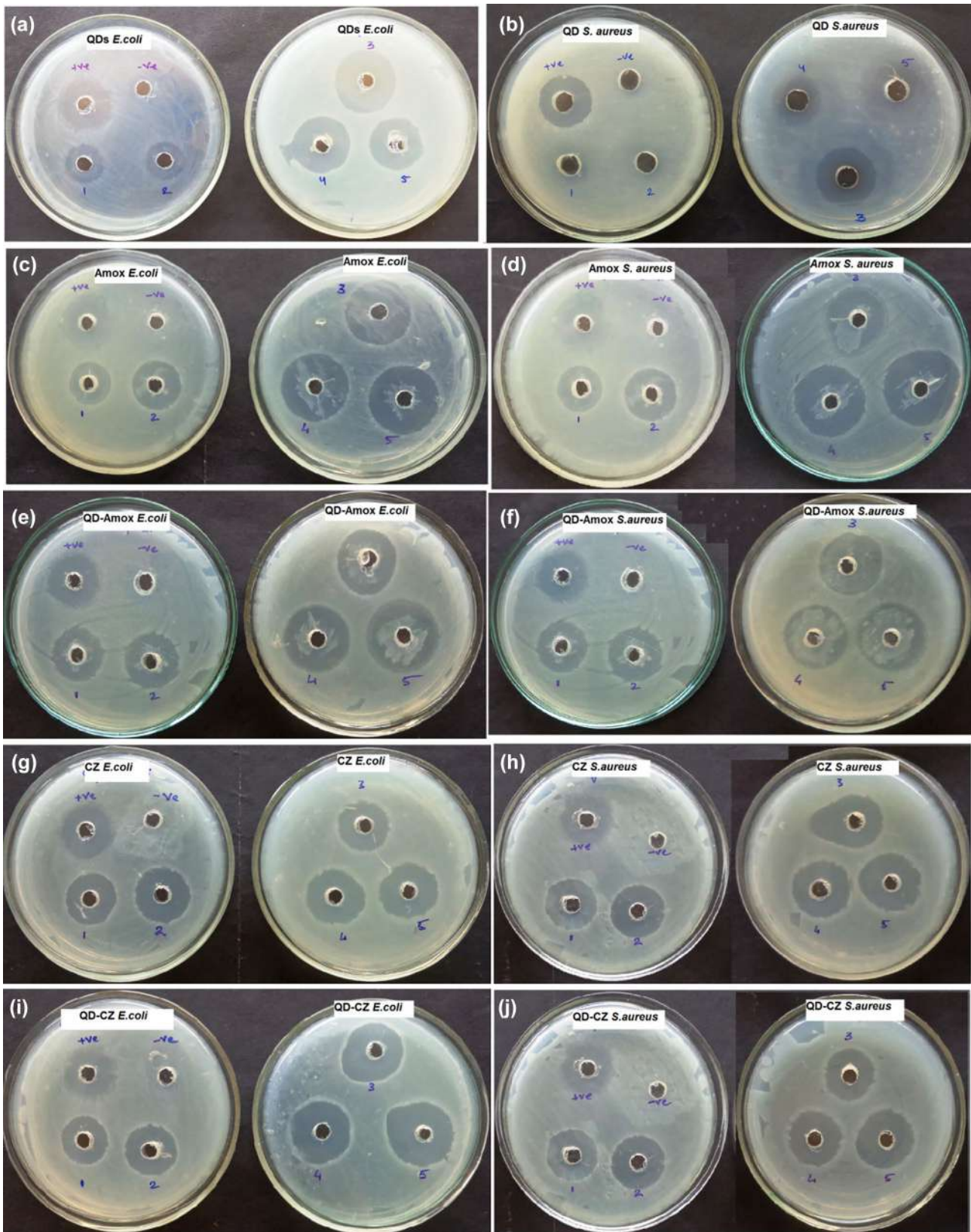


Fig. 8 Disc diffusion assay for *E. coli* and *S. aureus* (a–b) QDs against *S. aureus* and *E. coli*, (c–d) Amox against *S. aureus* and *E. coli*, (e–f) QDs-Amox conjugates against *S. aureus* and *E. coli*, (g–h) CZ against *S. aureus* and *E. coli*, (i–j) QDs-CZ conjugates against *S. aureus* and *E. coli*

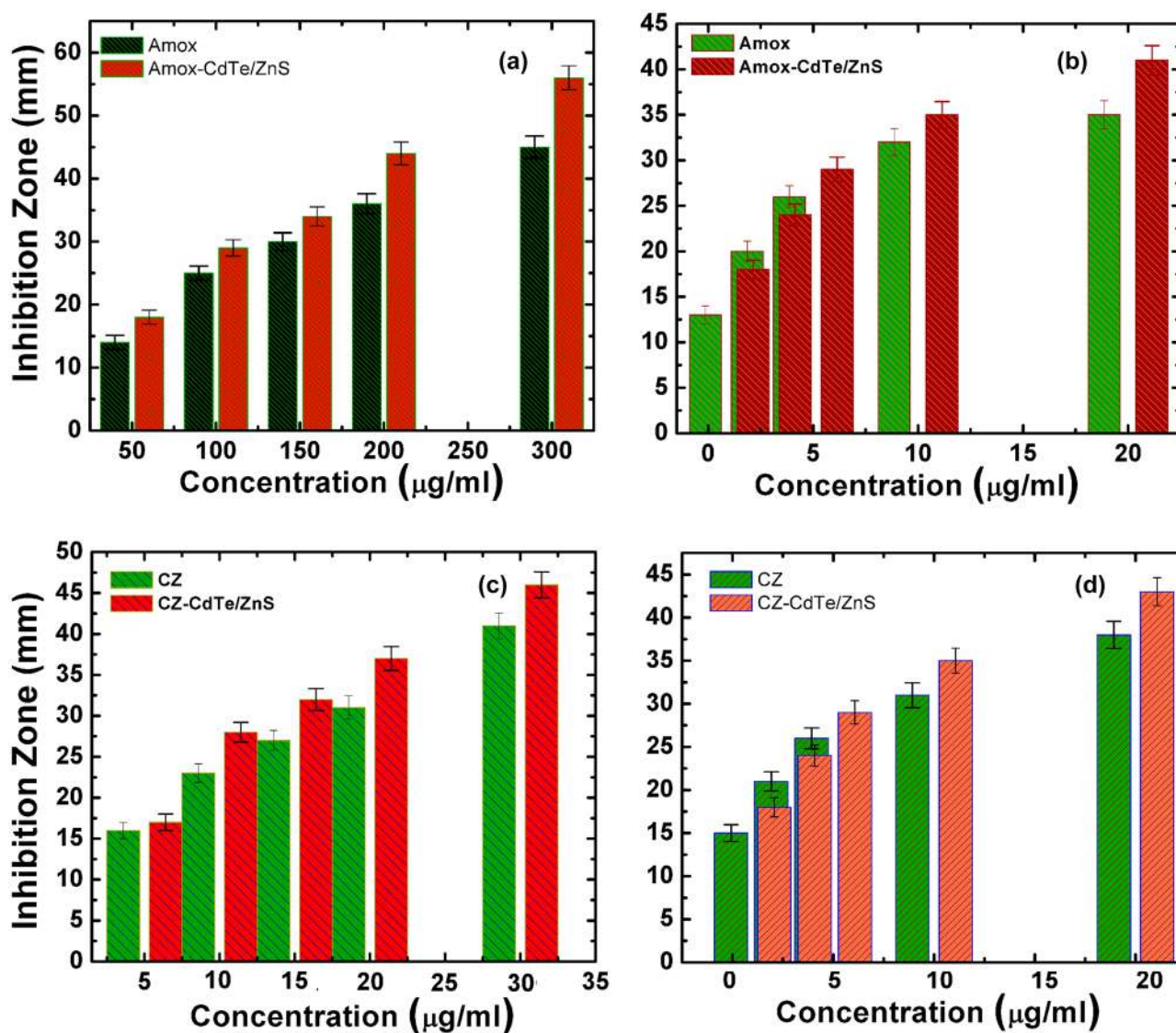


Fig. 9 Inhibition Zone profile of Amox, Amox-CdTe/ZnS, CZ and CZ CdTe/ZnS conjugates against *E. coli* (a-c) and *S. aureus* (b-d)

the diffusion of bare QDs, pure antibiotics and QD-antibiotic conjugates. The diameter of inhibition zone by Amox-CdTe/ZnS conjugates (50, 100, 150, 200 and 300 $\mu\text{g/ml}$) against *E. coli* is found to be 18.0, 29.0, 34.0, 44.0 and 56.0 mm which is greater than the diameter of inhibition zone created by free Amox which shows 14.0, 25.0, 30.0, 36.0 and 45.0 mm after 24 h treatment at 37 °C. Similarly, the inhibition zone produced by Amox-CdTe/ZnS conjugates (1, 3, 5, 10 and 20 $\mu\text{g/ml}$) against *S. aureus* is found to be 18.0, 24.0, 29.0, 35.0 and 41.0 mm which is greater than the inhibition zone produced by free Amox (Tables 5 and 6). Similar trends were observed for CZ-CdTe/ZnS conjugates and pure CZ against both the bacterial strain. In contrast, bare CdTe/ZnS exhibited very low inhibition against both bacterial strains while antibiotics showed quite strong inhibition for both the

bacterial strain. Moreover, the Amox-CdTe/ZnS and CZ-CdTe/ZnS conjugates displayed greater inhibition than the pure antibiotics.

The observed antibacterial efficacy of Amox-CdTe/ZnS and CZ-CdTe/ZnS conjugates can be explained on the basis of earlier studies. We proposed that β -Lactam antibiotics exhibit bactericidal properties by disrupting the formation of bacterial cell walls through covalent binding to crucial penicillin-binding proteins (PBPs). These enzymes are responsible for the final stages of peptidoglycan cross-linking in both Gram-negative and Gram-positive bacteria. Furthermore, The QDs insert into the cell membrane to cause membrane stress; and heavy metal ions are released into the cells to decline the gene expression of superoxide dismutase (SOD) [51]. In addition, the QD-antibiotic

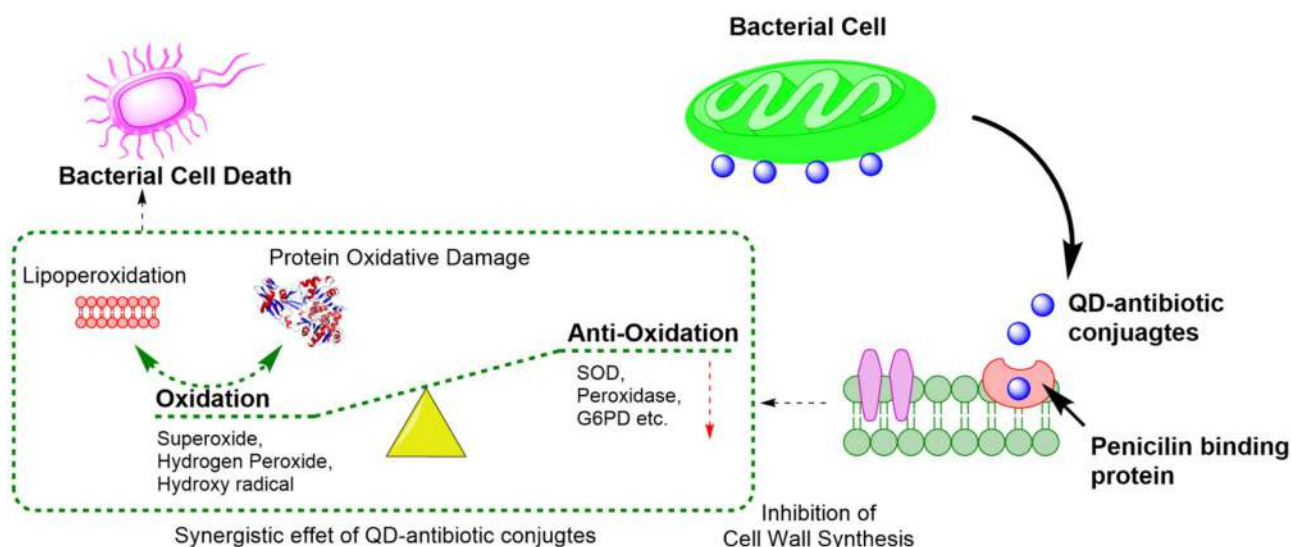


Fig. 10 Mechanism of antibacterial activity

conjugates attach to nuclear material and interfere with protein synthesis or nucleic acid replication (Fig 10) [52]. The synergistic effect of a CdTe/ZnS-antibiotic conjugates can contribute to the superior antibacterial efficacy of CdTe/ZnS-Amox and CdTe-CZ conjugates compared to that of bare CdTe/ZnS quantum dots and antibiotic.

Conclusions

The CdTe/ZnS core shell quantum dots with high quantum yield up to 48% were successfully synthesized. Furthermore, the GSH functionalized CdTe/ZnS core shell QDs was successfully conjugated with amoxicillin and ceftazidime to form QDs-antibiotics conjugates. The Amox-CdTe/ZnS and CZ-CdTe/ZnS conjugates showed enhanced antibacterial activity against *E.coli* and *S. aureus* bacteria, which are used as Gram-negative and Gram-positive model bacteria, respectively. The results showed that the conjugation of CdTe/ZnS QDs with Amox and CZ antibiotics fosters a small synergistic effect and reduces the concentrations of antibiotics required to inhibit both bacterial strains. This research can provide helpful insights to the development of new kind of antimicrobial agents.

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Authors' Contributions S.K.V.: experiment, data interpretation and drafting of the manuscript; J.K.: some measurement of fluorescence; R.N.: correction and review of manuscript; T.V.: helped in performing the antibacterial activity experiment and interpretation; S.K.J.: supervise all the antibacterial activity experiment and interpretation; M.L.S.: supervise all the experiment, interpretation of data and manuscript writing.

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Data Availability All the data and materials from this manuscript will be made available on request.

Declarations

Ethical Approval Not Applicable.

Consent to Participate Not Applicable.

Consent for Publication Not Applicable.

Conflict of Interests The authors declare no competing interest.

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Chitosan decorated magnetic nanobiocatalyst of *Bacillus* derived α -amylase as a role model for starchy wastewater treatment, detergent additive and textile desizer

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Starch

ABSTRACT

In this study, *Bacillus tequilensis* TB5 α -amylase from rice-milled by-products (rice bran and de-oiled rice bran) was successfully immobilized onto biologically synthesized magnetic nanoparticles fabricated with chitosan (MNP-Ch) and characterized via different biophysical techniques. Furthermore, the study emphasized incorporating this nanostructure framework (MNP@2mgchitosan_DORB-amy and MNP@3mgchitosan_RB-amy) to offer diverse applications, including enzymatic desizing, cleaning starchy stains, and treating synthetic starchy wastewater. An enzyme loading of > 90 % for both enzymes indicated increased binding sites due to the functional moieties of chitosan on the MNP. The K_m was 0.28 and 0.31 mg/mL for the immobilized and free forms of DORB-amy, respectively, and 0.18 and 0.27 mg/mL for the immobilized and free forms of RB-amy, respectively. A low K_m indicated an increased affinity of MNP-Ch-immobilized forms of enzymes toward the substrate. The performance of both immobilized enzymes improved at a wide range of pH and temperature, which may be attributed to the covalent binding of the enzyme on to the MNP-Ch. The nanobiocatalysts in the detergent act synergistically to fade the starchy stains. Furthermore, an 8–9 TEGEWA scale rating with > 11 % of starch removal was obtained through the biodesizing of starch-sized cotton fabric. The nanobiocatalyst efficiently decomposed starch and liberated 650–670 mg/L of reducing sugar from the synthetic wastewater, therefore offering promising opportunities for its exploration in a wastewater treatment plant. Thus, the study recommends the potential exploration of sturdy matrices like MNP to offer remarkable applications with maximum operational stability, easier recovery, and higher efficiency.

1. Introduction

Microorganisms have proven as a boon since time immemorial by aiding synthesis of bio-products like enzymes. The motivation to do this research was found because of the excellent potential of microorganisms in synthesizing application-based enzymes. Hydrolytic enzymes from microbial sources are the need of the hour due to their immense application in various sectors. α -Amylase (E.C 3.2.1.1 1,4- α -glucan-glucohydrolase) is an α -glucanase which preferentially cleaves internal α -D-(1,4) glycosidic linkages of starch in a random manner to generate short chain α -anomeric product at random locations [1]. α -Amylase is the backbone of starch-based firms which accounts for about 30 % share of the whole enzyme market and the second most demanded enzyme after proteases [1,2]. It offers endless applications in food/bakery, biofuels, textile, detergents, textile, pharmaceuticals and wastewater remediation

[3,4].

Enzymes have numerous advantages including eco-friendliness, cost-effectiveness, require mild operational conditions and high specificity. Despite having the aforementioned plus points, its solubility in the reaction mixture, a non-recovery and poor catalytic performance due to structural disruption at the extreme condition of pH and temperature limits its usage in industries [5–8]. Immobilization has proven to be the promising solution for all these shortcomings of free enzymes. Immobilization is an empiric technique of confining an enzyme in/onto a suitable support known as a matrix via several weak and strong interactions for enhancing its stability, reusability and recovery [7,9,10]. The main advantage of immobilization is that it reduces the cost of the entire production process because the enzyme prepared once can be used multiple times with even better catalytic efficiency [2,7,8].

The correlation between nature and nanotechnology has proven to

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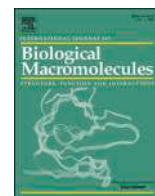
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Biovalorizing agro-waste 'de-oiled rice bran' for thermostable, alkalophilic and detergent stable α -amylase production with its application as laundry detergent additive and textile desizer

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ABSTRACT

The current research was concerned with the use of abundant agro-waste 'de-oiled rice bran (DORB)' as a sustainable substrate to produce α -amylase followed by several targets like process parameter optimization for augmented production and immobilization. In addition, we have also focused on investigating the application of DORB_{amy} as an efficient laundry detergent additive and textile desizer. The best production was recorded at pH 8.0 at 37 °C after 96 h incubation with 1.5 % (w/v) maltose. The DORB_{amy} has optimum activity at pH 9.0 at 60 °C with a K_m and V_{max} of 0.31 mg/mL and 222.22 mg/mL/min respectively. The catalytic performance of DORB_{amy} was further enhanced after immobilization in 3.0 % calcium alginate beads with 61.95 \pm 0.17 % of operational stability after five continuous reaction cycles. The findings showed excellent performance of DORB_{amy} in cleaning starchy stains. The washing performance of enzyme and detergent together was better than their individual performance which increases the application of α -amylase as a laundry detergent additive. About 17.34 % weight loss or desizing was done by DORB_{amy} with an 8–9 TEGEWA rating. The reported biochemical features like thermostability, alkalophilic and detergent-stable nature of the DORB_{amy} make it industrially fit with great significance.

1. Introduction

The extracellular hydrolytic enzymes produced by a diverse group of microorganisms have vital importance in the biotechnology sector due to their countless applications. Since it is easier and faster to cultivate microorganisms than plants or animals, and it is easy to genetically modify the producing organisms to generate desired grades and quantities of enzymes, microbial enzymes proved to be economically advantageous. Hydrolytic enzymes have superior selectivity and can be used in mild reaction conditions than chemical catalysts, they are highly intriguing biocatalysts that have been the subject of much research [1,2]. Chemical catalysts have been surpassed by microbial enzymes nowadays. Microbial hydrolases like proteases, amylases, lipases, cellulases and pectinases have long-term applications in industries such as food, paper and pulp, feed, textile, detergent, pharmaceutical, leather, biopolymer and waste treatment [1,3]. One such hydrolase owing versatile application in starch-based industries is α -amylase which is the need of the hour.

Starch is an abundant polysaccharide and the ultimate reservoir of

energy for the organisms on earth. The demand for starch and its hydrolytic products is increasing in various industries, reinforcing the search for an efficient α -amylase enzyme. α -Amylase (endo-1, 4- α -D-Glucan glucohydrolase; E.C. 3.2.1.1) is an α -glucosidase widely used by industries to offer several vital applications [1,3]. It randomly cleaves the α -(1,4) glucosidic bonds of starch and other similar polysaccharides to release short-chain products like glucose, maltose and dextrin in α -anomeric configuration. Approximately 30 % share of the industrial enzyme market is dominated by α -amylases [3,4]. A lot of research and development is going on in searching for an efficient α -amylase for the detergent and textile industry that can withstand extreme conditions of temperature, pH and harsh chemicals.

On taking account of sustainability, the cheaper production medium is very significant for enzyme production. The use of agricultural by-products including various crop residues like wheat straw, wheat bran, groundnut husk, corn straw, coconut coir and sugarcane bagasse for extracellular α -amylase production has grown rapidly in recent decades [3,4]. Agro-waste has many supremacies such as its diversity, easy availability, cost-effectiveness, environment friendliness and high

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Bioethanol Production by Immobilized *Enterobacter Cloacae* Using Different Matrices

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Abstract

Biofuels can be produced through the bioconversion of lignocellulosic substrates, which are derived from sustainable and renewable resources. One such biofuel, bioethanol, stands out as a viable alternative for transportation fuel, offering a sustainable approach to address the challenges posed by fossil fuels. The present study aimed to investigate the immobilization of *Enterobacter cloacae* cells for bioethanol production from rice husk hydrolysates. For this purpose, the biocompatible carriers such as Calcium alginate and activated charcoal beads were used for immobilization. The parameters of bioethanol fermentation, such as the incubation period in different carriers and the choice of a convenient carrier for efficient ethanol production were studied. The maximum bioethanol production of 10.8% was obtained in the 24 hour of the incubation period, with *Enterobacter cloacae* immobilized in Ca-alginate using a droplet method. However, after the second fermentation cycle, Calcium alginate beads got degraded and resulted in lower bioethanol production. The *Enterobacter cloacae* immobilized on activated charcoal also showed better production at 48 hour of 9.15% as compared to free cells (8.03%).

Keywords: Agro-waste; Bioethanol; Ca–alginate; *Enterobacter cloacae*; Immobilization

Introduction

The overuse and combustion of fossil fuels are severely impacting the environment by releasing carbon dioxide and other harmful gases, thus intensifying the greenhouse effect, global warming, and climate change. The transportation sector alone accounts for almost 40% of all fossil fuel usage, highlighting the urgent need to minimize CO₂ emissions through advanced technology and reduce reliance on fossil fuels (Chacón-Navarrete et al., 2021). One of the most promising sustainable fuels that have gained significant attention worldwide is biofuels, as they are renewable, environmentally friendly, and do not interrupt the balance of the environment. Biofuels possess low carbon and sulfur emissions, which make them cheap and could eventually displace energy sources generated from petroleum. The usual natural process of fossil fuel generation takes hundreds or thousands of years, whereas biofuels are manufactured from biomass in a very short period of time. Biofuels from lignocellulosic waste are produced as a substitute for renewable sources of energy (Beliya et al., 2013; Takano and Hoshino, 2018). Among all the biofuels, bioethanol can be used in the transport sector mixed with gasoline or as an octane enhancer as ETBE (ethyl tertiary butyl ether, with 45% ethanol by volume and 55% isobutylene). Bioethanol can directly be used in vehicles as it has similarities with conventionally used fuels, with some modifications in the engine. Bioethanol and gasoline (5–10% by volume) can be used without modifying the vehicle engine. (Bušić et al. 2018).



Morphological and biochemical alterations during in vitro microrhizome formation of *Curcuma caesia* Roxb

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Abstract

Curcuma caesia Roxb., a critically endangered herb in the Zingiberaceae family, can be conserved through microrhizomes, which are easily transported, germinate like seeds, and are independent of seasonal variations. The current investigation attempts to induce microrhizomes of this endangered herb for conservation purpose using high concentration of sucrose. To encourage the establishment of microrhizomes, six-month-old cultures of *C. caesia* were transferred to Murashige and Skoog supplemented with containing 8 mg L⁻¹ benzyladenine, 8 mg L⁻¹ kinetin, 100 mg L⁻¹ citric acid, 200 mg L⁻¹ adenine sulphate, and 2 mg L⁻¹ indole-3-acetic acid (standard medium). For this, standard medium was examined with sucrose concentrations of 3%, 6%, 9%, and 12%. The standard medium with 9% sucrose showed the highest rate of microrhizome formation (now referred as microrhizome production medium, MPM). During acclimatization, the survival rate of microrhizomes exceeded 90%. The physiology behind the microrhizome formation was also evaluated using enzymatic and non-enzymatic tests on days 0, 30, and 60 after inoculation. Superoxide dismutase activity, an enzymatic defence molecule, and total soluble sugar and ascorbate content, a non-enzymatic defence molecule, both increased in the MPM microrhizomes relative to the control [shoot multiplication medium (standard medium with 3% sucrose) at day 0]. Further, protein, 2-thiobarbituric acid reactive substances, and hydrogen peroxide content also increased. The biochemical results proved that 9% sucrose in MPM induces osmotic stress which eventually led to the formation of *C. caesia* microrhizomes, an in vitro storage organ.

Keywords Ascorbate · Black turmeric · Osmotic stress · Storage organ · Sucrose · Superoxide dismutase

Abbreviations

ANOVA	Analysis of variance
APX	Ascorbate peroxidase
CAT	Catalase
DAI	Days after inoculation
DMRT	Duncan's multiple range test
H ₂ O ₂	Hydrogen peroxide
MPM	Microrhizome production medium
MS	Murashige and Skoog
ROS	Reactive oxygen species
SMM	Shoot multiplication medium
SOD	Superoxide dismutase
TBARS	2-Thiobarbituric acid reactive substances

Storage organ crops are now second to cereal crops in cultivation as they are a prime source of secondary metabolites used in medicinal and human health applications (Natarajan et al. 2019). An efficient method is required to produce storage organs, which could help increase their population and obtain a sufficient number of clones (Quraishi et al. 2017). *Curcuma caesia* Roxb., commonly known as black turmeric, is a tuberous rhizomatous herb belonging to the Zingiberaceae family. It is an endangered plant native to Central and North-East India. The rhizome is the only part used for the propagation of plants and also possesses pharmacological properties. The extract of *C. caesia* has been well-documented for its anticancer, anti-acne, anti-asthmatic, anti-inflammatory, and antimicrobial properties, along with its potential in treating fever, diarrhea, skin disorders, rheumatic pains, typhoid, neurological and central nervous system disorders, as well as muscle and anxiety-related problems (Arya et al. 2022). This species has also been reported to have protective effects against Alzheimer's disease and other inflammatory bowel diseases (Benya et al. 2023). The plant has two storage organs: the rhizome and multiple root tubers,

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Low-temperature storage in dark condition improved the *in vitro* regeneration of *Plumbago zeylanica* synthetic seeds: a medicinally valuable species

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Abstract

Medicinal applications of *Plumbago zeylanica* and its metabolites on various diseases and low viability and inconsistent germination of its seeds are the reasons behind the loss of its genetic diversity. Hence, an efficient protocol for the short-term storage of *P. zeylanica* synthetic seeds, which is an overexploited medicinally valuable plant, was developed. Initially, *in vitro* culture was performed from nodal explants to develop synthetic seeds from its proliferated shoots. Murashige and Skoog (MS) medium augmented with 0.5 mg L⁻¹ 6-benzylaminopurine (BAP) resulted in the best morphogenetic response. Thereafter, the developed synseeds were stored for 2 wk at a temperature of 10 or 25°C in different conditions and further evaluated for regeneration. Higher re-growth rate (80%) and the identical morphogenetic response were recorded for the *P. zeylanica* synthetic seeds, which were stored at a temperature of 10°C in dark condition after its storage period. As per the available literature, this is the first report pertaining to *in vitro* low-temperature storage of synthetic seeds of *P. zeylanica* and can further be utilized for the conservation of elite clones for the study of medicinally potent species.

Keywords Cold storage · Encapsulation · *In vitro* conservation · Micropropagation · Synseed

Introduction

Plumbago zeylanica L. is an herbaceous species generally known as Chitrak, which is widely distributed across the subtropics of the world, more particularly southern and central India (Jain *et al.* 2018; Santra and Ghosh 2023). Previous reports have shown its medicinal and pharmacological impacts on hemorrhoids, rheumatism, and skin diseases, and it exhibited anti-cancer, anti-microbial, central nervous system stimulatory, and hepato-protective properties due to the presence of an important bioactive—plumbagin (Edwin *et al.* 2009; Sharma and Agrawal 2018; Zheng *et al.* 2023). These impacts cause an increase in market demand for the targeted species, resulting in constant overexploitation, which ultimately results in the loss of future genetic

diversity (Mittal *et al.* 2010; Pandey *et al.* 2023). *P. zeylanica* propagation through seeds is not reliable due to low viability and inconsistent germination (Chaplot *et al.* 2006). Hence, in order to preserve *P. zeylanica*, an efficient *in vitro* conservation strategy is needed.

In comparison to field-grown plants, *in vitro* regenerated cultures required limited care for their conservation over time (Alzubi *et al.* 2019; Sota *et al.* 2023). However, tissue culture-grown plants need successive subcultures that are economically not feasible and may induce off-types *via* somaclonal variations (Quraishi *et al.* 2017). There are several efficient techniques to preserve elite germplasm of clonally propagated plants. Among them, the slow-growth conservation technique allows the conservation of plant materials for short to long periods of time (Reed *et al.* 2011) in a small area and at a low cost by slowing down the plant's physiological metabolism (Deepa and Thomas 2020; Lacerda *et al.* 2021). Production of synseeds is also one of the chief approaches for conservation and transportation with high germination and bears immense potential as a substitute for true seed (Jain *et al.* 2018). It can be defined as the artificial encapsulation of totipotent cells or tissues, which can grow under both *in vivo* and *in vitro* conditions

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In vitro seed germination for the seedling rescue of *Buchanania cochinchinensis* (Lour.) M.R. Almeida - a valuable tropical forest tree

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Abstract

Buchanania cochinchinensis (Lour.) M.R. Almeida is a tropical tree from the Anacardiaceae family. Because of the high nutritional value of its seeds and the medicinal properties of various parts, the tree species is socio-economically important. This tree is a rich source of phytochemicals of great medicinal value in root, bark, leaf, fruit and seeds. This multifunctional tree serves as a vital economic resource for tribal people living in Indian forests by providing food, fuel, fodder, timber, and medicine. However, the tree is at serious risk of extinction due to a lack of natural regeneration capacity and overexploitation of natural habitat. The seeds are the major source of propagation of *B. cochinchinensis*, but the main constraint is the low germination frequency caused by hard shell and fungal infestation during germination. Traditional plant propagation methods like vegetative propagation are time-consuming and inefficient for this species. A need for alternative seed germination strategies for quality planting material is imperative. Therefore, seed germination was carried out in the current study under ex vitro as well as in vitro condition. The germination of 52% was observed in seeds germinated in the greenhouse with a low seedling conversion rate. Total soluble sugars were estimated from different parts of the *B. cochinchinensis* seedling; to investigate this low germination rate. The investigation revealed that the root part had the maximum soluble sugar, followed by cotyledons, and the dried kernels had the least. Therefore, in vitro seed germination was attempted with the insight that higher sugars in the early-stage seedlings might be responsible for a low germination rate due to fungal attacks. Murashige and Skoog medium at full and half-strength was used for seed germination, along with different sucrose concentrations- 0%, 1%, 2%, 3%, 4.5% or 6%. Half-strength MS medium fortified with 3% sucrose resulted in highest germination (96.60%) and seedling conversion (60%). Further, during acclimatization, in vitro seedlings survived at a rate of 80%, more than the ex vitro greenhouse-raised seedlings. This study proposed an efficient in vitro seed germination protocol for mass propagation of *B. cochinchinensis*, where the early-stage susceptible seedlings could be rescued from fungal attack.

Keywords Anacardiaceae · Greenhouse · Propagation · Seedling conversion · Sucrose

Introduction

Buchanania cochinchinensis (Lour.) M.R. Almeida (Common name: Hindi- *Chironji*, English- Almondette) (Synonym: *Buchanania lanzan* Spreng.) is a deciduous fruit nut tree in India's tropical forests (Hiwale 2015). It is a tropical dicot tree of the Anacardiaceae family that is economically significant as Non-Timber Forest Product (NTFP)

and originated in Indian subcontinent (Avani et al. 2019). This tree has been reported in north, west, and central dry regions, predominantly in the forests of the Indian states of Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Maharashtra, Bihar, Jharkhand, Orissa, Andhra Pradesh, and Gujarat (Malik et al. 2010). It is indigenous to India and found throughout the Indo-Malaysian region (Foundation for Revitalisation of Local Health Traditions (FRLHT), Bengaluru, Karnataka, India). The tree is also found growing in Australia, the Pacific islands and tropical Asian countries (Siddiqui et al. 2016). The tree is a very common associate of Sal (*Shorea robusta*), Kaldhi (*Anogeissus pendula*), Teak (*Tectona grandis*), Salai (*Boswellia serrata*) and Mahua (*Madhuca longifolia*) in the forest dwellings (Malakar et

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Targeting Pathways and Integrated Approaches to Treat Rheumatoid Arthritis

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ABSTRACT: Rheumatoid arthritis (RA) is a chronic symmetrical systemic disorder that not only affects joints but also other organs such as heart, lungs, kidney, and liver. Approximately there is 0.5%–1% of the total population affected by RA. RA pathogenesis still remains unclear due to which its appropriate treatment is a challenge. Further, multitudes of factors have been reported to affect its progression i.e. genetic factor, environmental factor, immune factor, and oxidative factor. Therapeutic approaches available for the treatment of RA include NSAIDs, DMARDs, enzymatic, hormonal, and gene therapies. But most of them provide the symptomatic relief without treating the core of the disease. This makes it obligatory to explore and reach the molecular targets for cure and long-term relief from RA. Herein, we attempt to provide extensive overlay of the new targets for RA treatment such as signaling pathways, proteins, and receptors affecting the progression of the disease and its severity. Precise modification in these targets such as suppressing the notch signaling pathway, SIRT 3 protein, Sphingosine-1-phosphate receptor and stimulating the neuronal signals particularly efferent vagus nerve and SIRT 1 protein may offer long term relief and potentially diminish the chronicity. To target or alter the novel molecules and signaling pathway a specific delivery system is required such as liposome, nanoparticles and micelles and many more. Present review paper discusses in detail about novel targets and delivery systems for treating RA.

KEY WORDS: rheumatoid arthritis, causative factor, notch signaling, sirtuin, sphingosine-1-phosphate, neuronal signals, delivery system

I. INTRODUCTION

Rheumatoid arthritis (RA) is a chronic systemic autoimmune disorder that systematically affects the whole body. RA chronicity is manifested as destruction of cartilage lining by synovial capsule, the formation of pannus, morning stiffness, and intolerable pain particularly in cold conditions.¹ Globally, around 1% of the total world population suffer from RA.² The incidence of RA in women is two to three-times higher than men. At any age, RA can occur but it generally occurs at the age of 40–60 years in women while in men it is 60 years.³ Along with these, 40% of RA patients suffer from extra-articular symptoms such as glomerulonephritis, atherosclerosis, and small vascular vacuities. This deteriorates the quality of patient life both socially and economically which results



A comprehensive report on valorization of waste to single cell protein: strategies, challenges, and future prospects

Sharda Devi Rajput¹ · Neha Pandey¹ · Keshavkant Sahu¹

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Abstract

The food insecurity due to a vertical increase in the global population urgently demands substantial advancements in the agricultural sector and to identify sustainable affordable sources of nutrition, particularly proteins. Single-cell protein (SCP) has been revealed as the dried biomass of microorganisms such as algae, yeast, and bacteria cultivated in a controlled environment. Production of SCP is a promising alternative to conventional protein sources like soy and meat, due to quicker production, minimal land requirement, and flexibility to various climatic conditions. In addition to protein production, it also contributes to waste management by converting it into food and feed for both human and animal consumption. This article provides an overview of SCP production, including its benefits, safety, acceptability, and cost, as well as limitations that constrains its maximum use. Furthermore, this review criticizes the downstream processing of SCP, encompassing cell wall disruption, removal of nucleic acid, harvesting of biomass, drying, packaging, storage, and transportation. The potential applications of SCP, such as in food and feed as well as in the production of bioplastics, emulsifiers, and as flavoring agents for baked food, soup, and salad, are also discussed.

Keywords Microbial protein · Microorganisms · Fermentation · Downstream processing · Food source · Green protein

Introduction

The global population is predicted to increase to nine billion by 2050. In light of the present pattern of food consumption, we may probably require 1250 million tonnes of dairy and meat products per year to fulfill the demand of animal-derived proteins (Verstraete et al. 2016). In the future, requirement of additional proteins cannot be fulfilled with the existing food production strategies such as agriculture. However, the proteins are quite essential for cellular and metabolic activities and serves as a source of nitrogen for animals and humans to form their functional and structural components for survival. In recent decades, protein-calorie malnutrition (PCM) has been reported to affect children, resulting in poor mental growth and weak immunity (Junaid et al. 2020). The nutritional value of proteins depends on

their constituent amino acids. Due to their inability to be synthesized by the cells, animal populations typically require essential amino acids (EAAs) from external food sources to achieve their daily demand (Junaid et al. 2020). Proteins derived from different fruits, vegetables, and typical grains are often out of reach of the average person; therefore, microbial protein can be an alternate source of food for economically deprived population worldwide. Hence, this is high time to concentrate on deriving alternate, innovative, affordable, and unconventional protein sources to satisfy the nutritional requirements of the growing population. In regard, single-cell proteins (SCPs), cultured meat, plant-based new proteins, macroalgae, seaweed, and insects are some of the examples of sources of alternate proteins. Production of SCP is one of such potential approaches.

Single-cell protein mainly consists of a dried mass of microorganisms with high protein content, carbohydrates, lipids, minerals, and vitamins. The term SCP was coined by Carol L. Wilson in 1966 to define microbial biomass products (Suman et al. 2015). It can be total biomass or proteins isolated from pure culture or a mixed culture of microbial populations such as bacteria, algae, and fungi. The SCP has countless significant advantages over other protein sources:

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Nano zinc oxide mediated resuscitation of aged *Cajanus cajan* via modulating aquaporin, cell cycle regulatory genes and hormonal responses

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Abstract

Key message Nanoparticle pretreatment improved the health of aged *Cajanus cajan* seeds viz., regulation of redox status, gene expression, and restoration of hormonal homeostasis.

Abstract Ageing deteriorates the quality of seeds by lowering their vigor and viability, and terminating with loss of germination. These days, nanotechnology has been seen to revolutionize the agricultural sectors, and particularly nano zinc oxide (nZnO) has gained considerable interests due to its distinctive properties. The aim of the present work was to decipher the possibilities of using nZnO to rejuvenate accelerated aged (AA) seeds of *Cajanus cajan*. Both chemically (CnZnO) and green (GnZnO; synthesized using *Moringa oleifera*) fabricated nZnOs were characterized via standard techniques to interpret their purity, size, and shape. Experimental results revealed erratic germination with a decline in viability and membrane stability as outcomes of reactive oxygen intermediate (ROI) buildup in AA seeds. Application of nZnO substantially rebated the accrual of ROI, along with enhanced production of antioxidants, α -amylase activity, total sugar, protein and DNA content. Higher level of zinc was assessed qualitatively/ histologically and quantitatively in nZnO pulsed AA seeds, supporting germination without inducing toxicity. Meantime, augmentation in the gibberellic acid with a simultaneous reduction in the abscisic acid level were noted in nZnO invigorated seeds than that determined in the AA seeds, suggesting possible involvement of ROI in hormonal signalling. Furthermore, nZnO-subjected AA seeds unveiled differential expression of aquaporins and cell cycle regulatory genes. Summarizing, among CnZnO and GnZnO, later one holds better potential for a revival of AA seeds of *Cajanus cajan* by providing considerable tolerance against ageing-associated deterioration via recouping the cellular redox homeostasis, hormonal signaling, and alteration in expression patterns of aquaporin and cell cycle regulatory genes.

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Role and uptake of metal-based nanoconstructs as targeted therapeutic carriers for rheumatoid arthritis

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Abstract

Rheumatoid Arthritis (RA) is a chronic autoimmune systemic inflammatory disease that affects the joints and other vital organs and diminishes the quality of life. The current developments and innovative treatment options have significantly slowed disease progression and improved their quality of life. Medicaments can be delivered to the inflamed synovium via nanoparticle systems, minimizing systemic and undesirable side effects. Numerous nanoparticles such as polymeric, liposomal, and metallic nanoparticles reported are impending as a good carrier with therapeutic properties. Other issues to be considered along are nontoxicity, nanosize, charge, optical property, and ease of high surface functionalization that make them suitable carriers for drug delivery. Metallic nanoparticles (MNPs) (such as silver, gold, zinc, iron, titanium oxide, and selenium) not only act as good carrier with desired optical property, and high surface modification ability but also have their own therapeutical potential such as anti-oxidant, anti-inflammatory, and anti-arthritis properties, making them one of the most promising options for RA treatment. Regardless, cellular uptake of MNPs is one of the most significant criteria for targeting the medication. This paper discusses the numerous interactions of nanoparticles with cells, as well as cellular uptake of NPs. This review provides the mechanistic overview on MNPs involved in RA therapies and regulation anti-arthritis response such as ability to reduce oxidative stress, suppressing the release of proinflammatory cytokines and expression of LPS induced COX-2, and modulation of MAPK and PI3K pathways in Kupffer cells and hepatic stellate cells. Despite of that MNPs have also ability to regulates enzymes like glutathione peroxidases (GPxs), thioredoxin reductases (TrxRs) and act as an anti-inflammatory agent.

Keywords Rheumatoid arthritis · Metallic nanoparticle · Targeting · Cellular uptake

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Introduction

Rheumatoid Arthritis (RA) is a chronic systemic autoimmune disorder. It is characterized by the destruction of bone and cartilage inflammation at a synovial site, leading to enhanced mortality disability and reduced quality of life. (Song et al. 2021; Devi Dwivedi et al. 2023) Out of 100,000 of the total population, 40 persons are affected by RA, more significant than 0.5 to 1%. It commonly starts at the age of 40 to 60 years (Zheng et al. 2021). According to the Global Burden of Disease 2010, the prevalence of RA in women is almost three times greater than in males which is usually one female in 28 and one male in 59. RA can develop at any stage of life. Women between the ages of 30 and 60 are more likely than males to acquire RA (Brennan-Olsen et al. 2017). Advancement in RA therapy was associated with the joint damage, inhibition, control the progression of disease

**A STUDY OF THE AMOUNT FLOAT INTO THE MARKET FOR NEW EMPLOYMENT
GENERATION UNDER PRADHAN MANTRI MUDRA YOJANA (PMMY)**

(With special reference to Raipur , Mahasamund and Balodabazar Districts of Raipur Division)

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Abstract

Financial inclusion is one of the most treasured strategies in India. Our monetary arrangements has driven by a basic plan of a practical and comprehensive development . The major concern behind the monetary policy is to cover all the segments of population under monetary administrations .The major steps is to “the fund the unfunded” “Micro enterprises segment”. In the presented research work, the amount of new employment created through the Pradhan Mantri Mudra Yojana has been analysed as to what amount is being released into the market for each employment creation. Through research work, it is known that Rs. 19656.7 rupees in the Shishu category, Rs. 170463.3 rupees in the Kishor category and Rs. 733653.3 rupees in the Tarun category are being released for new employment generation. At the end of the research, a suggestion has been presented that it is necessary to increase the loan limit in the Shishu category so that more employment can be generated by distributing less amount.

Keywords : RRBs - Regional Rural Banks,MFIs - Micro Finance Institutions,NBFCs -Non Banking Financial Company, Unfunded, Shishu , Kishor , Tarun , Monetary.

Introduction

- Pradhan Mantri MUDRA Yojana (PMMY) is a scheme launched by the Hon’ble Prime Minister on April 8, 2015 for providing loans up to 10 lakh to the non-corporate, non-farm small/micro enterprises. These loans are classified as MUDRA loans under PMMY. These loans are given by Commercial Banks, RRBs, Small Finance Banks, MFIs and NBFCs .The borrower can approach any of the lending institutions mentioned above or can apply online through this portal www.udyamimitra.in . Under the aegis of PMMY, MUDRA has created three products namely 'Shishu', 'Kishor' and 'Tarun' to signify the stage of growth / development and funding needs of the beneficiary micro unit / entrepreneur and also provide a reference point for the next phase of graduation / growth. Their basic purpose is to attain development in an inclusive and sustainable manner by supporting and promoting partner institutions and creating an ecosystem of growth for micro enterprises sector.
- Shishu Covering Loan – Up to Rupees 50,000
- Kishor Covering Loan - Above Rupees 50,000 and Up to Rupees 5 Lacs
- Tarun Covering Loan - Above Rupees 5 Lacs and Up to Rupees 10 Lacs

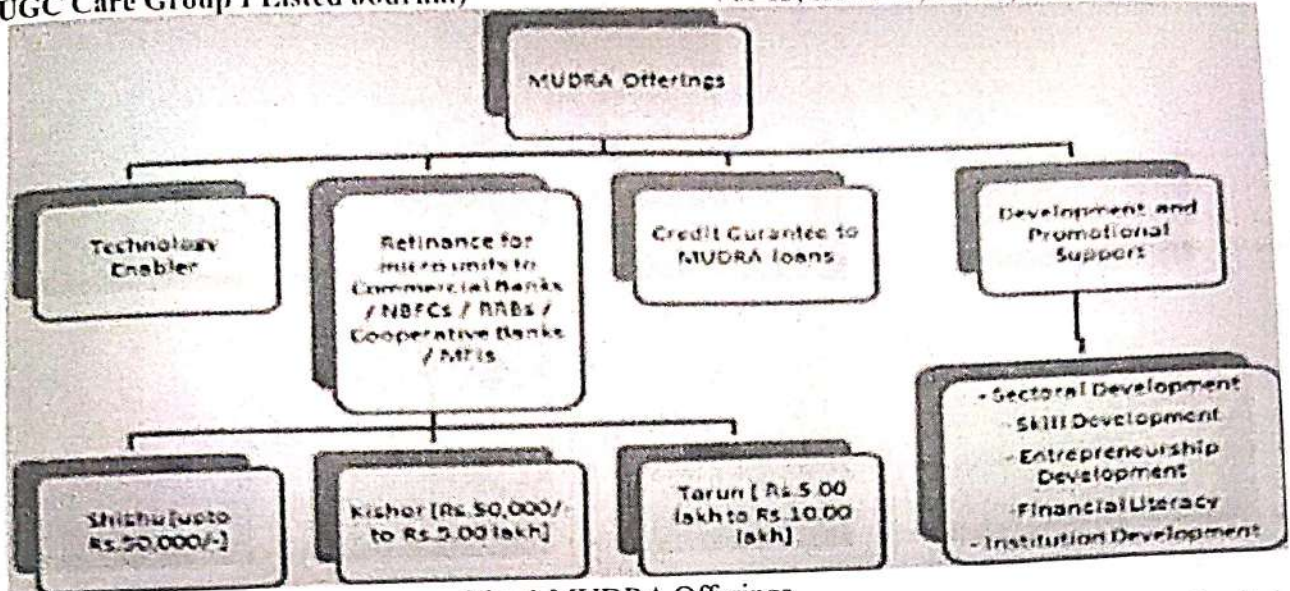


Fig :1 MUDRA Offerings

Here we are showing the impact of Pradhan Mantri Mudra Yojana in the state Chhattisgarh under the district division of Raipur, Mahasamund, Balodabazar. The state of Chhattisgarh is being reflected as a bastion of opportunities. The state already had reserves of minerals and multiple wealth, through which the state developed rapidly in the initial years of its establishment and the gross domestic product of the state also increased with unique potential. After this, new policies were established to promote entrepreneurship in the state. Through this, entrepreneurship emerged as a culture in the state. The surge in entrepreneurial capabilities of the state came through state special schemes as well as the Pradhan Mantri Mudra Yojana. Pradhan Mantri Mudra Yojana provides loans for entrepreneurship under three categories. Under the scheme, a loan of up to Rs 50,000 is available to entrepreneurs starting a business for the first time under the Shishu category. Under the Kishor category, a loan of up to Rs 5 lakh is available to those entrepreneurs who need financial assistance in the middle of their business, while under the Tarun category, a loan of up to Rs 10 lakh is available to those entrepreneurs who want to expand their business. The intention of the scheme is to provide financial assistance to entrepreneurs and encourage them to create new employment along with self-employment. Maximum tenure as per existing rules of the PMMY, the maximum repayment period for a MUDRA loan can extend to 5 years, however, the repayment period can be shorter if the lender decides so while sanctioning the loan.

For this, loans have been provided to the entrepreneurs of the state without any mortgage of property or guarantee. The government is releasing funds into the market through these loans. That is, money is being made available in the market through financial assistance, due to which the size of the market is increasing and employment is being created. In the present research work, an attempt has been made to find out how much money has been transferred to the market by the Centre for each new employment creation.

Literature Review

(Gangadhar M, 2022) Various aspects of Pradhan Mantri Mudra Yojana have been shown and the categories of Mudra Yojana such as 'Shishu', 'Kishor' and 'Tarun' have been presented in detail. The region wise performance of Targets vs. Achievements divided into five regions based on their geography and the distribution of PMMY loans sanctioned during the year has been analysed. This paper fulfil its purpose shows the performance of top 10 states, where Karnataka ranks first in loan sanctions. Along with this, bank accounts and Sanction loans have also been shown under the Mudra scheme in different regions of India. Out of the total amount sanctioned, 41% went to the women borrowers. 66% of the accounts in Shishu category belonged to women who were sanctioned 69% of the amount in the Shishu category. The reason for high share of women in Shishu category is lending of micro-loans by the MFIs primarily to women.

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Women Empowerment: Liberty of Economic Decision among the Salaried Women

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Abstract: After the constitution of India came into force, such laws were made which gave equal rights to women. After independence, many schemes have been continuously made for women empowerment, whether it is to stop feticide, whether it is education or health related or security. Efforts are being made continuously for women and to bring them equal in every field. Researchers identified eight factors infusing of the present study; SPSS 'version 20' and Jamovi 'version 2.2.2' has been used for processing of the data and Independent T-test has been performed to test the relationship. T-test result shows that with marital status, MHB, RP, RV and DTV are statically significant at 5% level of significant (p-value < .05); but Know ATM password, DIA, ME and DJC are statically not significant at 5% level of significant (p-value > .05). T-test result shows that with Income level, MHB, RP and RV are statically significant at 5% level of significant (p-value < .05); but Know ATM password, DIA, ME, DTV and DJC are statically not significant at 5% level of significant (p-value > .05). Study results find out that there is no significant difference between the liberty of economic decision of married and unmarried, low income level and high income level salaried woman. It is clear that women need to get more aware for regarding economic decisions.

Keywords: Women Empowerment; Economic liberty; Economic Decision; Salaried women; Income level;

1. Introduction

We know that any section of the society is left behind, and then we try to empower it! God created the soul and divided it into two categories, male and female, the two characteristics that have to be used to move the creation forward. It was divided into two categories on the basis of need; they were formed as a complement to each other. Work was divided, on the basis of physical characteristics; more labour and more hazardous work were kept for men and house work for women. An important reason for this must have been because woman was also a mother in ancient times all over the world. This was almost the same situation. If we look at the history of India, it is completely clear that in the pre-vedic period, the position of women was very high in the society, in every field in the society, then in all areas political, religious, economic or social, about the strength and intelligence of women. There was no doubt. But in the later vedic period, due to many customs, evils, social, political and religious factors, the condition of women deteriorated and she joined such a section of the society which was in need of salvation. Before and after independence, many such laws were made which played a special role in strengthening the status of women. After the constitution of India came into force, such laws were made which gave equal rights to women. After independence, many schemes have been continuously made for women empowerment, whether it is to stop feticide, whether it is education or health related or security. Efforts are being made continuously for women and to bring them equal in every field. The result is that women have become more educated and capable than before, the mind-set of the people in the society is changing for them. Are working side by side with men in the field but is there any drawback? Is there real empowerment in working in



छत्तीसगढ़ के जिलों में मृत्यु दर का विश्लेषणात्मक अध्ययन

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सारांश: छत्तीसगढ़ में स्वास्थ्य स्थिति बहुत खराब है। विश्व स्वास्थ्य संगठन के अनुसार 1000 व्यक्तियों पर 1 डाक्टर की उपलब्धता प्राप्त करने में भारत को 6 वर्ष लगेगा और छत्तीसगढ़ को 18 वर्ष लगेगा। छत्तीसगढ़ में 2017 में शिशु मृत्यु दर 37 प्रति हजार है अखिल भारत में यह 33 प्रति हजार है। बारहवीं पंचवर्षीय योजना में शिशु मृत्यु दर 25 प्रति हजार का लक्ष्य था जो प्राप्त नहीं हो सका। भारत में औसत जीवन प्रत्याशा 65.2 वर्ष है और छत्तीसगढ़ में 62.5 वर्ष है। जो अखिल भारतीय स्तर से काफी कम है। छत्तीसगढ़ में शिशु मृत्यु दर अखिल भारतीय स्तर से अधिक है। ग्रामीण क्षेत्र में शिशु मृत्यु दर शहरी क्षेत्र से अधिक होने का मुख्य कारण उसे जन्म से ही भाइयों से घटिया भोजन, वस्त्र सुविधा, शिक्षा, चिकित्सा, उपलब्ध होती है। छत्तीसगढ़ में मातृत्व मृत्यु दर अखिल भारतीय स्तर से अधिक है।

शब्द कूजी : शिशु मृत्यु दर, मातृत्व मृत्यु दर, बाल मृत्यु दर, नवजात शिशु मृत्यु दर।

प्रस्तावना

मानव ज्ञान के विकास में मृत्यु ने महत्वपूर्ण भूमिका निभायी है। चिकित्सा शास्त्र का विकास मृत्यु पर विजय पाने के लिए किये गये परिश्रमों का परिणाम है। यद्यपि मृत्यु एक जीव की आयु की समाप्ति की स्वाभाविक प्रक्रिया है तथा यह जीव की एक अनिवार्य घटना भी है। किंतु दीर्घायु के उपरांत ही देहवासन स्वाभाविक लगता है। मृत्यु दरें किसी जनसंख्या में किसी निश्चित अवधि में मृतकों की संख्या एवं जनसंख्या का 1000 में व्यक्त अनुपात है।

अध्ययन का उद्देश्य

1. छत्तीसगढ़ एवं छत्तीसगढ़ के जिलों में शिशु मृत्यु दर का अध्ययन करना।
2. छत्तीसगढ़ एवं छत्तीसगढ़ के जिलों में मातृत्व मृत्यु दर का अध्ययन करना।
3. छत्तीसगढ़ एवं छत्तीसगढ़ के जिलों में बाल मृत्यु दर का अध्ययन करना।
4. छत्तीसगढ़ एवं छत्तीसगढ़ के जिलों में नवजात शिशु मृत्यु दर एवं जन्म के बाद शिशु मृत्यु दर का अध्ययन करना।

अध्ययन पद्धति

प्रस्तुत अध्ययन द्वितीयक समकों पर आधारित है। अध्ययन हेतु छत्तीसगढ़ की जनांकिकी एवं आर्थिक सर्वे 2019.20 से समंक लिया गया है।

अध्ययन का महत्व

मृत्यु दर संबंधी सुचनायें किसी समाज में उपलब्ध स्वास्थ्य सेवाओं पर प्रकाश डालता है। मृत्यु दर संबंधी सुचनाओं से अनाथों की संभावना का पूर्वानुमान आसानी से लगाया जा सकता है। मृत्यु दर संबंधी सुचनायें जीवन प्रत्याशा को प्रभावित करता है। मृत्यु दर जन्म दर को भी प्रभावित करता है। मृत्यु दर के अध्ययन से किसी देश की श्रमशक्ति का ज्ञान होता है। मृत्यु दर किसी देश की सम्यता का सर्वोत्कृष्ट माप है। जिस देश की मृत्यु दर निम्नतम होती है वहां जीवन प्रत्याशा अधिक होती है। जिस देश की जीवन प्रत्याशा अधिक होती है वह देश उतना ही सम्य होता है।

शोध साहित्य का अध्ययन

सोनेकर, सेठी एवं चंद्रा 2019 इन्होंने अपने अध्ययन में बताया कि छत्तीसगढ़ में शिशु मृत्यु दर एवं मातृत्व मृत्यु दर भारत की तुलना में अधिक है। इसका कारण स्वास्थ्य पर अपेक्षाकृत कम व्यय करना है। 2018.19 में छत्तीसगढ़ में सकल राज्य घरेलू उत्पाद का 1.68 प्रतिशत एवं सार्वजनिक व्यय का 1.91 प्रतिशत व्यय किया गया था। **कृष्णा नंद यादव 2019** इन्होंने अपने अध्ययन में बताया कि पर्यावरण क्षति के कारण मानव के स्वास्थ्य पर विपरीत प्रभाव पड़ता है। इसके कारण आयु प्रत्याशा कम होती है एवं शिशु मृत्यु दर एवं मातृत्व मृत्यु दर में वृद्धि होती है। **किरण कुमारी 2019** इन्होंने अपने अध्ययन में बताया कि पर्यावरण स्वास्थ्य को प्रभावित करने वाले तत्वों में प्रमुख है। बढ़ती जनसंख्या, औद्योगीकरण, नगरीकरण ने पर्यावरण को प्रदूषित किया है। अच्छे स्वास्थ्य के लिए यह आवश्यक है कि पर्यावरण की रक्षा की जाये। **ए.तिवारी 2017** इन्होंने अपने अध्ययन में बताया कि मानव आधुनिक आविष्कारों के कारण भौतिक उपकरणों का गुलाम हो गया है। इन उपकरणों में मोबाइल फोन मुख्य है। मोबाइल फोन एक लघु उपकरण है लेकिन मगर कार्य करने के लिए उन सूक्ष्म तरंगों को अवशोषित करता है जो मानव हड्डी को भेद सकता है। मोबाइल फोन आंतरिक अंगों के साथ वाह्य अंगों को भी प्रभावित करता है। जिससे मानव का स्वास्थ्य प्रभावित होता है।

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जनजातियों के आर्थिक स्तर पर लघुवनोपज की भूमिका का अध्ययन (छत्तीसगढ़ के जशपुर जिला के विशेष संदर्भ में)

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सारांश
भारत में जहाँ लघु वनोपज आधारित लघु उपक्रम 20-30 प्रतिशत ग्रामीण श्रम शक्ति को 50 प्रतिशत आय प्रदान करते हैं, वहीं वानिकी क्षेत्र में केवल लघु वनोपज ही 55 प्रतिशत रोजगार प्रदान करने में सक्षम है। अनार्थिक जोत, सिंचाई साधनों की कमी तथा न्यून उत्पादकता के कारण जनजातीय क्षेत्रों की मानसून आधारित कृषि, भरपूर उत्पादन लेने के आदर्श से प्रेरित होकर जीवन निर्वहन योग्य फसल लेने के यथार्थ से बंधी है। फलतः जनजातियों द्वारा कृषि उत्पाद का न्यूनतम मात्रा में विपणन किया जाता है। लघु वनोपज के विपणन प्रणाली को 2 भागों में बाँटा जा सकता है। 1. राष्ट्रीयकृत लघु वनोपज और 2. अराष्ट्रीयकृत लघु वनोपज। राष्ट्रीयकृत लघु वनोपज के विपणन पर शासन का पूर्ण अधिकार होता है। अराष्ट्रीयकृत लघु वनोपज का सर्वाधिक विपणन 30.56 प्रतिशत साप्ताहिक बाजार एवं सहकारी विपणन केंद्र में होता है। सबसे कम 3.27 प्रतिशत लघु वनोपज का विपणन ब्यापारी के पास होता है। सर्वाधिक 38.69 प्रतिशत निदर्श जनजाति परिवार की वनोपज से 5000 से 10000 रु तक वार्षिक आमदनी है। 28.57 प्रतिशत परिवार 1000 से 15000 रु. प्राप्त करते हैं। 1.49 प्रतिशत जनजाति परिवार 5000रु. तक आय प्राप्त करते हैं।

शब्द कूजी :

लघु वनोपज, विपणन, राष्ट्रीयकृत, अर्थव्यवस्था।

प्रस्तावना

जनजातीय अर्थव्यवस्था वन एवं पर्यावरण से गहराई से जुड़ी है। जनजातियों की समस्त सामाजिक आर्थिक एवं सांस्कृतिक गतिविधियों में वन एवं वनोपजों की महत्वपूर्ण भूमिका है। वन उनके लिए प्राकृतिक आवासगृह के समान है, जहां से उन्हें खाद्य पदार्थ, रोजगार, आर्थिक समृद्धि एवं उनकी संस्कृति के विकास को बल मिलता है। वस्तुतः वन जनजातियों के पोषक रहे हैं, जिनसे उन्हें प्रत्यक्ष लाभ जैसे-ईंधन, काष्ठ, चारा, फल-फूल, छाल, रेशे एवं अनेक वाणिज्यिक महत्व के लघुवनोपज आदि प्राप्त होते हैं। जनजातियों की सम्पूर्ण जीवन पद्धति में लघुवनोपजों की महत्वपूर्ण भूमिका है ना कि केवल जीवन निर्वहन हेतु वरन् अत्यधिक रोजगार, आय एवं विदेशी विनिमय की प्राप्ति हेतु भी लघु वनोपज जहां 50 प्रतिशत से भी अधिक आय प्रदान करते हैं, वहीं रोजगार का एक महत्वपूर्ण स्रोत भी है। गरीब ग्रामीण जनसंख्या अतिरिक्त आय एवं रोजगार हेतु लघु वनोपजों पर अत्यधिक निर्भर हैं। कुछ जनजातीय समुदायों में वनोपज से प्राप्त आय का प्रतिशत कृषि आय से भी अधिक है।

अध्ययन क्षेत्र :-

जशपुर जिला छत्तीसगढ़ के 27 जिलों में से एक जिला है, इसका मुख्यालय जशपुर नगर में है। इस जिले की उत्तर-दक्षिण लम्बाई लगभग 150 किमी. है और इसकी पूर्व-पश्चिम चौड़ाई लगभग 85 किमी. है। इसका कुल क्षेत्रफल 6205 वर्ग किमी. है। यह 22° 17' और 23° 15' उत्तरी अक्षांश और 83° 30' और 84° 24' पूर्व रेखांश के बीच है।

अध्ययन का उद्देश्य :-

अध्ययन का उद्देश्य निम्नलिखित है -

- 1- जशपुर जिला में लघुवनोपज का संग्रहण एवं उपभोग का अध्ययन करना।
- 2- जशपुर जिला में लघुवनोपज के विपणन पद्धति का अध्ययन करना।
- 3- जशपुर जिला में लघुवनोपज के माध्यम से जनजातियों की रोजगार, आय पर पड़ने वाले प्रभाव का अध्ययन करना।
- 4- अध्ययन पश्चात आवश्यक सुझाव प्रस्तुत करना।

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RESEARCH ARTICLE

भारतीय नई कृषि नीति (Indian New Agricultural Policy)

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ABSTRACT:

भारत सरकार की कृषि नीति कैसी होनी चाहिए, यह इस बात पर निर्भर करता है कि कृषि विकास के किस चरण में है। इस समय सरकार को कृषि के आधुनिक साधनों की आपूर्ति पर बल देना चाहिए। नई कृषि विधेयक सकारात्मक थे किसान अपनी उपज कहीं भी बेच सकेंगे अभी राज्य के कानून पर निर्भर है। इन बिलों के आने से राज्य अपना कमीशन और मंडी शुल्क खो देंगे। लेकिन किसानों को डर था कि इससे सरकार द्वारा गारंटीयुक्त न्यूनतम समर्थन मूल्य समाप्त हो जायेगा, जिससे उन्हें अपनी फसलों के लिए प्राप्त होने वाली कीमतें कम हो जायेगी। जिससे किसानों ने इन अधिनियमों के खिलाफ प्रदर्शन किया। भारत के सर्वोच्च न्यायालय ने जनवरी 2021 में कृषि कानूनों के कार्यान्वयन पर रोक लगा दी।

KEYWORDS: कृषि नीति, न्यूनतम समर्थन मूल्य, प्रति हेक्टेअर आय।

प्रस्तावना : -

कृषि नीति का अर्थ कृषि के सर्वांगीण विकास करने से है। कृषि नीति कृषि उत्पादन में वृद्धि एवं किसानों के जीवन स्तर को उठाने की नीति है। भारत की अधिकांश जनसंख्या कृषि में संलग्न है, लेकिन उचित नीति के अभाव में वे निम्न जीवन जीने को मजबूर हैं। उचित कृषि नीति के क्रियान्वयन से भारतीय कृषि की दशा सुधारी जा सकती है।

अध्ययन का उद्देश्य

OBJECTIVE OF STUDY

1. भारतीय कृषि नीति का अध्ययन करना।
2. कृषि विधेयकों का अध्ययन करना।

इस समय सरकार को कृषि के आधुनिक साधनों की आपूर्ति पर बल देना चाहिए। इस उद्देश्य की आपूर्ति के लिए सरकार को न केवल देश में उत्पादन की ब्यवस्था करनी चाहिए वरन आवश्यकतानुसार इसे देश के बाहर से आयात भी करना चाहिए। साथ ही सरकार को इनके प्रयोग करने के लिए किसानों को प्रोत्साहित करना चाहिए। जनसंख्या वृद्धि पर नियंत्रण भी सरकार का उद्देश्य होना चाहिए। उत्पादक एवं उपभोक्ता दोनों वर्गों के हितों की रक्षा होनी चाहिए।



भारतीय जनांकिकीय लाभांश ¹⁹²

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सारांश

भारत को जनांकिकीय लाभांश का लाभ उठाने और अविश्वनीय आर्थिक विकास प्राप्त करने के लिए ऐसे विभिन्न पहलू हैं जिस पर भारत को कार्य करने की आवश्यकता है। भारत में 25 वर्ष की आयु वाले लोग कुल जनसंख्या का 50 प्रतिशत हैं तथा 35 वर्ष की आयु वाली जनसंख्या 65 प्रतिशत है। जनसंख्या का इतना बड़ा हिस्सा राष्ट्र के विकास में महत्वपूर्ण भूमिका निभाता है भारत को कौशल, शिक्षा और स्वास्थ्य लाभांश 2018 से शुरू हुई है जो 2035 में अपनी चरम पर होगा और यह 2055 तक प्राप्त होगा। भारत को जनांकिकीय लाभांश का लाभ उठाने के लिए प्रभावी शिक्षानिधियों को लागू करके और स्वास्थ्य सेवाओं की पहुंच पर ध्यान देने और लैंगिक अंतर को भी कम करने की आवश्यकता है। परिवार नियोजन, बाल स्वास्थ्य, शिक्षा और लैंगिक समानता में निवेश लंबी अवधि के लिए जनांकिकीय लाभांश में सुधार के लिए कुछ महत्वपूर्ण कदम हैं। आज आवश्यकता है कि शिक्षा, स्वास्थ्य पर निवेश बढ़ाया जाये। अनुसंधान एवं कौशल विकास पर निवेश बढ़ाया जाये। जिससे जनांकिकीय लाभांश का लाभ प्राप्त हो सके।

शब्द कूजी : जनांकिकीय लाभांश, प्रजनन दर, मानव संसाधन, आश्रित जनसंख्या।

प्रस्तावना

पूर्व राष्ट्रपति डा अब्दुल कलाम ने कहा था हमारे पास युवा संसाधन के रूप में अपार संपदा है और यदि समाज के इस वर्ग को सक्षम बनाया जाये तो हम बहुत जल्द महाशक्ति बनने के लक्ष्य को प्राप्त कर सकते हैं। यदि वर्तमान भारत की जाए तो यह दुनिया का सबसे युवा देश है। जनसंख्या के आंकड़ों के अनुसार भारत में 25 वर्ष की आयु वाले लोग कुल जनसंख्या का 50 प्रतिशत हैं तथा 35 वर्ष की आयु वाली जनसंख्या 65 प्रतिशत है। जनसंख्या का इतना बड़ा हिस्सा राष्ट्र के विकास में महत्वपूर्ण भूमिका निभाता है इसी कारण पूरा विश्व भारत को उम्मीद की नजर से देख रहा है। किसी भी देश के युवा सबसे क्रियाशील वर्ग होता है अतः यह उम्मीद की जा रही है कि भारत 2025 तक विश्व की चौथी बड़ी अर्थव्यवस्था बन जायेगी। तब विश्व की सकल घरेलू उत्पाद में भारत का योगदान 6 प्रतिशत होगा। भारत में अगले कुछ दशकों में अपनी आश्रित जनसंख्या (0.14 और 60 आयु वर्ग) की तुलना में अपेक्षाकृत बड़ी कार्यशील आयु जनसंख्या (15 और 59 वर्ष के बीच की आयु) होगी। यह युवा उभार वर्ष 2035 में अपने चरम पर पहुंच जायेगा। विश्लेषक युवा वृद्धि के इस दौर को एक उछाल मानते हैं। जिसके दौरान मानव पूंजी की प्रचुरता का उपयोग देश के विकास को बढ़ावा देने के लिए किया जा सकता है। कोल और हूवर 1958।

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सारांश

अनादिकाल से वनसम्पदा भारतीय जनजातीय अर्थव्यवस्था का प्रमुख आधार रही है। जहाँ तक भारत से आर्थिक विकास का प्रश्न है वन सम्पदा के प्रत्यक्ष और अप्रत्यक्ष रूप से भारतीय अर्थव्यवस्था की दशा और दिशा आर्थिक समृद्धि की ओर ले जाने में महत्वपूर्ण भूमिका निर्वाहन किया है। लघुवनोपज वन्य क्षेत्र न केवल राजस्व की प्राप्ति होती है बल्कि यह जनजातियों की अर्थव्यवस्था में भी महत्वपूर्ण भूमिका निभाते हैं। सदियों से वन जनजातियों की शरण स्थली रहे हैं जिनसे वह लघुवनोपज के रूप में विभिन्न प्रकार की जड़ी-बूटियों, तेंदू पत्ता, माहुल पत्ता, महुआ, चिरौंजी, षहद, गोंद, एवं विभिन्न प्रकार की लकड़ियाँ आदि प्राप्त करते रहे हैं जिन्हें वे निकट के बाजारों में अपनी दैनिक आवश्यकताओं के लिए समान खरीदते हैं। 72.61 प्रतिशत जनजाति वनोपज विपणन मध्यस्थ द्वारा रखे है जिसमें से 40.47 प्रतिशत जनजाति अन्त्योदय कार्ड धारी है। 88.09 प्रतिशत जनजाति संतुष्ट नहीं है एवं 20.95 प्रतिशत जनजाति मध्यस्थ द्वारा करने वाले जनजातियों में से 79.05 स्वीकृत हुई कि मध्यस्थ को वनोपज विक्रय कर जनजाति संतुष्ट है एवं कोई स्कवेयर परीक्षण से परिकल्पना शब्द कूजी : जनजातियाँ, अन्त्योदय, गरीबी रेखा।

प्रस्तावना

जनजातीय समाज की अर्थव्यवस्था का प्रमुख आधार कृषि है। यदि छत्तीसगढ़ के अत्यधिक पिछड़े जिलों को देखा जाए तो कृषक एवं कृषि भूमि दोनों की स्थितियाँ खराब हैं। खेतों का लगातार छोटा होना, सिंचाई के साधनों का अभाव एवं भूमि का अनुपजाऊ होना उनकी आर्थिक उन्नति में बाधक है। एकल परिवार की प्रथा होने के कारण भी भूमि का अत्यधिक विभाजन होता जा रहा है। जिससे कि ऊपर प्रभावित होती है। गरीबी एवं अज्ञानता के कारण वह कृषि के आधुनिक तौर तरीकों का प्रयोग भी नहीं करता और यदि करना भी चाहे तो पर्याप्त अधोसंरचनात्मक सुविधाओं का अभाव है। क्षेत्र के करीब 90 प्रतिशत आदिवासी अपनी उपज को विक्रय हेतु मण्डी में नहीं ले जाते क्योंकि उस अनुरूप होती ही नहीं है। अतः वह अपनी उपज को स्थानीय साहूकार को ही बेच देता है, चाहे उसका मूल्य कुछ भी आए। आदिम जाति से ही जनजातियों की अर्थव्यवस्था पूर्णतया वनों पर आधारित रही है। वे अपनी जीविका के लिए पूर्णतया वनों पर आश्रित थे एवं उन्हें किसी भी बाह्य वस्तु की आवश्यकता नहीं होती थी। वन इनकी अर्थव्यवस्था की रीढ़ तो थे ही साथ ही वे वनों से मानसिक रूप से भी जुड़े हुए थे यह स्थिति आज से करीब 7-8 दशक पूर्व तक थी और इस समय जशपुर जिला भी घने वनों से आच्छादित था। महत्वपूर्ण बात यह थी कि यहाँ रहने वाले जनजातियों के द्वारा इन वनों का प्रबन्ध अच्छी तरह किया जाता था। जिसकी वजह से दोनों वन तथा आदिवासी एक-दूसरे से लाभान्वित होते थे किन्तु जनसंख्या में तेजी से हुई वृद्धि शहरी सम्पर्क एवं खाद्यान्न की बढ़ती माँग के चलते आदिवासी कृषि कार्य की ओर आकृष्ट होने लगे।

सोध साहित्य का अध्ययन

Manna, Samita & Sarkar, Rimi (2013)³- प्रस्तुत अध्ययन "Education and Patterns of Marriage System : A Micro Study on the Birhors in Hazaribag District, Jharkhand" में झारखण्ड के हजारीबाग जिले में आदिम जनजातियों में से बिरहोर जनजाति के शिक्षा एवं विवाह प्रणाली के बारे में अध्ययन किया और कहा कि हजारीबाग के बिरहोर जनजाति पूर्णरूप से प्राकृतिक वातावरण पर निर्भर हैं। Sahu, Purnima & Tiwari, Jyoti (2015)⁷- इनके अध्ययन "Cultural Aspects of Tribal Housing in Chhattisgarh" में बताया कि छ.ग. राज्य में सरकार जनजातियों की समस्याओं को दूर करते हुए हर योजनाओं से अवगत कराते रहे जिससे उन्हें भी सरकारी लाभ प्राप्त हो सके। T.Brahmanandam & T.Bosu Babu (2016)¹³- यह लेख "Educational Status Among the Scheduled Tribes: Issues and Challenges" में बताया कि आदिवासी समुदाय, भौगोलिक रूप से सामाजिक रूप से तथा आर्थिक रूप से अलग-अलग क्षेत्रों में वंचित है।

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Impact of anganwadi services towards Atmanirbhar Bharat in Chhattisgarh (Special reference to Janjgir-Champa District)

Archana Sethi

Abstract

The study aims to assess the use of the Chhattisgarh government program "Mukhyamantri Mahtari Jatan Yojana" by pregnant and nursing women, focusing on their awareness, satisfaction, and barriers to using services under the Integrated Child Development Scheme (ICDS), using a quantitative methodology and descriptive survey strategy. The Anganwadi Services in (Janjgir Champa district) Chhattisgarh, India, provide essential services to pregnant and nursing women, including IFA, calcium, deworming pills, and health check-ups. However, only a small percentage of nursing moms and pregnant women consume supplemental nutrition. Despite this, 92.5% of pregnant and lactating women receive health education and undergo health checks. The Mahtari Jatan Yojana Service performance is mediocre, requiring further oversight

Key Words: Nutrition, Anganwadi, Demographic, Descriptive statistics

1. Introduction

The Indian government launched the largest Integrated Child Development Services (ICDS) to enhance child and maternal health, particularly for pregnant women. The program provides supplemental nutrition and health care to children and mothers, ensuring their wellbeing. A study was conducted in rural areas to evaluate the nutritional status of ICDS recipients in Janjgir Champa district. Pregnant and nursing mothers receive daily meals and education on nutrition and health, while clinics monitor their well-being during pregnancy and breastfeeding.

Objectives of the study

This study aims to evaluate the utilization of Chhattisgarh Government program as well as the utilization of Anganwadi services by pregnant and lactating mothers in rural areas, as well as the various barriers to using Anganwadi services. Mahtari Jatan Mukhyamantri Yojana" by the lactating and pregnant women in the study area.

Statement of the issue: An experiment to determine whether "Mukhyamantri Mahtari Jatan" is effective Yojana" on mothers' awareness of and use of ICDS services in chosen villages, Janjgir Champa neighborhood.

Research hypothesis

H1 There is a significant difference between the pre and post-test level of knowledge and utilization on ICDS services among mothers in study group.

H2 - There is a significant difference in post-test level of knowledge and utilization on ICDS services among mothers in study group and control group.

H3 There is a relationship between the utilization and knowledge of mothers on ICDS services in study group and control group.

H4 - There is a significant association between the post-test level of knowledge and utilization on ICDS among mothers with selected demographic variables in study group and control group.



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Millets “The shri ann”: A study of production of coarse cereals status in India’s Agriculture Production.

Bhumika Sharma *
Archana Sethi **

ABSTRACT

Millets are one of the oldest foods estimated to have been cultivated since 8000. The word millets is derived from the French word ‘Mille’ which means thousands, which can be interpreted to mean that one handful of millets is equal to thousands of grains. millets are also popularly known as “Nutri cereals” because of their nutritional content. Information obtained from various authentic websites like RBI .etc. That in the initial 20 to 30 years the area of production of coarse cereals remain stable 30 to 50 lakh hectares. In 2021-22, the growth rate was 1% less but the productivity rate remained positive in 2021-22 the growth rate was 6%. It is clear from above study that coarse grains have an important place in agricultural products, the export and export income from coarse grains is increasing every year in India’s export. India is the leader in the production of coarse grains in the world. Not only millets have many healthy properties, but it is also better in terms of cost and environment friendly than the production of other grains, but the grains are not included in the consumption habits of people as much as other grains can be dealt with, for this it is necessary to promote their benefits and methods of use as much as possible among the people, the efforts made by the government should be further accelerated, if it is again to become a major part of Indian food, if this becomes a part then there will be a lot of economic & social benefits

Keywords: Millets, Food Grains, Coarse cereals, Agriculture Production.

Introduction

Millets are one of the oldest foods estimated to have been cultivated since 8000. The word millets is derived from the French word ‘Mille’ which means thousands, which can be interpreted to mean that one handful of millets is equal to thousands of grains. millets are also popularly known as “Nutri cereals” because of their nutritional content.

There are different types of millets, different types of millets are produced in different countries, the major are produced in India are pearl millets (Bajra), Finger Millets (Ragi), Sorghum (Jowar), little millets (Samai), Kodra (Kodo) etc, on and health benefits of these grains the government of the country presented these grains as a brand in the last few years in the budget of 2024 they were called ‘shri Ann’ or **Super Food**. It is due to India’s efforts that the United Nations declared 2023 as the **International year of Millets**. Millets were featured in the recent G-20 summit held in Delhi Sep 23.

Objectives of the study:

- To study about the area production, productivity (yield) of coarse cereals /millets in India since 1951 to 2022.
- To find out the CAGR (compound annual growth rate) of millets in India since 1951 to 2022.
- To study the relationship between Total Food Grain production and Total Coarse Cereals production of India since the period of 1951-to 2022.
- To study the present status of millets production in different states of India.
- To study present status of India Global context of production of millets.
- To study the status of consumption of coarse cereals /millets in India and Analyse the problem and solution.

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Impact of Public Expenditure on Education in Chhattisgarh

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Abstract

This paper objective to investigate the correlation between public spending on education and the growth of the state of Chhattisgarh. Time-series data spanning from 2000 to 2021 was utilised. Public expenditure has several effects in economy. It can increase economic growth. It can increase social welfare. It is directly expected education is helps Positive Social change of citizen. The result shows that total public expenditure and Education expenditure is highly and statistically significant on economic growth indicator such as GER and DOR in primary level in Chhattisgarh. Public expenditure helps in achieving equitable distribution income and promote growth and welfare. The findings indicate that total public spending and education spending have a statistically significant and positive impact on economic growth indicators like the state's Gross Enrollment Ratio (GER) and the percentage of primary school dropout children (DOR) at the primary level. Education is directly expected to contribute to citizens' positive social transformation. The study's findings show that public spending on education and economic growth are correlated over the long term. Over time, there is a found unidirectional causal relationship between public education spending and Gross State Domestic Product (GSDP).

Keywords: Economy, Public Expenditure, GER, DOR, State economy, Education,

Introduction

After reviewing the literature, it was found that several scholars have examined the connection between public spending and the expansion of various national and international economies, but only a small number of these analyses have been conducted at the state level. This study will pay particular attention to the economy of the Chhattisgarh state to disclose the spending and growth patterns of the state since its founding and to show the relationships between factors that make sense. Additionally, the study will provide a road map for other states that were created on November 1 of the same year as Chhattisgarh.

Since its establishment on November 1, 2000, the economy of Chhattisgarh State has seen a growing growth trajectory (Figure 1.1). The data is shown in Table 1 that is provided below, as well as in Figures 1 and 2, which show that the state's total expenditure and its gross state product have been increasing over the past 20 years. It increased to Rs. 47862.29 of GSDP and Rs. 9291.53 for government expenditure in 2005, with growth rates of 85.18% and 69.82%, respectively, in the first five years of its inception from Rs. 25846.16 crore and Rs. 5471.48 crore of overall government expenditure.

Objectives of the research

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छत्तीसगढ़ राज्य में सार्वजनिक व्यय का स्वास्थ्य पर प्रभाव का अध्ययन

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सारांश
कुल सार्वजनिक व्यय में स्वास्थ्य पर व्यय के प्रतिशत में उतार-चढ़ाव की प्रवृत्ति देखने को मिलती है एवं अध्ययन अवधि के अंत में दोनों में सकल राज्य घरेलू उत्पाद (जी.एस.डी.पी.) तथा कुल सार्वजनिक व्यय में वृद्धि हो रही है। है। जिसमें वर्ष 2001-02 में GSDP में 25846.2 करोड़ रुपये है। राज्य में कुल सार्वजनिक व्यय 5471.5 करोड़ रुपये किया गया। सकल राज्य घरेलू उत्पाद के प्रतिशत के रूप में सार्वजनिक व्यय सर्वाधिक 26.1 प्रतिशत 2018.19 में है एवं सबसे कम 2015.16 में 19.5 प्रतिशत है एवं अध्ययन अवधि के अंत में दोनों में सकल राज्य घरेलू उत्पाद (जी.एस.डी.पी.) तथा कुल सार्वजनिक व्यय में वृद्धि हो रही है। सकल राज्य घरेलू उत्पाद में औसत वार्षिक वृद्धि दर सर्वाधिक 32.4 प्रतिशत 2012.13 में है एवं सबसे कम वृद्धि 2016.17 में 1.9 प्रतिशत है। सार्वजनिक व्यय में औसत वार्षिक वृद्धि दर सर्वाधिक 26.8 प्रतिशत 2006.07 में एवं सबसे कम 2020.21 में -3.6 प्रतिशत है। कुल सार्वजनिक व्यय एवं शिशु मृत्यु दर के बीच उच्च स्तर का ऋणात्मक सहसंबंध गुणांक-0.925 एवं कुल सार्वजनिक व्यय एवं मातृत्व मृत्यु दर के बीच उच्च स्तर का ऋणात्मक सहसंबंध गुणांक -0.941 हैं। जिससे स्पष्ट है कि कुल सार्वजनिक व्यय का स्वास्थ्य के घटकों पर सार्थक प्रभाव पड़ रहा है।

शब्द कूजी : सार्वजनिक व्यय, शिशु मृत्यु दर, मातृत्व मृत्यु दर

प्रस्तावना
स्वास्थ्य ही मनुष्य का असली धन है। अच्छे स्वास्थ्य के अन्तर्गत शारीरिक शक्ति, क्षमता और सहनशीलता तथा मानसिक सन्तुलन भी आता है। किसी भी राष्ट्र तथा समाज की उन्नति उसके नागरिकों के स्वास्थ्य पर निर्भर करता है। वहीं देश उन्नति के उच्च शिखर पर पहुँच सकता है जहाँ के निवासी स्वस्थ हो। छत्तीसगढ़ सरकार द्वारा सामाजिक सेवाओं पर किये गये सार्वजनिक व्यय का सार्थक एवं सकारात्मक प्रभाव मानव विकास के संकेतों पर पड़ रहा है। (Reddy & Reddy 2019) किसी भी कार्य को कुशलतापूर्वक करने के लिए व्यक्ति को शारीरिक एवं मानसिक रूप से स्वस्थ होना आवश्यक होता है। स्वस्थ व्यक्ति की कार्यक्षमता अधिक होती है तथा वह अपने सभी कार्यों को मन लगाकर कर सकता है। अस्वस्थ व्यक्ति अपने कार्यों से दूर भागता है अपने कार्यों को टालता रहता है। स्वास्थ्य लोगो की दक्षता तथा स्थिरता सुनिश्चित करता है। (patra 2019)

अध्ययन का उद्देश्य

1. अध्ययन अवधि के दौरान छत्तीसगढ़ के शासन की सार्वजनिक व्यय का अध्ययन करना।
2. छत्तीसगढ़ केशशासन की सार्वजनिक व्यय का स्वास्थ्य के विभिन्न घटक शिशु मृत्यु दर एवं मातृत्व मृत्यु दर पर प्रभाव का अध्ययन करना।

अध्ययन की शोध प्रविधि : प्रस्तुत अध्ययन मुख्य रूप से द्वितीयक आंकड़ों पर आधारित है। शिक्षा एवं स्वास्थ्य पर किये जाने वाले सार्वजनिक व्यय तथा कुल पंजीयन दर, ज़ाप आउट दर तथा शिशु मृत्यु दर एवं मातृत्व मृत्यु दर से सम्बंधित आंकड़ों को राज्य सरकार द्वारा प्रकाशित छत्तीसगढ़ का आर्थिक सर्वेक्षण एवं राज्य की जनगणना रिपोर्ट से एकत्रित किया गया है।

आंकड़ों के विश्लेषण के लिए प्रतिशत, औसत वार्षिक विकास दर, विचरण गुणांक, सहसंबंध गुणांक एवं प्रतीपगमन गुणांक का प्रयोग किया गया है।

अध्ययन की परिकल्पना

Ho: सार्वजनिक व्यय का स्वास्थ्य स्तर के विभिन्न संकेतकों पर सार्थक प्रभाव नहीं पड़ा है।

H1: सार्वजनिक व्यय का स्वास्थ्य स्तर के विभिन्न संकेतकों पर सार्थक प्रभाव पड़ा है।

जनजातियों के आर्थिक स्तर पर लघुवनोपज की भूमिका का अध्ययन (छत्तीसगढ़ के जशपुर जिला के विशेष संदर्भ में)

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सारांश
भारत में जहाँ लघु वनोपज आधारित लघु उपक्रम 20-30 प्रतिशत ग्रामीण श्रम शक्ति को 50 प्रतिशत आय प्रदान करते हैं, वहीं वानिकी क्षेत्र में केवल लघु वनोपज ही 55 प्रतिशत रोजगार प्रदान करने में सक्षम है। अनार्थिक जोत, सिंचाई साधनों की कमी तथा न्यून उत्पादकता के कारण जनजातीय क्षेत्रों की मानसून आधारित कृषि, भरपूर उत्पादन लेने के आदर्श से प्रेरित होकर जीवन निर्वहन योग्य फसल लेने के यथार्थ से बंधी है। फलतः जनजातियों द्वारा कृषि उत्पाद का न्यूनतम मात्रा में विपणन किया जाता है। लघु वनोपज के विपणन प्रणाली को 2 भागों में बाँटा जा सकता है। 1. राष्ट्रीयकृत लघु वनोपज और 2. अराष्ट्रीयकृत लघु वनोपज। राष्ट्रीयकृत लघु वनोपज के विपणन पर शासन का पूर्ण अधिकार होता है। अराष्ट्रीयकृत लघु वनोपज का सर्वाधिक विपणन 30.56 प्रतिशत साप्ताहिक बाजार एवं सहकारी विपणन केंद्र में होता है। सबसे कम 3.27 प्रतिशत लघु वनोपज का विपणन ब्यापारी के पास होता है। सर्वाधिक 38.69 प्रतिशत निदर्श जनजाति परिवार की वनोपज से 5000 से 10000 रु तक वार्षिक आमदनी है। 28.57 प्रतिशत परिवार 1000 से 15000 रु. प्राप्त करते हैं। 1.49 प्रतिशत जनजाति परिवार 5000रु. तक आय प्राप्त करते हैं।

शब्द कुंजी :
लघु वनोपज, विपणन, राष्ट्रीयकृत, अर्थव्यवस्था।

प्रस्तावना
जनजातीय अर्थव्यवस्था वन एवं पर्यावरण से गहराई से जुड़ी है। जनजातियों की समस्त सामाजिक आर्थिक एवं सांस्कृतिक गतिविधियों में वन एवं वनोपजों की महत्वपूर्ण भूमिका है। वन उनके लिए प्राकृतिक आवासगृह के समान है, जहां से उन्हें खाद्य पदार्थ, रोजगार, आर्थिक समृद्धि एवं उनकी संस्कृति के विकास को बल मिलता है। वस्तुतः वन जनजातियों के पोषक रहे हैं, जिनसे उन्हें प्रत्यक्ष लाभ जैसे-ईंधन, काष्ठ, चारा, फल-फूल, छाल, रेशे एवं अनेक वाणिज्यिक महत्व के लघुवनोपज आदि प्राप्त होते हैं। जनजातियों की सम्पूर्ण जीवन पद्धति में लघुवनोपजों की महत्वपूर्ण भूमिका है ना कि केवल जीवन निर्वहन हेतु वरन् अत्यधिक रोजगार, आय एवं विदेशी विनिमय की प्राप्ति हेतु भी लघु वनोपज जहां 50 प्रतिशत से भी अधिक आय प्रदान करते हैं, वहीं रोजगार का एक महत्वपूर्ण स्रोत भी है। गरीब ग्रामीण जनसंख्या अतिरिक्त आय एवं रोजगार हेतु लघु वनोपजों पर अत्यधिक निर्भर हैं। कुछ जनजातीय समुदायों में वनोपज से प्राप्त आय का प्रतिशत कृषि आय से भी अधिक है।

अध्ययन क्षेत्र :-
जशपुर जिला छत्तीसगढ़ के 27 जिलों में से एक जिला है, इसका मुख्यालय जशपुर नगर में है। इस जिले की उत्तर-दक्षिण लम्बाई लगभग 150 किमी. है और इसकी पूर्व-पश्चिम चौड़ाई लगभग 85 किमी. है। इसका कुल क्षेत्रफल 6205 वर्ग किमी. है। यह 22° 17' और 23° 15' उत्तरी अक्षांश और 83° 30' और 84° 24' पूर्व रेखांश के बीच है।

अध्ययन का उद्देश्य :-

अध्ययन का उद्देश्य निम्नलिखित है -

- 1- जशपुर जिला में लघुवनोपज का संग्रहण एवं उपभोग का अध्ययन करना।
- 2- जशपुर जिला में लघुवनोपज के विपणन पद्धति का अध्ययन करना।
- 3- जशपुर जिला में लघुवनोपज के माध्यम से जनजातियों की रोजगार, आय पर पड़ने वाले प्रभाव का अध्ययन करना।
- 4- अध्ययन पश्चात आवश्यक सुझाव प्रस्तुत करना।



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In Achieving Zero Hunger Goal: A Study on Goal 2 Zero-hunger and Collective efforts of India

Gaurav Jain *
Archana Sethi **

This study examines India's progress towards SDG 2's zero hunger targets, focusing on the country's progress with starvation and malnourishment. Despite the largest rationing plan for food distribution, India faces precarious conditions like not eating twice a day, especially during the 75th anniversary of independence. India is tackling hunger through the government's Poshan Abhiyan 2.0 initiative, aiming to make food nutritious and healthy for women, children, and the entire population. Problems such as stunting, and anemia have been addressed and efforts are ongoing to lower the rate. Door-to-door medical units promote awareness, and families receive sukha-ration and a noon meal. Research focuses on agriculture, food security, manufacturing, and distribution.

Keywords: Poverty, Poshan Abhiyan 2.0, Food security, sustainable agriculture, Zero Hunger, Production: - "A two-time meal is what a man all need". The bread (Roti) of two times is obtained with great fortune or hard work. A man works day and night to quench his hunger. India has the 2nd largest population in the world, standing at around 1.4 billion people. Feeding 1.4 billion stomachs is not an easy task. It is thus an opportune time to encourage a shift in tackling global hunger—from a "food security" focus to an agenda that promotes "nutrition security" instead. The drive to reduce hunger in the world has largely relied on crops such as wheat and rice that provide calories. But an increase in calories alone is not good enough. Improved diets and good health require bolstering nutrition. (M.S. Swaminathan, 2014) Here is a developing economy with a GDP of 160.06 trillion rupees in 2022-23 (PBI 2023), Fastest-growing nation in the world. We landmarks have achieved so many targets in the fields of science, technology (digital yug of India), roads, and electricity connectivity that are getting better and stronger. But The triple burden of malnutrition—the coexistence of undernourishment, micronutrient deficiency, and over nutrition manifest in overweight and obesity—is a growing challenge all over the world (Gomez et al. 2013). To satisfy hunger, food is necessary; the matter is to have nutrition in it. Nutrition has the power to empower present and future generations. We are Celebrating 75 years of independence (Azadi ka Amrit Mahotsav) in India. Hunger (roti) is still questionable in our people's bucket lists. India put a massive effort together to tackle and achieve SDG goal 2: reducing hunger to zero by 2030. Here are some outlooks that show we are on a good path to achieving the target. Since the green revolution, India has become self-sufficient in food production. India has made tremendous strides over the last six decades in reducing hunger. Hunger can be reduced by increasing the production of cereals, and farmers in India have done this, but at the cost of losing soil fertility, environmental degradation, bio-diversity affected, water table down, and more chemical fertilizer uses for more productivity. With more production, nutrition's getting less in cereals. Scientists, agriculturists, economists, and research and development teams of various nations look into this, and to overcome this situation, new technologies have been made according to the need that not only enhance productivity but also take care of the soil, from the increasing use of chemical fertilizer to bio fertilizer. Here are some Indian perspectives on achieving the second goal of zero hunger.

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A Comparative Study of Income-based and Deprivation-based Poverty Approach: A Study on Birhor Tribe of Chhattisgarh

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Chhattisgarh, India.

Abstract :

The present paper is attempted to investigate the difference and discrepancy between the income-based and deprivation-based poverty measurement in poverty of Birhor tribes of Chhattisgarh. Two international poverty measurement approach is considered for poverty measurement of Birhor tribes, first income-based measurement developed by World Bank and second, Multidimensional Poverty Index developed by United Nation Development Program (UNDP). Research study is based on primary data of 80 household collected from 8 village of 2 block of Raigarh & Korba district (1 block each) of Chhattisgarh State. Results shows that 83.75% Birhor peoples are poor in income-based poverty whereas, 48.86% Birhor peoples are poor in deprivation-based poverty measurement. A difference of 34.89% is found in the measurement of poverty by both the poverty measurement approach and this discrepancy is more in income-based poverty as compare to multidimensional poverty measurement. The study also reveals that

Education, health facilities, cooking fuel, sanitation and housing conditions are the major contributor in the poverty of Birhor Tribes.

Keywords: Multidimensional Poverty Index, Income-based Poverty, Birhor Tribe

Introduction :

Poverty, a global phenomenon and biggest hurdle in the path of development. It is a challenge for economists, policymakers, and even government to understand it. Every developing country faces poverty as a big challenge. The effort which governments are taking in different nations to eradicate poverty in rural and urban areas are really appreciable but to reach tribal areas is a big challenge in itself. There are various measures of poverty, however, two international approach of poverty measurement, First income based developed by World bank and second Deprivation based multidimensional poverty index developed by United nation development Program is popularly famous in poverty measurement. But researcher and policy makers are always debate between income-based and deprivation-based poverty measurement because of difference or discrepancy in the results of both the measures. Sen (1992) in his book "Inequality Re-examined" written that poverty is not due to lack of income but it is deprivation in basic human capabilities. Income poverty seems poverty as a result of inability of the individual or family to congregate their basic needs (world bank, 2000). Still most of the nation developed or developing nation like India consider and using income or consumption expenditure of the people's to measure poverty (Santos and Alkire, 2011). There is negative relationship between income and multidimensional poverty (Wang et.al, 2016).

There are some other literature studies which argues that the poverty is due to experience of various deprivations and non-monetary measure is complementary to monetary measure for measuring poverty (Alkire and Santos, 2010; Nishimwe-Niyimbanira, R

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शोध सारांश

कोरोना महामारी के समय जब सम्पूर्ण अर्थव्यवस्था चरामरा गयी थी तब ग्रामीण व कृषि ही थी जो टिकी रही। कृषि एवं ग्रामीण क्षेत्र का विकास और उन्नति किसी भी राष्ट्र या समाज की प्रगति का सूचक है। यही कारण है कि पहली व तृतीय पंचवर्षीय योजना में कृषि और पांचवी व छठवी पंचवर्षीय योजना में ग्रामीण विकास को प्राथमिकता दी गई। अतः शोधकार्य की दृष्टि से कृषि व ग्रामीण विकास महत्वपूर्ण क्षेत्र है। प्रस्तुत शोध पत्र राजनांदगाँव जिले में कृषि विकास व ग्रामीण विकास की स्थिति का विश्लेषणात्मक अध्ययन प्रस्तुत करता है। कृषि विकास की स्थिति का अध्ययन करने के लिए कृषि से संबंधित विभिन्न घटकों जैसे—भूमि उपयोग, जोत का आकार, उत्पादन व उत्पादकता, द्वि-फसली क्षेत्र रबी फसल, सिंचाई व सिंचाई गहनता को शामिल किया गया है। ग्रामीण विकास के अध्ययन में ग्रामीण विद्युतीकरण, शैक्षणिक एवं स्वास्थ्य अधोसंरचना, ग्रामीण बैंकिंग इत्यादि घटकों को अध्ययन में शामिल किया गया है। जिला में शुद्ध बोया गया क्षेत्र में वृद्धि हुई तथा यहाँ जोत का औसत आकार 1.73 हेक्टेयर है एवं सीमांत व लघु जोतों की संख्या अधिक है। शस्य गहनता जिले में औसत 131.88 पायी गयी है। सिंचाई गहनता औसत 138.39% है। जिला में ग्रामीण साक्षरता 73.86% है। ग्रामीण यातायात में प्रमुख सड़क है जिसकी लम्बाई 6417.32 किमी है। कुल बिजली उपभोक्ता का अकेले 82.32% उपभोक्ता ग्रामीण क्षेत्रों में है। वहीं ग्रामीण विद्युत उपभोग कुल विद्युत उपभोग का प्रतिशत 59.48% है। यहाँ 1603 आबाद ग्रामों में शत-प्रतिशत विद्युतीकरण हो चुका है।

शब्दकुंजी : कृषि एवं ग्रामीण विकास, कृषि विकास, ग्रामीण विकास अधोसंरचना, शस्य गहनता।

प्रस्तावना

भारतीय अर्थव्यवस्था में कृषि आजीविका के प्रमुख स्रोत के रूप में सबसे बड़ा स्रोत है। इसे अगर आर्थिक प्रणाली का रीढ़ कहा जा तो अतिशयोक्ति नहीं होगी। वास्तव में कृषि क्षेत्र खाद्यान्न और कच्ची सामग्री तो उपलब्ध कराता ही है, साथ ही आबादी के एक बड़े भाग को रोजगार के अवसर भी प्रदान करता है। भारत गाँवों का देश है जिसकी सामाजिक-आर्थिक प्रणाली का आधार कृषि है। जैसे कि इस श्लोक से स्पष्ट होता है—

“यथा शूद्र जनप्राय, समृद्ध कृषिकला
क्षेत्रोप योग भूमर्ध्य, वसति ग्राम संज्ञिका”

मार्कण्डेय पुराण में ग्राम के सन्दर्भ में उल्लेख मिलता है कि जहाँ कृषि कार्य किया जाता है एवं जहाँ कृषि समूह है वह गाँव है।

ग्रामीण आबादी की आजीविका का मुख्य स्रोत कृषि है इसलिए कृषि को ग्रामीण अर्थव्यवस्था का जीवन रक्त कहा जाता है। ग्रामीण क्षेत्र, उत्पादन के तरीके, सामाजिक संगठन और राजनीतिक गतिशीलता के मामले में बहुत ही पिछड़ा एवं निम्न है। 70% से अधिक आबादी ग्रामीण क्षेत्रों में रहती है जिनमें से 50% से अधिक आबादी गरीबी रेखा के नीचे रहती है। स्वतंत्रता प्राप्ति के बाद पंचवर्षीय योजनाओं में ग्रामीण विकास व कृषि विकास को प्राथमिकता दी गई। विशेष रूप से प्रथम और तृतीय पंचवर्षीय योजनाओं में कृषि और ग्रामीण विकास को 5वीं और 6वीं पंचवर्षीय योजनाओं में प्राथमिकता मिलनी शुरू होती है। 7वीं पंचवर्षीय योजना में ग्रामीण अर्थव्यवस्था के सर्वांगीण विकास को सर्वाधिक महत्व दिया गया। कृषि सतत विकास के कई पहलुओं से सीधे तौर पर जुड़ी हुई है, जिसमें टिकाऊ उत्पादन, ऊर्जा संसाधन का प्रबंधन, व्यापार, शिक्षा अच्छी बाजार पहुंच और साथ ही तकनीकी हस्तांतरण और क्षमता निर्माण शामिल है। कृषि को देश के समग्र विकास में महत्वपूर्ण क्षेत्र माना जाता है। यह अनुमान लगाया गया है कि कृषि द्वारा उत्पन्न किये गये प्रत्येक अतिरिक्त रूपये में ग्रामीण क्षेत्रों में विभिन्न आर्थिक कार्यों से आय में तीन अन्य अतिरिक्त रूपये जुड़ते हैं। ग्रामीण अर्थव्यवस्था के दीर्घकालीन विकास की दृष्टि से रणनीतिक महत्व का क्षेत्र है। आज कृषि विकास व ग्राम्य विकास नितांत आवश्यक है।

A Study on Economic Status and Constraints of Handicraft Artisans in Chhattisgarh

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Abstract- The handicrafts are an important source of income for rural areas. Handicrafts hold enormous potential as they are essential to both the millions of artisans who already exist in the country and the growing number of newcomers entering the craft sector. The handicraft sector faces many challenges to cope with the current economic environment due to the advancement and development of technology. The present study examines the key marketing and financial constraints faced by handicraft artisans in Bastar and Kondagaon districts of Chhattisgarh. With the decline in demand and sales of handicraft products, artisans' incomes are also falling, forcing them to take up additional income-generating work by artisans. This study also attempts to identify the other sources of income as artisans in Bastar and Kondagaon districts of Chhattisgarh state. The study is based on primary data collected from 120 handicraft artisans of Bastar and Kondagaon districts of Chhattisgarh state.

Keywords: Handicraft, Artisans, Marketing Constraints, Financial Constraints, Source of Income.

INTRODUCTION

The handicrafts market will witness remarkable growth with an expected CAGR of 8.87 during 2022-2027. This growth is expected to increase the market size by \$407.15 billion. Several factors, including the need for reduced capital investment, increased travel and tourism, and greater government support and funding, play a key role in the future of the craft. In this comprehensive analysis, we examine the key marketing constraints faced by artisans in Bastar and Kondagaon districts of Chhattisgarh. Before the British era, the trade of artisans was flourishing, the sales of their products were also high and their socio-economic situation was also very good. Handicrafts were their only source of income, and the artisans generally devoted their entire working time to producing handicrafts. However, during the British era and the Industrial Revolution around the world, crafts lost their

identity and importance, resulting in a decline in demand for their handicraft products, resulting in low sales and therefore low production and income. Therefore, during this time, the artisans start looking for a new source of income in order to survive. The present study also tries to find out the source of income other than of handicraft artisans of Bastar and Kondagaon district of Chhattisgarh state. An important factor of the handicraft market is the minimum capital investment required to start a handicraft business. The handicrafts market faces a significant challenge in the form of a lack of managerial capabilities among manufacturers. Many handicraft producers often lack essential managerial skills, including workplace management, market research, inventory control, and sales promotion. This deficiency poses a barrier to the promotion of artisan handicrafts. Access to business development service providers (BDSPs) is limited for handicraft manufacturers, as they frequently operate on tight budgets and in isolation from urban businesses. This lack of access to managerial resources, coupled with a shortage of understanding regarding the needs of foreign exporters, constrains market growth during the forecast period.

1.1 Review of Literatures

Kumar, Dilip and PV, Rajeev (2014) Marketing Challenges of Handicraft Retailers in Changing Environment: - The article is divided into five parts, with the first part discussing the importance of craftsmanship and marketing in the changing environment of the retail industry and covering various aspects of retail stores. Upadhyay, Manali and Jain, U.C. (2018) Managerial Challenges of Handicraft Industry: An Indian Perspective: - The article throws light on the problem and different issues related to handicraft industries and marketing challenges in India. crafts have huge potential as it is important to maintain the existing pool of million artisans across the country. The craft sector plays an



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Difference in Poverty Measurement between Income based and Deprivation-based approach: A study in Kamar Tribe of Chhattisgarh

Kapil Kumar Chandra *

Sunil Kumar Kumeti **

B. L. Sonekar ***

Abstract

The present paper is attempted to investigate the difference and discrepancy between the income-based and deprivation-based poverty measurement in poverty of Kamar tribes of Chhattisgarh. Two international poverty measurement approach is considered for poverty measurement of Kamar tribes, first income-based measurement developed by World Bank and second, Multidimensional Poverty Index developed by United Nation Development Program (UNDP). Research study is based on primary data of 100 household collected from 8 village of 2 block of Gariyaband district of Chhattisgarh State. Results shows that 93% Kamar peoples are poor in income-based poverty whereas, 42.4% Kamar peoples are poor in deprivation-based poverty measurement. A difference of 50.6% is found in the measurement of poverty by both the poverty measurement approach and this discrepancy is more in income-based poverty as compare to multidimensional poverty measurement. The study also reveals that health facilities, cooking fuel, sanitation and housing conditions are the major contributor in the poverty of Kamar Tribes.

Keywords: Multidimensional Poverty Index, Income-based Poverty, Kamar Tribe

Introduction

Poverty, a global phenomenon and biggest hurdle in the path of development. It is a challenge for economists, policymakers, and even government to understand it. Every developing country faces poverty as a big challenge. The effort which governments are taking in different nations to eradicate poverty in rural and urban areas are really appreciable but to reach tribal areas is a big challenge in itself. There are various measures of poverty, however, two international approach of poverty measurement, First income based developed by World bank and second Deprivation based multidimensional poverty index developed by United nation development Program is popularly famous in poverty measurement. But researcher and policy makers are always debate between income-based and deprivation-based poverty measurement because of difference or discrepancy in the results of both the measures.

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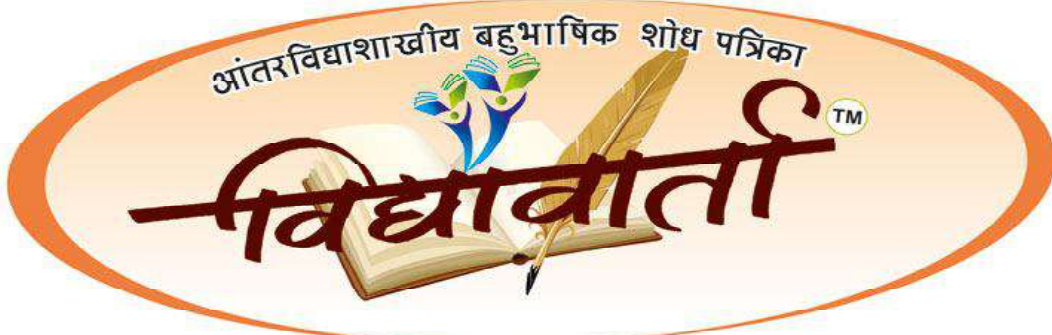
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Trade of Handicraft Products through E-commerce in Bastar District of Chhattisgarh: Issues and Challenges

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Abstract

The handicrafts are an important source of income for rural areas. It employs more than six million artisans, including many women and members of socially disadvantaged groups. Today, craftsmanship contributes significantly to exports and job creation. The craft holds enormous potential as it is vital to both the millions of artisans already in the country and the growing number of newcomers entering the craft industry. Each handcrafted item has a story that tells the craftsman's inspiration or enthusiasm in making it. This study is based only on primary data collected from the artisans of Bastar districts of Chhattisgarh. The study attempted to determine the level of digitalization of handicrafts in Bastar district and the challenges faced by artisans in adopting modern technology and e-commerce for trade.

Keywords: Handicraft, Artisans, E-commerce, Trading, Challenges, Digitalization.

1. Introduction

There was a time when traditional crafts flourished, but today they are threatened with

Bibliometric Analysis on Millennium Development Goals (MDGs) with Emphasis on “Poverty and Hunger”

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Abstract

Millennium development goals (MDGs) are the United Nations Development Programmes (UNDP) initiative launched in the year 2000 with eight objectives and twenty-one milestones to be achieved by 2015. Thus, it is a global agreement and collaborative action. (Hulme, 2009) Poverty is not a new concept, rather it is found in every sphere of life; not only this, it also stirs a lot of misgiving; and as a result, it has a very devastating effect on its victims. Henceforth, the principal threshold of the paper is to exhibit a sketch on the work done on “Millennium Development Goals” through its bibliometric analysis. Therefore, the paper highlights a descriptive-quantitative analysis of the concept of Millennium Development Goal- 1 A for the last twenty-one years, i.e., 2000-2021 and SciVerse Scopus was used to collect the research publications on MDGs. The results of the study show that the Mediterranean Journal of Social Sciences (MJSS) has contributed plenty of publications on the theme “Millennium Development Goals” and “Poverty and Hunger”. With respect to most contributing authors, the Author Fukuda-Parr S has got the maximum number of the papers and also had the highest h-index. Further the keyword mapping results emphasised that in all the seven clusters - “Millennium Development” is the predominant word followed by child mortality, maternal mortality, drinking water, sanitation, environmental sustainability etc.

Keywords: Bibliometric analysis, Child mortality, Hunger, Maternal mortality, Millennium Development Goals, Poverty, SCOPUS.

1. Introduction

Millennium development goals are the United National development Programmes (UNDP) initiative launched in the year 2000 with 8 objectives and 21 milestones to be achieved by 2015. The Millennium Development Goals (MDGs) is a global agreement and collaborative action (Hulme, 2009)¹ mark an epochal event and hailed as an effective method of global mobilisation to accomplish a set of key social priorities all around the globe (Sachs, 2012)². Furthermore, the MDGs sheds light on the widespread public attention in the sphere of poverty and hunger, health, unaddressed needs towards schooling, gender inequality, and environmental deterioration. As it is evidences that the importance and relevance of MDGs are increasing in the present era, it becomes indispensable to analyse and accumulate the past, present and futuristic literature, on the millennium development goals.

Poverty is very difficult to define, because different people have different perceptions on it. This means the fact that; what may be termed as poor may not always be seen as poor by the other people. Poverty is not a new concept, rather it is found in every sphere of life; not only this, it also stirs a lot of misgiving; and as a result, it has a very devastating effect on its

¹ Hulme, D. (2009). The Millennium Development Goals (MDGs): A short History of the World’s Biggest Promise. *BWPI Working Paper 100*, pp. 1-55.

² Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *The lancet*, 379(9832), pp. 2206-2211.



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Econometric modelling and forecasting of groundnut production and productivity in India using ARIMA Model

Ram Prasad Chandra *
Ravindra Brahme **

ABSTRACT

Groundnut is the largest oilseed produced in the world and stands third largest oilseed in India. The aim of this study was to model groundnut production and yield in India, using data from the period 1970-71 to 2021-22 in India an effort to forecast groundnut production and productivity amounts between the years 2022-23 to 2039-40 by using Autoregressive Integrated Moving Average (ARIMA) models. The Box Jenkins ARIMA methodology has been used for forecasting. The diagnostic checking has shown that ARIMA (0, 1, 2) and ARIMA (0, 1, 2), is the most appropriate model among twenty studied ARIMA models; and so for forecasted the groundnut production and yield amounts for the next 18 years. We forecasted that annual amount of groundnut production and yield obtained in the year 2022-23 was 93.136 lakh tonnes and 1850.777 kg/hectare respectively, and it reached to 119.459 lakh tonnes and 2488.912 kg/hectare respectively in the year 2039-40 with a significant acceleration for groundnut production and yield. Forecasting results of the ARIMA (0, 1, 2) and (0, 1, 2) illustrated an increasing trend in the amount of groundnut production & yield, and they might help to determine a better policy for increasing groundnut production in India.

Keyword: Groundnut, Forecasting, ARIMA, AIC, BIC, GPY

JEL Code: C12, C22, C52, C53

INTRODUCTION

Agriculture is back bone of the Indian Economy. Groundnut is the largest oilseed produced in the world and stands third largest oilseed in India. Groundnut is important oilseeds crop and oil content material of the seed varies from 44-50%, relying on varieties and agronomic conditions. Groundnut is additionally of price as a rotation crop (Mohapatra et al., 2018; Kumar et al., 2020). India is one of the second largest producers of oilseeds in the world and occupies an important position in the Indian agricultural economy. It is one of the most important food and cash crops of our country. While being a valuable source of all the nutrients, it is a low-priced commodity. Groundnut is also called as wonder nut and poor men's cashew nut. Groundnut is one of the most important cash crops of our country. It is a low-priced commodity but a valuable source of all the nutrients. The major groundnut producing countries in the world are India, China, Nigeria, Senegal, Sudan, Burma and the United States of America (Borkar, 2016; Saranyadevi, 2022). It is estimated that nine oilseeds namely groundnut, rapeseed-mustard, soybean, sunflower, safflower, sesame, Niger, castor and linseed, accounted for an area of 28.8 million hectares with the production of 35.9 million tonnes and yield 1247 kg/ht. in FY 2020-21 and in which groundnut cultivated area 6.01 million hectares, production 10.2 million tonnes and yield 1703 kg/ht. in FY 2020-21.

Attention has been given to the univariate time series Auto-Regressive Integrated Moving Average (ARIMA) Models, which is principally due to World of Box and Jenkins. Yule and Walker proposed the Autoregressive Moving Average (ARMA) model, and Box and Jenkins proposed the method (ARIMA) model afterward (Box and Jenkins, 1976; Saranyadevi, 2022). Among the stochastic ARIMA types are robust, effective and famous as they can correctly describe the found facts and can make forecasts with minimum forecast error (Aarekar and Reddy, 2017; Hemavathi and Prabakaran, 2018).

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Stochastic models for coffee production and productivity Forecasting in India

Ram Prasad Chandra *
Ravindra Brahma **
Suresh Kumar Patel ***

Abstract

Agricultural production and productivity forecasts are useful for farmers, policy makers and industries. In the present study, an auto-regressive and moving average model (ARIMA) has been applied for modelling and forecasting of annual coffee production and productivity in India. The augmented Dickey-Fuller (ADF) test has been used to test the stationarity of time series. The appropriate ARIMA model has selected based on the minimum Akaike information criterion (AIC). The residuals of the fitted models were diagnosed for the possible presence of autocorrelation and white noise effects, and Forecasts models are continuously increasing over the forecast period.

Keyword: Time Series Analysis; Stochastic model; Forecasting; ARIMA; AIC; BIC

JEL Code: C12, C22, C51, C52, C53

Introduction

Since then the journey of Indian coffee production is a long one dating back almost 400 years, it holds a very special place in historic taste. This unique journey has started from the hands of Yaman, who handed over seven magical beans to Bababudan, who planted it in the Chandragiri Hills of Karnataka. This magical beginning paved the way for coffee with the aroma, taste, flavour and acidity we experience today (Gopinath et al., 2019). Coffee is one of the most popular drinks in the world. Coffee from India is the best shade-grown light coffee in the world. Among plantation crops, coffee has contributed significantly to the Indian economy during the last 50 years (Naveena et al., 2017). It holds a notable place in the list of beverages due to its stimulating intensity, and among all the coffee producing regions, India is the only country where coffee is grown in shade. Indian coffee holds a great place in all the countries due to its flavour, aroma, soft and lower acidic nature (Prabha et al., 2021).

In India, traditional coffee growing States are Karnataka, Kerala and Tamil Nadu. Some of the non-traditional areas are Andhra Pradesh, Odisha and North Eastern Region including Assam, Meghalaya, Manipur, Arunachal Pradesh and Tripura. The three traditional areas together accounted for 79.7 per cent of area and 96.2 per cent of coffee production. The major coffee growing areas in India are Hassan, Chikmagalur and Coorg in Karnataka, Wayanad, Idukki and Nelliampathy in Kerala, Shevaroy, Palani, Pulneys and Nilgiri hills in Tamil Nadu (Coffee Board of India, 2023). Both (Arabica and Robusta) the varieties of coffee has been more or less equal in its area, production and productivity under traditional areas except Tamil Nadu. Tamil Nadu is the one of the State which has more production of Arabica coffee comparing with Robusta Coffee (Prabha et al., 2021). Since every Indian coffee grower spends his entire time in coffee production, it is no miracle or wonder that India produces extraordinary variety of coffee and exports it to different parts of the world over 150th years (Gopinath et al., 2019). Coffee production and productivity are incessant rising in India respectively 3195 lakh tonnes and 767 kg/hectare in FY 2018-19. In FY 2020-21, 3340 lakh tonnes and 790 kg/hectare which is increase to respectively 3420 lakh tonnes and 797 kg/hectare in FY 2021-22.

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Government Expenditure of Social Sectors and its impact on the Economic Growth of Chhattisgarh

Vikram*

Pragati Krishnan**

Ravindra K Brahme ***

Abstract

Since the 19th century, the liaison between economic growth and government spending has been explored, debated and discussed by many. Social sector expenditures, including education, health, shelter, nutrition and social protection/social security, are productive. The establishment and enhancement of social security systems by governments and access to basic social services for all should form an important component of policies for social development. The aim of the present study is to make an empirical study of the relationship between government expenditures on social sectors of Chhattisgarh at disaggregated level and Gross State Domestic Product (GSDP) during a twenty three time period (2000-21 to 2022-23). The study highlights the existence of a long-term relationship among GSDP, education expenditure, and health expenditure, emphasizing the interdependence and equilibrium among these variables despite their individual non-stationary behavior. The Vector Error Correction Model (VECM) employed captures both the long-term equilibrium relationships and short-term adjustments among these factors, providing a nuanced understanding of their dynamics. The study's implications offer a strategic roadmap for policymakers in Chhattisgarh.

Keywords: Cointegration, gross state domestic product, public expenditure, social sectors, unit roots test

Introduction

Since the 19th century, the liaison between economic growth and government spending has been explored, debated and discussed by many (Wagner, 1883; Keynes, 1936; Ram, 1986; and so on). Accordingly, in a country, the government spending either is being stimulated due to increase in the economic activities or it stimulates the economic activities (Bhavsar & Samanta, 2023). Over the years the economic activities of the government vis-à-vis public expenditure have grown both relatively and absolutely in all the states of the Indian union. A predominant objective of public expenditure policy is sustained and equitable economic growth. Public expenditures have played an important role in physical and human capital formation over a period of time. Appropriate public expenditures can also be effective in boosting economic growth even in the short run. Therefore, the effect of public expenditure on economic growth may be a comprehensive indicator of public expenditure productivity. The two components of such an indicator should be measurable: the contribution of public expenditures to economic growth, and the efficiency with which these expenditures yield their output (Lhoungu, et al, 2016). Jaman (2019) opined that Social sector expenditures, including education, health, shelter, nutrition and social protection/social security, are productive. The establishment and enhancement of social security systems by governments and access to basic social services for all should form an important component of policies for social development. The aim of the present study is to make an empirical study of the relationship between government expenditures on social sectors of Chhattisgarh at disaggregated level and Gross State Domestic Product (GSDP) during a twenty three time period (2000-21 to 2022-23).

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Bibliometric analysis on Public Expenditure and Economic Growth

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Ravindra K Brahme ***

Abstract

Over the past decade and a half, a substantial volume of empirical research has been directed towards identifying the elements of public expenditure (at its aggregate and disaggregate levels) that bear significant association with economic growth. A large body of empirical research supports the notion that healthy budgetary balances are, over the long run, good for growth. Henceforth, the principal threshold of the paper is to exhibit a sketch on the work done on Public Expenditure and Economic Growth" through its bibliometric analysis. Therefore, the paper highlights a descriptive-quantitative analysis of the concept of Public Expenditure and Economic Growth and SciVerse Scopus was used to collect the research publications on it. The results of the study show that the top two relevant sources are the Sustainability (Switzerland) and Applied Economics which published 9 and 8 articles respectively. Next to them is the Economic Modelling which has published 7 articles. With respect to most contributing authors, the Author Magazzino C, Minea A, Sasmal J and Villieu P has the highest h-index and g-index of 4. Further the word cloud results emphasised that economic growth is the predominant word followed by public spending, fiscal policy, economic development, expenditure etc.

Keywords: Bibliometric analysis, economic growth, education, health, public expenditure, fiscal policy, SOCPUS.

Introduction:

Over the past decade and a half, a substantial volume of empirical research has been directed towards identifying the elements of public expenditure (at its aggregate and disaggregate levels) that bear significant association with economic growth (Bose et al, 2007). A large body of empirical research supports the notion that healthy budgetary balances are, over the long run, good for growth (Easterly et al., 1994). The effect of fiscal consolidation on growth in the short run, however, remains open to question as a number of studies largely for industrial countries have drawn the conclusion that under some circumstances fiscal contractions can stimulate growth (Gupta et al,2005). Public expenditure allocations for education can improve economic growth while promoting equity (Jung & Thorbecke,2003). Gupta and Verhoeven (2001) and Gupta, Verhoeven, and Tiongson (1999) suggest that both the size and the efficiency of public education expenditure are important in improving socioeconomic performance. Allain (2015) presents a basic Kaleckian model, enriched by the simultaneous addition of an Harrodian investment function and an autonomous expenditure component that grows at an exogenous rate. In his study the model shows that the usual short-run properties (wage-led growth) are only transient, since the long-run growth rate converges towards that of autonomous expenditures.

However, the impact on the level of variables (output, capital stock, labour, etc.) is permanent. Further, the model also provides a conditional solution to the 'second' Harrod knife-edge problem: the destabilising behaviour of firms (as they adjust their investment decisions to the discrepancy between the actual and the normal rates of capacity utilisation) is now required to achieve the normal rate of capacity utilisation.

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Comparative Study of Gothans and Godhan Nyay Scheme in Chhattisgarh

Omprakash Verma*
Pragati Krishnan**
Ravindra K Brahme ***

Abstract

Vermicomposting is one of the generating additional sources of income, economic empowerment, and assuring sustainable livelihood approach along with the already known environmental benefits, has been newly found to be one of the most appropriate and successful models for the rural or not socio-economically resourceful communities. Godhan Nyay Yojana was started in Chhattisgarh on 20 July 2020, on the day of the Hareli festival. This scheme of purchasing cow dung at Rs.2 per kg has become very popular. This has curbed the practice of open grazing to a great extent. The scheme includes cleanliness and environmental protection, increase in area under double crops, reduction in the cost of cultivation through compost production, and promotion of organic farming. The present study is about the production and sale of vermicompost and super compost under Gothan and Godhan Nyay Scheme in Chhattisgarh. Based on secondary data; the findings of the study are Durg division has highest efficiency (26.03%) in terms of vermicompost production, followed by Bilaspur (23.09%) and Raipur (21.42%) respectively. Similarly, the efficiency of Gothan's in terms of super compost production shows that Raipur division has the highest efficiency (23.64%) followed by Durg (21.96%) and Surguja (21.87%) respectively. Likewise, the efficiency of Gothan's in sale of vermicompost and super compost shows that Durg division stood first (26.27%) in terms of vermicompost sale followed by Bilaspur (23.38%) and Raipur (22.10%) respectively. Similarly, the efficiency of Gothan's in terms of super compost sale shows that Raipur division has the highest efficiency (25.24%) followed by Surguja (20.52%) and Durg (19.61%) respectively.

Keywords : Gothan, Godhan Nyaya Scheme, super compost, vermi compost

I. Introduction

Godhan Nyay Yojana was started in Chhattisgarh on 20 July 2020, on the day of the Hareli festival. This scheme of purchasing cow dung at Rs.2 per kg has become very popular. This has curbed the practice of open grazing to a great extent. The scheme includes cleanliness and environmental protection, increase in area under double crops, reduction in the cost of cultivation through compost production, and promotion of organic farming. In the state of Chhattisgarh, till July 31, 2022, under the Godhan Nyaya Yojana, a total of Rs 155 crore 58 lakhs has been paid to cattle rearers, villagers, and cow dung sellers in lieu of the purchase of 77 lakh 39 thousand quintals of cow dung. Rs 155.88 crore has been paid to Gothan committees and women's self-help groups. More than 2 lakh 11 thousand rural, cattle rearing farmers are being benefited from the Godhan Nyaya Yojana.

Status of Gothan and Godhan Nyay Yojna

The state government launched the scheme to increase the income of farmers. Main objective of Gothan is to promote organic compost, to reduce chemical fertilizer usage and improve soil health. Gothan is a highland near the village where village's animals are collected in the morning as part of the animal's daily sojourn of posturing.

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Spectral features based speech emotion recognition using artificial neural network

Author(s): **N. Dewangan**¹, **S. Mandal**¹, **K. Thakur**¹, **B. K. Singh**²

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Energy harvesting in cellular radio access networks based on Q-learning

Author(s): S. Sharma¹, M. Dewangan², S. Mandal², K. Thakur², A. Sharma²

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Inspect keywords: energy consumption; energy conservation; 5G mobile communication; learning (artificial intelligence); artificial intelligence; radio access networks; telecommunication power management; cellular radio; telecommunication computing

Subjects: Mobile radio systems; Communications computing; Telecommunication systems (energy utilisation); Radio access systems

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Abstract— Emotion is an essential part of human communication. People communicate with emotions through words and body language. Speech emotion recognition is a well-known technique to detect emotions from speech signals. Here, we have proposed binary and multiclass classification models that combine two cepstral coefficients, i.e., Mel-Frequency Cepstral Coefficient (MFCC) and Mel-Frequency Magnitude Coefficient (MFMC) to extract the spectral features from the speech signals and classify them using backpropagation artificial neural network (BPANN). In our study, it is found that when significant features of both spectral coefficients are combined it shows improvement in training and classification results. The proposed model achieved 85.24% accuracy for the multiclass classification of seven emotions using statistically significant features. The proposed model also achieved 100% accuracy for the binary classification of Happy versus Sad emotion and Sad versus Fear emotion.

Keywords—MFCC, Mel-Frequency Magnitude Coefficient, Neural Network, Speech Emotion Recognition, Multiclass classification model

I. INTRODUCTION

Emotion is an internal state of feeling or agitation. One's mood or way of feeling about something is an affective state that facilitates communication. The expression of emotions in an identical situation varies from person to person [1]. Depending on the situation encountered, human convey their feeling using facial expressions and emotions within the voice. Emotions help us understand what other people think and feel through facial expressions, body language, and vocalizations. Most human communication involves conveying one's emotional state to another person. Thus, it serves as a communication tool. It is a natural, primary reaction of the human body. The person can recognize emotions while talking, working, watching movies, playing games, etc. Machines can learn these human emotional responses through physiological signals, speech signals, facial expressions (image or video signals), text signals, etc. Automatic speech emotion recognition (SER) is one of the state-of-the-art research topics in the human-computer interface (HCI). It has many applications in the medical field, call centers, crime investigation, telecommunication, robotics, computer games, and psychological assessment [2].

Speech is the primary medium of human communication;

therefore, detecting feelings or emotions is very easy and convenient compared to detecting emotions from the face or brain signal. Facial signals need high-quality video cameras, which are expensive, while brain signal acquisition is impossible at any time because it needs proper electrode setup, so speech emotion recognition is the easiest or less costly way to detect human emotions and is used for the human-computer interface.

Speech emotion recognition is a collection of methods that process and classify speech signals to detect embedded emotions [2]. To find the emotion embedded in a speech signal the first method is collecting data and then preprocessing it, the next step is to extract features from the utterance and then train the machine with these features with ground truth and finally trained machine will able to classify the inherent emotion in the speech. There are many types of features from which emotions can be identified from speech. These are prosodic features, spectral features, and Teager energy operators. Spectral features like Mel frequency cepstral coefficients (MFCC), log frequency power coefficients (LFPC), and linear predictive cepstral coefficients (LPC), and are the most used feature to extract emotion. Sato and Obuchi (2007) proved that spectral features give more accurate results than prosodic features [3]. The study by Zhang (2022) also shows the great result using Mel spectrograms for SER [14]. In this paper, we have used MFCC and MFMC based spectral coefficients to extract emotional features from a speech signal.

The forthcoming sections are arranged as follows: Section 2 discusses the work related to speech emotion recognition. Section 3 is the materials and methodology; it explains the dataset, feature extraction, and the proposed methodology. Sections 4 and 5 present the results and discussion, and conclusion, respectively.

II. RELATED WORK

Ancilin and Milton (2021) [1] introduced a new spectral feature, the Mel frequency magnitude coefficient (MFMC), which is a modification of MFCC. There are two steps involved in extracting the MFMC in comparison to the Mel frequency cepstral coefficient: To begin with, the magnitude square is substituted by the magnitude of the fast Fourier transform. As a second step, the discrete cosine transform used in the decorrelation extraction of MFCC is excluded.

Their experiment results show improved accuracy in higher-order MFMCs to recognize speech emotions. Also, experimental results show that the Mel frequency magnitude coefficients classify emotions better than Mel frequency cepstral coefficients (MFCC), log frequency power coefficients (LFPC), and linear predictive cepstral coefficients (LPC). With the MFCCs alone, emotion was recognized with an accuracy of 81.50% for Berlin databases, 64.31% for RAVDESS databases, 75.63% for SAVEE databases, 73.30% for EMOVO databases, and 56.41% for eNTERFACE databases.

Sönmez and Varol (2017) [4] developed a lightweight, effective speech emotion recognition method called 1BTPDN. In this method, first, they applied 1D discrete wavelet transform (DWT) on raw speech signals. Then features were extracted from each filter by a one-dimensional local binary pattern and a one-dimensional local ternary pattern. By using neighborhood component analysis (NCA), 1024 features are selected from 7680 features. For RAVDESS, EmoDB, SAVEE, and EMOVO databases, they achieved 95.16%, 89.16%, 76.67%, and 74.31% success rates, respectively.

Nagarajan et al. (2020) [5] reported novel triangular filter banks based on bark and ERB frequency scales to recognize speech signals. In this work, MFCCs, and human-factor cepstral coefficients (HFCC) features with different types of triangular filter banks such as TFBCC-M (for MFCC), TFBCC-HF (for HFCC), TFB-B (for bark scale) and TFB-E (for ERB scale) were utilized. The experimental results reported that triangular filter banks were much more effective in extracting cepstral features for recognition and characterizing emotions than conventional triangular filter banks. For EmoDB database, the proposed method got the accuracies of 83.23% and 81.99% for the speaker-dependent (SD) scenario, 75% and 60.94% for the Speaker Independent (SI) scenario, and SAVEE database, 75% and 66.67% for the SD scenario, and 44.17% and 55% for SI scenario.

Choudhury et al. (2018) [6] combined several spectral features with excitation source features. In this work, time and frequency domain spectral features were extracted from the raw speech signals. In this work, Sequential Minimal Optimization (SMO) and Random Forest (RF) were utilized as classifiers. They achieved the accuracies of 75.5% and 75.5% for EmoDB, 55.5% and 55.3% for SAVEE, 99% and 97.7% for TESS older, and 99.1% and 99% for TESS younger for SMO and RF, respectively.

Kathiresan & Dellwo (2019) [7] proposed new dynamic features to improve emotion recognition ability. The proposed features were temporal dynamics (temporal delta and delta-deltas) and cepstral derivatives (cepstral delta and delta-deltas). Two different languages database, i.e. EmoDB for German and SAVEE for English were utilized for this work. By using these new features of different dimensions, they achieved 67.7% accuracy for the EmoDB dataset and 60.8% for the SAVEE dataset.

Langari et al. (2020) [8] proposed adaptive time-frequency features based on fractional Fourier transform fusion with a cepstral coefficient. They used two categories of features to recognize speech signals. The first one is the prosodic feature, i.e. pitch, energy, and duration, and the other one is related to the vocal tract, i.e. cepstral coefficient, formants, and DFT harmonics. This work reported that the

discrete fractional Fourier transform represents the angle on the time-frequency plane, and the rotation of the angle can restore the original data from the distorted signal in other space, which improves the accuracy. This work achieved accuracies of 97.57% for EmoDB, 80% for SAVEE, and 91.46% for the PDREC dataset.

Daneshfar et al. (2020) [9] proposed a three-stage hybrid system for speech emotion recognition, which concludes feature extraction, dimensionality reduction, and feature classification. They used perceptual-spectral features such as MFCC, PLPC, and PMVDR in combination with the prosodic feature like pitch. In their paper, they used a new pQPSO method (QPSO-based approach) and gaussian elliptical basis function (GEBF)-type neural network as a classifier for SER. This work utilized EmoDB, SAVEE, and IEMOCAP datasets and got 79.94%, 59.38%, and 65.71% accuracies, respectively.

Zhang et al. (2022) [14] proposed Mel-IMel dual-channel complementary structure with a convolutional neural network-stacked sparse autoencoder (CNN-SSAE). They focused on the low-frequency part and the high-frequency part of the speech signal using the Mel-spectrogram and the inverse Mel spectrogram, respectively to prove that the two spectrograms are complimentary. The experiment was conducted on the EMO-DB, SAVEE, and RAVDESS datasets, they achieved high accuracies for all the datasets.

III. MATERIALS AND METHODOLOGY

This section describes the dataset, spectral feature extraction techniques, classification approach, and the proposed emotion recognition model.

A. Emotional database of the speech signal

In this paper, we have used SAVEE (Surrey Audio-Visual Expressed Emotion); it consists of acted audio-visual recordings of British English utterances. Four male actors in a visual media lab expressed seven emotions: anger, disgust, fear, happiness, neutral, sadness, and surprise. Each subject utters 15 sentences for each emotion, except neutral, which has 30 utterances. It contains 480 audio files in .wav format with 16-bit encoding and a sampling rate of 44.1 kHz [10].

B. Pre-processing of the raw speech signal

The preprocessing begins with pre-emphasis, in which the signal is passed from a high pass filter to increase the amplitude of weak signals and reduce the noise in the background, enhancing the raw speech signal. The next step is silence removal. When an audio or speech signal is recorded, there are three parts: voiced, unvoiced, and silent [2]. As noise removal is necessary to remove unwanted signals, silence part removal is also essential because it contains no information, and there is no need to keep that part of the signal. Here, the speech signal is first framed in 20ms duration. For each frame, a zero cross rate is calculated. Then those frames that contain zero ZCR are eliminated, which is the silence part of the speech signal. A zero cross rate indicates the change of rate in signal from positive to negative or negative to positive. When there is no change in signal or the value of ZCR is zero, that means there is no change in signal, or there is no signal. Equation (1) shows the ZCR of the m^{th} frame

$$\text{ZCR}(m) = \frac{1}{2N} \sum_{i=1}^N | \text{sgn}(s(k)) - \text{sgn}(s(k-1)) | \quad (1)$$

Where $sgn(s(k)) = \begin{cases} -1, & s(k) < 0 \\ +1, & s(k) \geq 0 \end{cases}$

$s(k)$ is the k^{th} sample amplitude of the m^{th} frame of length n [11].

Fig. 1 is depicted the raw speech signal and pre-processed speech signal after pre-emphasis and silent part removal using ZCR.

C. Feature extraction

Features are the essential characteristics of finding emotions from the speech signal. There are various features exist for SER. Here, cepstral coefficients are used to extract spectral features. Spectral features are the short-duration frequency signals obtained using Fourier transform from the time domain signal.

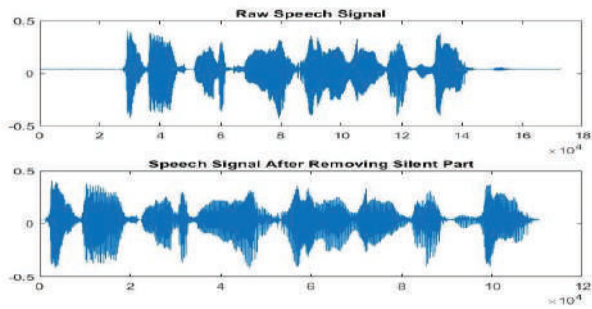


Fig. 1. Speech signal before and after preprocessing

Cepstral coefficients are a type of spectral feature used extensively in speech recognition. Although they've been around for some time, they've recently received more attention as researchers have developed computer algorithms that use cepstral coefficients to perform speech emotion recognition.

1) *MFCC*: Mel frequency cepstral coefficient is one of the most used features in speech emotion recognition [11]. It is obtained by dividing the speech signal into frames of short duration, here 20 ms frames are taken with 50% overlapping; then, each time domain frame is converted into a frequency domain using FFT. Fourier representation (2) represents the speech frame as different frequencies, and the Fourier transform coefficients indicate the number of different frequencies contained in the speech frame.

$$X(k) = \sum_{n=0}^{N-1} x(n) e^{-i \frac{2\pi kn}{N}} \quad k=0,1,2,\dots,N-1 \quad (2)$$

Where N represents the number of samples in the speech frame. $x(n)$ represents the n^{th} speech sample, and $X(k)$ represents the k^{th} Fourier transform coefficient.

Next, the energy spectrum is calculated from the FFT signal and passed through Mel filter banks to calculate the subband energies. Then logarithm is applied to those energies. Lastly, a discrete cosine transform is taken to obtain MFCC.

2) *MFMC*: In [1], a new cepstral coefficient was introduced, which is a modification of the Mel frequency cepstral coefficient (MFCC), known as the Mel frequency

magnitude coefficient (MFMC). MFMC is obtained by dividing speech signal into frames of short duration (usually 20-30 ms) with 50% overlapping. Then each time domain frame is converted into a frequency domain using FFT. MFCC considers the energy spectrum, while MFMC uses the magnitude spectrum instead of the energy spectrum for further steps.

Next, the magnitude spectrum is converted into the Mel spectrum and divided into uniform bands. These uniform bands are converted into linear frequency scales and become non-uniform bands. Then the non-uniform bands will be passed through the triangular windows (3) with 50% overlapping to get Mel band magnitude. Lastly, the logarithm is applied to get MFMC.

$$H_m(k) = \begin{cases} \frac{k-fx}{fy-fz}, & fx \leq k \leq fy \\ \frac{fz-k}{fz-fy}, & fy \leq k \leq fz \\ 0, & \text{otherwise} \end{cases} \quad (3)$$

Where k is the frequency, fx is the lower frequency, fy is the middle frequency, and fz is the highest frequency of the triangular window.

$$Y(m) = \sum_{k=0}^{t-1} X_m(k) | H_m(k), \quad 1 \leq m \leq M \quad (4)$$

Where t is the number of frequency components in the m^{th} band

$$\text{MFMC}(m) = \log_{10}(\sum_{k=0}^{t-1} X_m(k) | H_m(k)), \quad 1 \leq m \leq M \quad (5)$$

D. Cross-validation

Data division protocol or cross-validation is a technique used in machine learning to divide the dataset into two parts: the training set and the testing set. The model learns through the training set, and the remaining dataset, i.e. testing set, is used to test the model's performance [12]. Here, hold-out with dataset divided into a ratio of 67:33 and K-fold with $K=5$ are used to classify emotion.

1) Hold-out :

Hold-out cross-validation is the simplest and most common technique used for cross-validation (CV) [12]. The algorithm of the hold-out technique:

1. Divide the dataset into two parts: the training set and the test set. It can be set to 80:20, 70:30, 60:40, or another ratio as suitable. The first number represents the percentage of the dataset for training, and the other one represents the percentage of the dataset for testing purposes.
2. Training of model on the training set
3. Validation of the model on the test set

In this paper, hold-out is repeated 5 times to train the model and to get better accuracy in the testing phase.

2) K-fold :

The K-fold method is another technique of cross-validation similar to the hold-out method. It splits the dataset into K equal parts known as folds. $K-1$ folds of datasets are used for training, and one part of the dataset is used for testing; it repeats itself K times ($K=5, 10$, etc.). Each

validation tests a different set of datasets [12]. Here, 5-fold is selected for training the proposed model, the total dataset is divided into 5 equal parts and 4 parts were used for training and only one part is used in testing. This process repeats itself 5 times, each time new parts of the dataset were tested.

E. Backpropagation artificial neural network

A backpropagation artificial neural network is a supervised learning method that contains one input layer, one output layer, and some hidden layer. It enhances the output by changing the weight of neurons according to the errors between the actual output value and the expected output value. The training in this method is carried out by repeating the entire dataset until the errors are minimized [13].

F. Proposed emotion recognition model

The framework of speech emotion recognition is shown in fig. 2. Firstly, audio signals are pre-processed using a pre-emphasis filter. A ZCR-based algorithm is used to remove the silence part from the audio signals. The whole audio database is divided into two parts namely training and testing part using data division protocol. From fig. 2, it can be seen that the proposed model is also divided into two parts namely training and testing part using a vertical discontinued line. Except for ground truth, the training and testing part is almost the same. In the present work, spectral coefficients namely MFCCs and MFMCs are extracted as features in the next step. In the next step, significant feature selection is performed using an independent t-test and analysis of variance (ANOVA) for the binary and multiclass classification, respectively. Further, the classifier is trained with a feature vector and ground truth. After training of the classifier, learning parameters are generated. These parameters will help the classifier to emotion recognition during the validation and testing.

The basic steps are as follows:

1. Collecting raw data of speech signal
2. Pre-processing of the speech signal
3. Extracting and selecting the spectral features
4. Classification and validation

IV. RESULT AND DISCUSSION

This paper classified seven emotions from the SAVEE dataset, i.e. anger, disgust, fear, happy, neutral, sad, and surprise. Out of these seven emotions, four basic emotions namely anger, fear, happy, and sad are used to build binary classification problems (CP). In the present work, six binary CP (CP1 to CP6) and one multiclass CP (CP7) are used as a classification problem. The accuracies of six binary emotions CPs and one multiclass CP(all seven emotions) using MFCC, MFMC, and a combination of MFCC and MFMC features with hold-out and 5-fold are shown in Table I. Here, CP with numbers 1, 2, 3, 4, 5, and 6 are denoted by the binary emotion classification problems namely Fear versus Anger, Happy versus Anger, Happy versus Fear, Happy versus Sad, Sad versus Anger, and Sad versus Fear, respectively. CP7 is denoted the multiclass classification problem (all seven

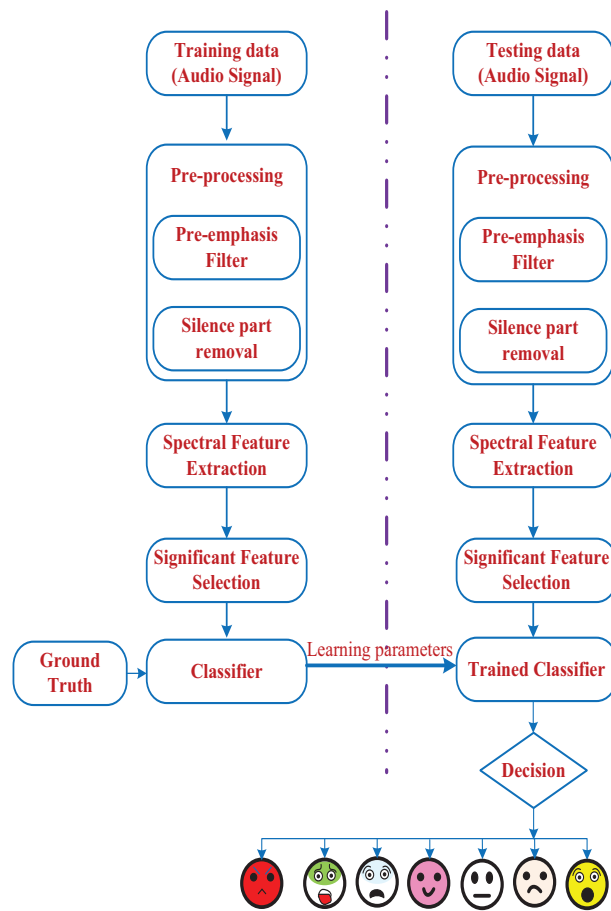


Fig. 2. Proposed model of speech emotion recognition

emotions). The alphanumeric code FV1, FV2, and FV3 are denoted the MFCC, MFMC, and combined MFCC+MFMC feature vectors, respectively.

The proposed model shows the 81.5%, 70.5%, 83.5%, 91%, 92%, 90.5%, and 81.5%, 66%, 83.5%, 94.5%, 93%, 93% accuracies for Fear versus Anger (CP1), Happy versus Anger (CP2), Happy versus Fear (CP3), Happy versus Sad (CP4), Sad versus Anger (CP5), and Sad versus Fear (CP6) for MFCC and MFMC features, respectively with hold-out CV and BPANN classifier. And 97.5%, 92.5%, 94.16%, 98.34%, 97.5%, 98.3%, and 84.98%, 74.16%, 85.82%, 98.32%, 97.5%, 95.82% accuracies for MFCC and MFMC features, respectively with 5-fold CV and BPANN classifier. When both features were combined, it shows the accuracy of 87.0% and 97.5% for CP1, 67.5% and 92.5% for CP2, 79.5% and 97.5% for CP3, 97.5% and 99.16% for CP4, 99.05 and 99.16% for CP5, and 95.0% and 98.33% for CP6 with hold-out and 5-fold CV, respectively. Here we also get 66.4% and 79.26% accuracies for all seven emotions (CP7) of SAVEE dataset for combined features (FV3) using hold-out and 5-Fold CV, respectively. We get the highest accuracy of 99.16% in 5-fold CV for Happy versus Sad (CP4) and Sad versus Anger (CP5) using FV3 feature vector with 5-fold CV and 80.74% accuracy for all seven emotions (CP7) using FV1 feature vector with 5-fold CV.

TABLE I. COMPARISON WITH COMBINED FEATURES ON SAVEE DATASET (%)

CV	Hold-Out			5-Fold		
	FV1	FV2	FV3	FV1	FV2	FV3
Features Vector → Emotion CP↓						
CP1	81.5	81.5	87.0	97.5	84.98	97.5
CP2	70.5	66.0	67.5	92.5	74.16	92.5
CP3	83.5	83.5	79.5	94.16	85.82	97.5
CP4	91.0	94.5	97.5	98.34	98.32	99.16
CP5	92.5	93.0	99.0	97.5	97.5	99.16
CP6	90.5	93.0	95.0	98.34	95.82	98.33
CP7	65.64	50.0	66.4	80.74	54.28	79.26

Table II shows the classification accuracies for statistically significant features of the FV3 feature vector. Here we get 100% accuracy for Happy versus Sad (CP4) and Sad versus Fear (CP6) in the 5-fold method for significant features of FV3 and get 85.24% accuracy for CP7. The results show that the 5-fold CV gives a better result compared to hold-out except for some cases. When MFCC and MFMC features are merged (FV3) the proposed method gives higher accuracy compared to MFCC (FV1) and MFMC (FV2) are used alone. From Table I and II, it can also see that multiclass CP (CP7) classification accuracy is improved by 5.98% using significant features from FV3 and 5-fold CV.

TABLE II. CLASSIFICATION ACCURACY FOR STATISTICALLY SIGNIFICANT FEATURES

Features Vector CV→ Emotion CP↓	Significant features from FV3	
	Hold-Out	5-Fold
CP1	80	95.84
CP2	65	80.84
CP3	85	96.6
CP4	97.5	100
CP5	97.5	88.34
CP6	97.5	100
CP7	57.98	85.24

A ROC (receiver operating characteristic curve) plot represents the performance of the classification model in graphical form. The ROC plot of CP2-FV3 for 5-Fold, CP6-FV3 for hold-out, and CP1-FV3 for 5-fold of Table I is shown in Fig. 3, Fig. 4, and Fig. 5, respectively.

Table III shows a comparison of the proposed work with some recently reported work. The results show that the proposed method gets a high accuracy of 85.24% for the SAVEE dataset compared to other works done on spectral features, as shown in Table III.

TABLE III. COMPARISON OF ACCURACIES FOR DIFFERENT WORK DONE ON SAVEE DATASET

Author(Year)	Features	Classifiers	Accuracy (%)
Ancilin and Milton (2021)	LPCC, LFPC, MFCC, MFMC	Support Vector Machine (SVM)	75.63
Sönmez and Varol (2017)	Time based, Frequency based, Cepstrum based, Wavelet transform based, Texture based, Deep features	DT, LDA, KNN, SVM	76.67
Nagarajan et al. (2020)	Cepstral coefficients	SVM	75, 66.67(SD) 44.17, 55(SI)
Choudhury et al. (2018)	Spectral features	SMO, Random Forest	55.5, 55.3
Kathiresan & Dellwo (2019)	MFCCs, 2TΔ, 2CΔ	SVM, DNN	60.8
Langari et al.(2020)	MFCC, LPCC, Format	SVM	80
Daneshfar et al.(2020)	MFCC, PLPC, PMVDR, Pitch	GEBFNN	59.38
Proposed Method	MFCC, MFMC	BPANN	79.26
Proposed Method	Significant FV MFCC, MFMC	BPANN	85.24

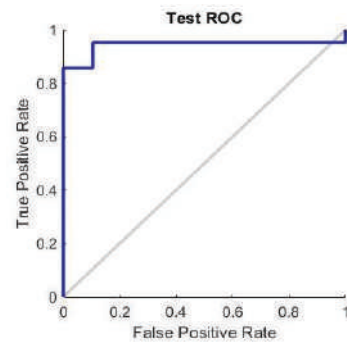


Fig. 3. ROC plot of CP2-FV3 for 5-fold CV (accuracy 92.5%)

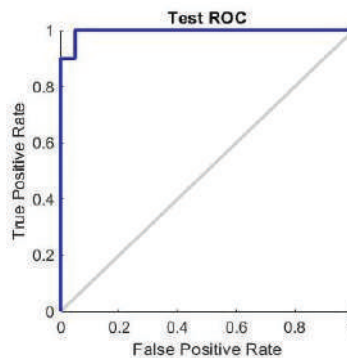


Fig. 4. ROC plot of CP6-FV3 for hold-out CV (accuracy 95 %)

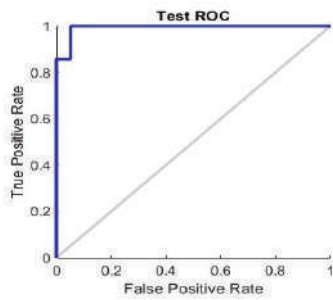


Fig. 5. ROC plot of CP1-FV3 for 5-fold CV (accuracy 97.5%)

V. CONCLUSION

This paper used the combination of MFCC and MFMC to recognize emotion from the speech signal. MFCC and MFMC are both cepstral coefficients. MFMC feature has not been used in many works. Our work shows that both features, MFCC and MFMC, can stand alone and recognize the emotion from speech signals very well; also, when combined with MFCC, it gives better results. On binary classification, 100% accuracies are obtained for Happy versus Sad and Sad versus Fear classification problem. When MFCC and MFMC have used stand-alone, we get 80.74% accuracy using the MFCC feature for all seven emotions with a 5-fold CV and BPANN classifier. Compared to other work done on SAVEE dataset, we got the highest accuracy of 85.24% for all seven emotions when significant features are selected from a combination of MFCC and MFMC. Hence, the proposed model may help the machine recognize human emotion for further applications.

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Subject Dependent and Subject Independent Analysis for Emotion Recognition Using Electroencephalogram (EEG) Signal

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Abstract. Brain signals for the human-computer interface is a research interest in recent years. The brain is the most vital part of our body. It handles and manages all types of activities of the body. Brain signals appear when neurons inside the brain send electrical impulses to communicate and elicit electrical potentials. This electrical activity can be measured by Electroencephalogram (EEG) through electrodes. EEG signals can help to recognize human emotions effectively. It is a non-invasive method to collect brain signals. In this paper, we have studied the subject-dependent and subject-independent analysis for four emotions (happy, sad, fear, and neutral) using the SEED-IV dataset of EEG signals for emotion. The raw EEG signals of the SEED-IV dataset have been preprocessed to remove unwanted signals and noise. 32 statistical features have been extracted from the preprocessed EEG signals and used as input for classifiers. Here, we achieved an average of 95.73% accuracy for 15 subjects for subject-dependent analysis for emotional classification using a cubic support vector machine (SVM). Based on cubic SVM and fine Gaussian SVM, we achieved an average classification accuracy of 78.46% and 83.7% for subject-independent analysis.

Keywords: Electroencephalogram, Support Vector Machine, Emotion

1. Introduction

Complex psychological and physiological states known as emotions can be brought on by both internal and external factors. They are subjective experiences that involve a range of cognitive, behavioral, and physiological responses [1,2]. Some common emotions are fear, anger, happiness, surprise, sadness, love, and disgust. Emotions are also categorized as positive or negative emotions, as they vary in duration and intensity. They are affected by various reasons, including genetics, culture, upbringing, personality, and experiences. Emotions play an important role in communication.



EEG (electroencephalogram) signals provide details about the electrical activity of the human brain [3]. EEG signals are recorded by placing electrodes on the scalp and are measured in microvolts (μV) [3]. The signals can be used to track the brain's activity associated with different states and functions, such as during sleep, during emotional responses, and in response to external stimuli. EEG signals can be used to diagnose certain neurological disorders, such as epilepsy, and to monitor the effects. EEG signals can help to recognize human emotions effectively. It is a non-invasive method to collect brain signals. Emotion recognition through EEG is the process of identifying the emotional state of a person by analyzing the brain signals. This technology is based on the fact that different emotions are associated with different patterns of brain activity. Machine learning algorithms are used to analyze EEG signals and classify them into different emotional categories such as happiness, sadness, anger, and fear.

The approaching sections are arranged as follows: Section 2 discusses the work related to EEG emotion recognition. Section 3 is the methodology; it explains the dataset, channel selection, preprocessing, feature extraction, classifier, and the proposed methodology. Sections 4 and 5 present the results and discussion, and conclusion, respectively.

2. Related works

Some of the related work on emotion recognition using EEG signals are listed below.

Huang et al. (2012) present an emotion detection system that detects emotions using EEG signals. They used short EEG segments of 1s [4]. They proposed a new feature extraction method called asymmetric spatial filtering (ASF) for high-dimensional EEG data. An ASF aims to maximize the variance difference between the two hemispheres of an EEG signal filtered by band-pass. The experiment result shows that for only 1s part of EEG data. The ASF achieved an average classification accuracy of 79% and 83% for valence and arousal classification, respectively. Zhang et al. (2016) proposed an algorithm based on EEG signals to detect emotion using sample entropy and empirical mode decomposition (EMD) [5]. EEG signals containing only two channels are first decomposed using EMD into intrinsic mode functions (IMFs). A feature vector is formed by selecting the first four IMFs and calculating their entropies. For training and testing the feature vectors are used as input to a support vector machine (SVM) classifier. For binary-class tasks, the proposed method achieves 94.98% accuracy, and for multi-class tasks, the best accuracy is 93.20% by using the DEAP database. Liu et al. (2018) used pre-trained ResNets to recognize emotions from EEG signals [6]. First, they preprocessed raw EEG data from the DEAP dataset and converted it into a 2D image. They extract deep semantic information using ResNets and LFCC features from preprocessed signals. They fused these two features and improved the classification performance for emotion recognition. LOO and 10-fold cross-validation (CV) are performed for three different tasks in their experiments. They used several classifiers in their experiment and found that the k-nearest neighbor (KNN) gives the best performance.

Qing et al. (2019) demonstrate how emotion can be extracted using the emotional activation curve [7]. First, the algorithm used EEG signals from DEAP and SEED dataset to extract feature and classifies emotions based on machine learning (ML) approaches, which involved training models based on portions of trials and assessing their effectiveness in recognizing emotional states. Secondly, they construct novel activation curves of emotions and gave two emotion coefficients, first the correlation coefficients and second the entropy coefficients. based on the classification results. The results based on their experiment show that a weight coefficient obtained from the two coefficients can significantly enhance the accuracy of EEG-based emotion recognition. Gao et al. (2020) proposed a novel deep learning method, namely a channel fused dense CN, based on EEG signals for emotion recognition [8]. In their paper, they combine contextual features along the temporal dimension from EEG signals to form a 1D convolution layer. They stated that they were able to extract valuable features from noisy EEG signals by handling electrode correlations and temporal dependencies in their algorithm. They worked on SEED and DEAP datasets. Their framework achieved average accuracies of 92.58%, and 90.63% on the DEAP and SEED datasets, respectively.

Salama et al. (2021) proposed an emotion recognition model for humans based on face and EEG signals [9]. In the proposed method, deep learning-based 3DConvolutional Neural Network (3D-CNN) architecture has been utilized to extract the spatiotemporal features from the human faces data signal, and the EEG signals. They proposed three approaches to emotion recognition for humans i.e., object detection using Mask-RCNN technique with OpenCV libraries with SVM, 3DCNN for the final predictions of the EEG-based emotion recognition approach, and 3D-CNN for face-based emotion recognition technique, and bagging, and stacking fusion techniques for emotion detection based on fusion technique. The experiments have been conducted on DEAP dataset. The average accuracy of 96.13% and 96.79% has been obtained for valance and arousal respectively for fusion-based human emotion recognition. Liu and Fu (2021) proposed human emotion recognition from the EEG signals [10]; where sound signal stimulation produces an EEG signal. They used PCA and ReliefF methods to select suitable channels from multi-channel EEG. They extracted time domain features from multi-channel EEG and textual features. CNN approach has been used by them for textual feature extraction. Feature vector fusion is then further used in PCA analysis for feature reduction. 47%–81% classification accuracy has been achieved using SVM as a classifier.

Pusarla et al. (2022) investigated an efficient approach for extracting and classifying emotional information from 2D spectrograms of EEG signals using deep learning [11]. They proposed a Deep Convolution neural network (DCNN) for Emotion Recognition (DCERNet) with high connections between layers to extract features from EEG signals. Using pre-trained Densenet121 as a base model, DCERNet is customized over softmax and SVM classifiers. The experiments were done using SEED and DEAP datasets. Their proposed model based on DCERNet for emotion recognition shows an improvement of almost 8% as compared to the other methods used for emotion recognition. Rajpoot et al. (2022) presented a novel deep learning method for emotion recognition [12]. It is based on unsupervised LSTM and CNN approaches. Here, lower dimensional latent space has been used to represent the EEG data signals. Firstly, they used a channel attention auto-encoder with unsupervised LSTM to extract features from EEG signals. After that, CNN is used to perform subject-independent emotion recognition. They compared their autoencoder approach with other encoding methods and the CNN attention classifier with series classifiers. They experiment with their model using DEAP, SEED, and CHB-MIT datasets. 69.5% and 76.7% classification accuracies have been achieved by the proposed method for DEAP and SEED datasets, respectively. Also, for the CHB-MIT dataset, 69%-73% classification accuracies have been achieved for different types of experiments.

Some research gaps have been found during the literature survey; they are as follows:

1. Many researchers studied on valence arousal model, which assigns scores to an individual based on their positive/negative feeling and arousal level. The model assumes that every person's reaction to a situation follows a linear path with an expected degree of response. However, human emotion is far more nuanced than this simple model allows for. Also, emotions involve a wide variety of subjective experiences that cannot be captured by numerical values alone or just positive/negative.
2. The datasets used were old and contained fewer amounts of EEG signals for various emotions, making it difficult for researchers to analyze their data effectively in real-time applications.
3. Also, a deep learning-based model needs a significant amount of training data to accurately identify and interpret emotions, when these datasets are used, they lack a sufficient amount of data, which can lead to false accuracy.

The core contributions of the present work are as follows:

1. We implement and evaluate a multiclass emotion recognition model using kernel-based SVM classifiers and EEG signals.
2. We also investigate the performance of this model for subject-dependent and subject-independent analysis.

3. Methodology

This section describes the dataset, channel selection and preprocessing techniques, feature extraction techniques, classification approach, and the proposed emotion recognition model.

A. Emotional database of the EEG signal

In this paper, the SEED-IV dataset has been used. The EEG signals from 15 participants who watched Chinese cinema snippets are included in the SEED-IV dataset. Happy, sad, fearful, and neutral are the four emotion categories shown in the movie clips. A preliminary investigation picked 72 movie snippets in total (18 clips for each emotion category). 24 trials are included in each experiment to ensure that all 72 film clips were seen by the participants. The ESI Neuroscan equipment was used to record the EEG data with a 62-channel cap following the 10-20 method [13].

B. Channel selection and preprocessing techniques

From the SEED-IV dataset, out of 62 channels 27 most relevant channels have been selected for emotion recognition from the frontal and temporal lobes. These two lobes are responsible for generating emotions [3,13]. Then from these selected 27 channels the raw EEG signals have been preprocessed to remove unwanted signals and noise using a bandpass filter (0.5-49.5 Hz). Also, a notch filter with 60 Hz has been used to remove baseline noise.

C. Feature extraction techniques

Features are the essential characteristics of finding emotions from the EEG signal. There are various features exist for the detection of emotions from EEG signals. Here, statistical methods have been used for the feature extraction process. 32 statistical features have been extracted from the preprocessed signal. MATLAB@2021a has been utilized to extract the features from the EEG signals. Table 1 shows the details of 32 features.

The spectrum of frequency bands of EEG signals contains the same pattern for the same emotions and different patterns for each emotion. Similarly, statistical features contain patterns and values for each emotion. The selected features for extraction of emotional pattern help to improve the performance of the emotion recognition model. Here, to select the significant features for emotion recognition using EEG signal, statistical analysis has been performed using IBM SPSS Statistics (version 20) software mentioned in section 6.

Table 1: List of features that were taken out of the preprocessed EEG signals

Feature Name	Features
V1	Mean curve length
V2	Hjorth Activity
V3	Hjorth Mobility
V4	Hjorth Complexity
V5	First Difference
V6	Normalized First Difference
V7	Second Difference
V8	Normalized Second Difference
V9	Mean Energy
V10	Mean Teager Energy
V11	Log Root Sum Of Sequential Variation
V12	Tsallis Entropy
V13	Shannon Entropy
V14	Log Energy Entropy
V15	Renyi Entropy
V16	Arithmetic Mean

V17	Standard Deviation
V18	Variance
V19	Median
V20	Maximum
V21	Minimum
V22-V25	Auto Regressive Model
V26	Kurtosis
V27	Skewness
V28	Band Power Delta
V29	Band Power Theta
V30	Band Power Alpha
V31	Band Power Beta
V32	Band Power Gamma

D. Proposed emotion recognition model

The framework of EEG emotion recognition is shown in Fig. 1. Firstly, we select the most relevant channels from 62 channels of the SEED-IV dataset for emotion recognition. Then these selected raw EEG signals have been preprocessed to remove unwanted signals and noise using a bandpass filter (0.5-49.5 Hz). After that 32 statistical features have been extracted from the preprocessed EEG signals. The features were divided into two parts namely the training and testing part using data division protocol. Further, the support vector machine (SVM) classifier is trained with a feature vector and ground truth. After training the classifier, learning parameters are generated. These parameters will help the trained classifier to recognize emotion during the validation and testing.

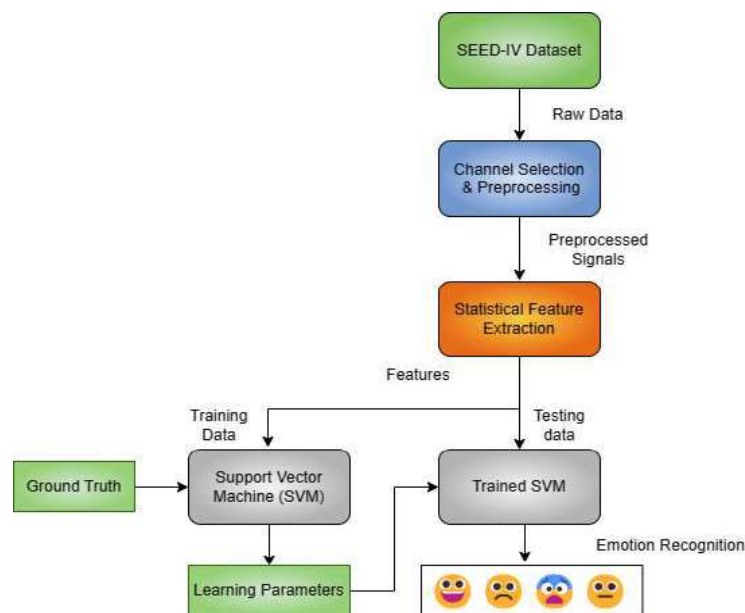


Fig. 1 Proposed model for emotion recognition

4. Results and Discussions

In this paper two type of analysis has been performed i.e., subject-dependent (SD) analysis and subject-independent (SI) analysis. The subject-dependent analysis gives a person's perception of various emotional states. The same stimulus may elicit distinct feelings in other persons. When the subject-dependent analysis is performed, it only reveals the subject's efficiency in recognizing

emotions; however, when other subject's emotional data is tested for emotion recognition, the system may not be able to recognize the true emotion because it has only been trained and learned the pattern on the emotions of a specific subject. While in the case of subject-independent analysis, the system learns the patterns of various emotions from a variety of subjects, and if new subjects' emotional data are provided for the test, it will produce accurate findings because the system has learned the patterns from a variety of subjects. The system looks for a pattern in the input data and returns a result.

Here, we achieved an average of 95.73% accuracy for 15 subjects for SD analysis for emotional classification using a cubic support vector machine (SVM). Fig. 2 shows that subject 5 shows higher accuracy of 97% and subject 8 shows the lowest accuracy of 93.6%. Based on cubic SVM and fine Gaussian SVM, we achieved an average classification accuracy of 78.46% and 83.7% for SI analysis. Fig.3 shows Subject independent accuracies for 4 emotions using Cubic SVM & Fine Gaussian SVM as a classifier.

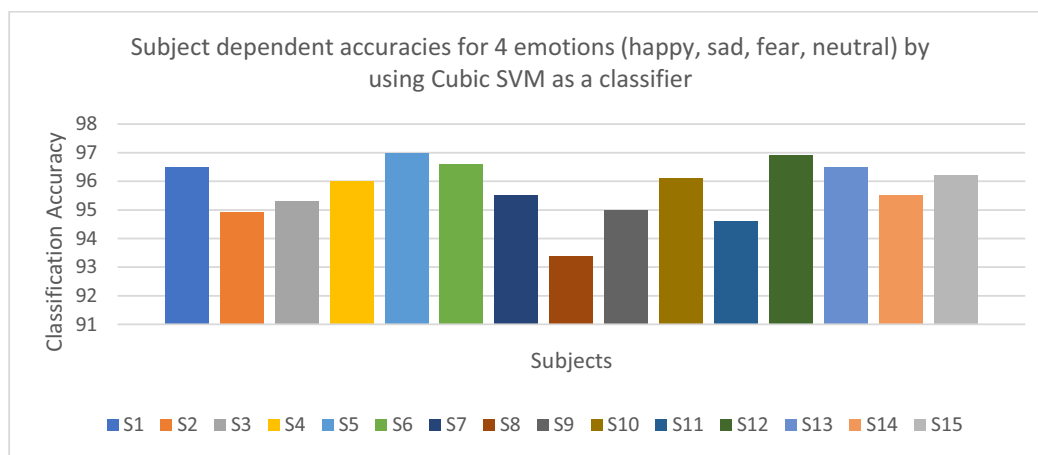


Fig. 2 Subject-dependent accuracies for 4 emotions (happy, sad, fear, neutral) by using Cubic SVM as a classifier

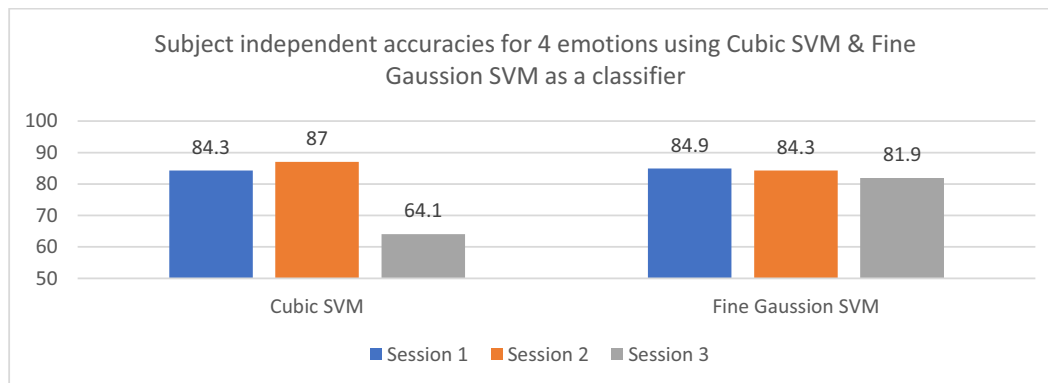


Fig. 3 Subject-independent accuracies for 4 emotions using Cubic SVM & Fine Gaussian SVM as a classifier

Using IBM SPSS Statistics (version 20) software, the F score and significant value of each character have also been determined, and the results are displayed in Table 2. The analysis of variance (ANOVA) test is a statistical analysis used to compare the means of two or more groups. It is used to determine if there is a significant difference between the group means and identifies which group(s) are responsible for any observed differences. This test is a parametric test, which means it assumes that data is normally distributed. While conducting an ANOVA, the F value is employed as a

parameter. Two mean squares are divided to calculate it. The ratio of explained variance to unexplained variance is calculated using this formula. The F value and degrees of freedom of the sources of variation are used to calculate the probabilities of the F values. The probability is the test's significance value means, a significant value determines the probability of obtaining the result by chance. Conventionally, a significant value of 0.05 or less is considered statistically significant. If the calculated significant value is less than 0.05, it indicates that the differences between group means are entirely due to chance, and the null hypothesis can be rejected. Conversely, if the significant value is greater than 0.05, it suggests that the differences between means are not significant, and the null hypothesis cannot be rejected [14,15]. In Table 2, 30 features' significant values are < 0.05. This indicates, out of 32 features 30 features are significant, which means they are more suitable to determine emotions from EEG signals and V19 and V27 are not suitable for emotion detection.

Table 2: 32 Features with their F score and significant value

Feature Name	F Score	Significant Value
V1	17.757	.000
V2	12.627	.000
V3	27.561	.000
V4	65.045	.000
V5	17.758	.000
V6	10.864	.000
V7	19.455	.000
V8	59.332	.000
V9	12.625	.000
V10	16.656	.000
V11	7.270	.000
V12	30.833	.000
V13	411.993	.000
V14	18.219	.000
V15	228.719	.000
V16	22.962	.000
V17	7.296	.000
V18	12.627	.000
V19	0.938	.421
V20	13.068	.000
V21	11.072	.000
V22	37.815	.000
V23	14.952	.000
V24	21.546	.000
V25	14.983	.000
V26	30.484	.000
V27	0.965	.408
V28	5.955	.000
V29	13.804	.000
V30	13.687	.000
V31	13.567	.000
V32	13.716	.000

Table 3 shows a comparison of the proposed work with some similar existing work. The results show that our proposed work gets an accuracy of 78-96% for the SEED-IV dataset and shows improvement for both SD and SI analysis compared to other works done on EEG datasets as shown in Table 3.

Table 3: Performance comparison of present work with similar existing work

Sr. No.	Author/Year	Dataset used	Feature Extraction	Classifier/ Machine Learning Approach	Performance/ Accuracy
1.	Huang et al. (2012) [4]	EEG signal	Asymmetric spatial filtering (ASF)	Linear, Naive Bayes (NB), K-Nearest Neighbor (KNN), and Support Vector Machine (SVM).	83% for arousal 79% for valence
2.	Zhang et al. (2016) [5]	DEAP	Empirical mode decomposition (EMD), Sample entropy	SVM	94.98% for binary-class tasks 93.20% for the multi-class task
3.	Liu et al. (2018) [6]	DEAP	Linear frequency cepstral coefficient (LFCC)	K-nearest neighbor (KNN)	61.55% for valence and 54.53% for arousal
4.	Qing et al. (2019) [7]	DEAP SEED	1 st and 2 nd order difference differential entropy	Decision Tree, KNN and Random Forest	63.09% 75%
5.	Heekyung Yang et al. (2019) [16]	DEAP	--	convolutional neural network (CNN)	90.01% for valence & 90.65% for arousal.
6.	Salama et al. (2021) [9]	DEAP	Spatiotemporal features	3D-Convolutional Neural Network (3D-CNN) deep learning	96.13% for valence and 96.79% for arousal
7.	Rajpoot et al. (2022) [12]	DEAP SEED	--	LSTM and CNN	69.5% 76.7%
8.	Zong et al. (2020) [17]	SEED SEED-IV		Regularized graph neural network (RGNN)	94.24% for SD 85.30% for SI & 79.37% for SD 73.84% for SI
9.	Our Proposed Model	SEED-IV	Statistical features	Support Vector Machine (SVM)	95.73% for SD 78.46% & 83.7% for SI

5. Conclusion

In this work, we proposed an electroencephalogram (EEG) based machine learning approach for emotion recognition. The new dataset "SEED-IV" provided by BCMI laboratory is used in the proposed work. The 32 statistical features from the selected EEG signals have been utilized to train the SVM-based machine learning approach. Here, subject-dependent (SD) and subject-independent (SI) analysis has also been performed for four emotions namely happy, sad, fear & neutral. We further found that the trained SVM classifier shows good classification accuracies for 15 subjects for SD and SI analysis. F score and its significant values also have been calculated which shows that 30 features are most suitable for the detection of emotions using EEG signals. As compared to the previous work done, the proposed machine learning approach shows good accuracy with a simple and easy-to-implement multiclass emotion recognition model.

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Energy Harvesting in Cellular Radio Access Networks based on Q- Learning

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Abstract— In the modern communication world, capacity of future mobile networks will continuously rise for enhanced data traffic and high reliability. The current evolution trends in 5G networks and beyond impose drastic increase in energy consumption and therefore, a high level of carbon footprint by industry network infrastructures. Modern 5G wireless communication can be a potential driver for machine learning (ML) and artificial intelligence architecture at network edge. Herein, we investigate the performance and evaluation analysis of cellular radio access networks (RAN) simulated and based Q-learning approach by turning on-off some base stations (BSs) to achieve enhanced energy savings in a cellular RAN. In this work, we study the BS switching actions, considering traffic load variations. We formulate the network models as action state, environment and reward. It was shown that the proposed learning scheme results in efficient energy saving under varying workloads.

Keywords— cellular network, energy harvesting, radio, neural network, switching

I. INTRODUCTION

Energy is very vital for our life and in modern electronics world. The energy consumption is therefore a concern in various research areas. Being a non-renewable source of energy, there is an urgent need to overcome this energy constraint in modern science and technology and human life. The demand for wireless communication services has increased rapidly over the years, resulting in a significant increase in the energy consumption of cellular networks. With the growing trend of green and sustainable communication, energy harvesting (EH) has emerged as a promising technique for powering cellular networks. EH technologies enable the utilization of ambient energy sources, such as solar, wind, and radio frequency (RF) signals, to generate electrical energy that can be used to power energy-constrained devices. Various research activities are attempted for reducing the consumption of energy after the energy crisis in 1970s [1]. So far, the energy crisis is not overcome completely due to continuously consumption of energy worldwide [2]. Therefore, energy consumption needs to be minimized and use of renewable sources of energy must be encouraged. Each country across the globe is now trying to minimum possible energy and relying on the energy from agriculture,

solar energy harvesting as well as from the waste [3]. Likewise, the energy from the fossil deposits and nuclear wastes, there is a great need to keep monitoring the energy from these sections [4].

In this way, we can make a prediction on the amount of energy to be used in advance in various areas and plan accordingly for specialized applications and usage. All these usage of energy and its prediction over years is advantageous for the government and industrialist for raising the economy of the country. The amount of energy usage depends upon many factors like water, sunlight and wind. Therefore, energy consumption is highly complex [5]. In modern science and technology, machine learning approaches are very useful for predicting the amount of the energy used over time. The machine learning approaches act like a mapping function of input to output data with high accuracy.

In modern telecommunication, there is a geometric increase in the number of smartphones and electronic gadgets promoting the mobile data services. The fifth generation technology (5G) is the key to overcome the vast data traffic and demand [1]. Other variations associated with the 5G, such as cloud radio access networks (CRAN), manage the operating expenditures, and inter-cellular noise to overcome the data rates and energy consumption [2]. The 5G cellular mobile communication services boast to provide thousand times higher data rates than existing cellular systems. Therefore, new network architectures and applications, like internet of things are crucial. A popular trend in 5G technology is large scale distributed cells deployment as base station. This trend is coined as network densification. However, this type of trend for getting specified goals based on the modern 5G approach is very tough to achieve due to the increased energy crisis and environmental issues.

All these issues in advanced wireless communication can be overcome by several approaches as done in the past, such as network plan and deployment, switch off and on technology, radio resource and component level optimization, and finally use of renewable sources of energy [6]. Among these mentioned techniques, the one with sleep mode is highly regarded as efficient one for energy saving strategy. In [5], authors proposed

multiobjective optimisation method in large distributed multiple input multiple output (MIMO) systems. Presently, over 90% of the power is consumed by base stations (BSs) of RANs [4]. This is because of the deployment of the BS based on peak traffic loads. Mostly this BS are on active state regardless of the dynamic traffic load variations [7]. Valerdi et al., proposed a method to manage the power consumption of the BS which is part of the renewable energy resource and (solar, wind etc) [8]. The authors in [9] focused on C-RAN by using reinforcement learning and applying switch on-off techniques to save energy. In [10] authors showed the chance of energy saving by algorithm and simulations. In [11] and [12] authors studied how to alter the active state of BS to inactive mode dynamically, based on the expected traffic loads. In this work, we propose algorithm for energy harvesting by using a multiple agent system. In this approach, each agent has its own independent decision. Within this framework, we propose a machine learning approach with distributed multiple agents based algorithm, widely known as Q learning [12].

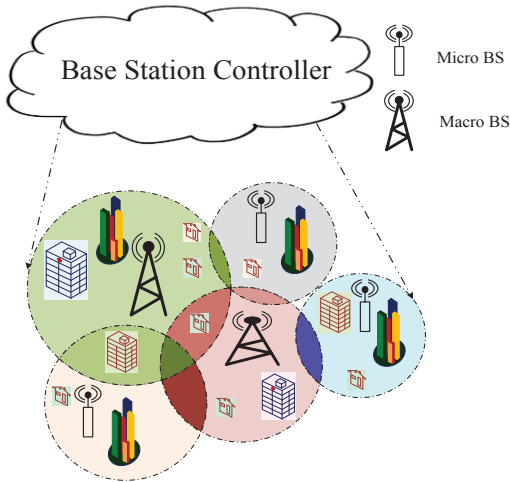


Figure 1: The framework of cellular radio access networks

In this approach, each of the cellular networks (agent) operates by resource management. We propose to maximize the energy efficiency. The framework of cellular networks is shown in Fig. 1. We adopt a cellular radio access network's for energy harvesting approach in this work. This paper presents a novel approach based on Q-learning for energy harvesting in cellular radio access networks (RANs). The proposed method aims to maximize the total harvested energy in the network while ensuring that the network performance meets certain quality of service (QoS) requirements. In this paper, we crack this problem by reinforcement learning (RL) [11-14]. A RL approach has one benefit that is there is no requirement to have a prior knowledge the traffic loads.. We proposed the novel ML based Q-learning method is to save energy. The BS controller first check variations of the traffic load based on the Q-learning. Subsequently, it can select one of the switching actions and then reduces or increase the balances repetition of the same action on the basis of the required cost which aims is to save energy. After several actions and receiving the costs, the controller which act as a agent how to turn on-off the BSs. Additionally, the ML method, the switching scheme is would improve energy efficiency

of networks. The learning operation is further enhanced by Q-learning. In the proposed methodology, ML methods is used as reward function for Q-learning techniques.

The rest of the paper is ordered as follows. System model is present in Section II. In Section III and Section IV, we discuss the energy saving pattern and simulation result respectively. Finally, conclusions are present in Section V.

II. SYSTEM MODEL

In this section, we consider cellular RAN usually comprises of numerous BSs while the traffic loads of these BSs are generally unstable, thus often making BSs under-utilization. The cells are further divided into two types such as macro and small (micro) cells. In such scenario, macro cells base station (BS) is attached to the power grid providing energy to whole cells. The micro cells are also deployed to enhance the system capacity as needed e.g., home, university, school, hospital etc.

A. Power Consumption Model

A BS comprises of many power components like processor, amplifier, transceiver, backhaul link and air conditioner tool. The total power consumption, P_c , can be calculated as follows [16]

$$P_c = B \cdot (BM_x \cdot P_a + P_{tran} + P_p + P_{gen} + P_{link} + P_{ac}) \quad (1)$$

where B represent the number of cell, BM_x is transmitting antennas per cell, and P_a is power if amplifier, P_{tran} is , transceiver power, P_p , P_{gen} , P_{link} and P_{ac} are the power consumptions of the processor, generator, link tools, and air cooler respectively.

We maximize the throughput T of the whole network by assuming the traffic intensity and coverage constraints as [17]

$$\max T = \sum_{i=1}^k T \quad (2)$$

$$\text{s.t. } 0 \leq P_c \leq P_{max}$$

$$\rho_i \leq \rho_{max}$$

$$\bigcup_{i=1}^k G_i = U$$

where ρ_i indicate effective traffic intensity for cell i , G_i denote the area served by cell.

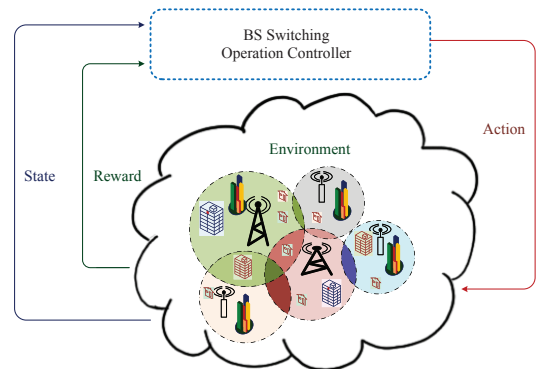


Figure 2: Working Concept of Reinforcement Learning

Hence, we study RL methods to crack energy saving problem without demanding the previous knowledge of traffic loads and precisely apply the q-learning algorithm. As the name denotes, it encompasses four components: action, state, environment, and reward as shown in Fig. 2. These microcells are operated through the energy harvested from the sun, i.e., solar energy monitored by Q learning agents.

We choose a reward function here to achieve the desired solution of the optimization problem. There are various proposed reward functions in the past using cooperative learning, independent learning [8-10, 19-20]. The QoS constraint of the macro cells was considered to optimize the sum capacity of the entire network. The cooperative Q learning has also been verified to optimize the capacity of macro cells without designating a reward function in a dense network. The use of reward function ensures a fair allocation of resources in Q-learning approach at base stations.

III. PROPOSED ENERGY SAVING SCHEME

A. Q-learning on/off switching algorithm

Here, we employ Q-learning approach. We have N distributed users for making decisions in either on or off condition independently.

As described in previous section, we consider cellular radio access networks of N agents (users). All the devices are monitored via a multiple agents system. The goal of this proposed method is to learn with environment by means of a Q-learning approach. In Q-learning system, the value function is saved in a Q-table which is expressed as

$$Q(a^t, b^t) \leftarrow Q(a^t, b^t) + \alpha \left[r(a^t, b^t) + \gamma \max_{a_1^t} Q(a_1^t, b_1^t) - Q(a^t, b^t) \right] \quad (3)$$

where α and γ is the learning rate and the discount factor respectively. $Q(a^t, b^t)$ is the state-action pair; and $Q(a_1^t, b_1^t)$ is state-action pair of next state.

B. Definition of State, Acton, Reward function

State: The state b is expressed as

$$b_i^t = [B_i^t, J_i^t, K_i^t] \quad (4)$$

where B_i^t is renewable energy source during day time and night, J_i^t represent the level of battery, K_i^t is the state of the load for i -th cell in time t .

Action: The actions A contain two actions of on state and off state of the controller. When a controller is turned off, the users connect to the macro BS. Although, the macro BS unable to contribute service, they will be leave and wait for decisions.

Reward function: A reward function is expressed as:

$$r_i^t = \begin{cases} 0 & J_i^t < J_{th} \\ 1/J_i^t & J_i^t \geq J_{th}, \text{ OFF state} \\ \nu T_i^t & J_i^t \geq J_{th}, \text{ ON state} \end{cases} \quad (5)$$

where T_i^t is the normalized throughput of i th cell in slot t , and J_{th} is a threshold value on the battery level. Thus, the controller can be turned off and offload the macro BS. The second line represent that the reward is proportional to the inverse of the energy buffer level when the controller is in *off* state to save energy. The third line represent that the reward is directly proportional to the ν times of throughput when the controller is *on*. After learning, controller will remain on state. In third line, constant ν is used to balance throughput and energy saving.

During the training phase, the users use the energy data to generate the Q-tables offline, these Q-values are used to generate the Q-tables for the micro cell users in online mode. This proposed training algorithm is given in Table 1.

Algorithm 1: Proposed Training Algorithm Framework

Start	
1.	Initialize state-value function
2.	Train $Q(a^t, b^t)$
3.	Calculate current $Q(a^t, b^t)$
4.	Choose action a^t and state b^t
5.	Calculate new state and reward value based on q-learning
6.	Find the traffic loads accordingly and update state $b^t \rightarrow b_1^t$
7.	Update the state-value function (3);
8.	Stop

The given algorithm describes a Q-learning approach for achieving energy savings in cellular radio access networks (RAN) by turning on-off some base stations (BSs) based on traffic load variations. The algorithm is as follows: First step involves initializing the state-value function, which represents the expected reward for each state and action. In second step, the Q-function is trained for the given state-action pair (a^t, b^t) . The Q-function estimates the expected reward for each action in a given state. In third step the current Q-value for the chosen state-action pair is calculated. Next we choose action a^t and state b^t based on the current state of the network and the Q-function. In the fifth step the network moves to a new state based on the chosen action a^t , and the reward value for the new state is calculated using the Q-function. In next step the traffic loads are determined based on the new state and the state is updated accordingly. In seventh step the state-value function is updated based on the observed reward for the chosen action in the current state. Finally the algorithm stops when a stopping criterion is met, such as reaching a maximum number of iterations or a desired level of energy savings.

IV. SIMULATION RESULTS

The cellular RAN network of N distributed agents and we confirm the energy saving by proposed q- learning scheme under practical configurations. We assume the power consumption of the components of a BS are P_a is 10.4 W, P_{tran} is 30 dBm, P_p is 100 W, P_{link} is 80 W P_{gen} is 384 W, P_{ac} 690 W. We consider the propagation channel of this network by modified Hata model [18]. The goal of the proposed algorithm is for each agent to learn, through the environment, an energy saving scheme via Q-learning technique. Precisely, the energy consumption is defined when few BSs are switched off since our simulation starts. This explanation is reasonable because it show the energy efficiency enhancement, which is our goal of an energy harvesting.

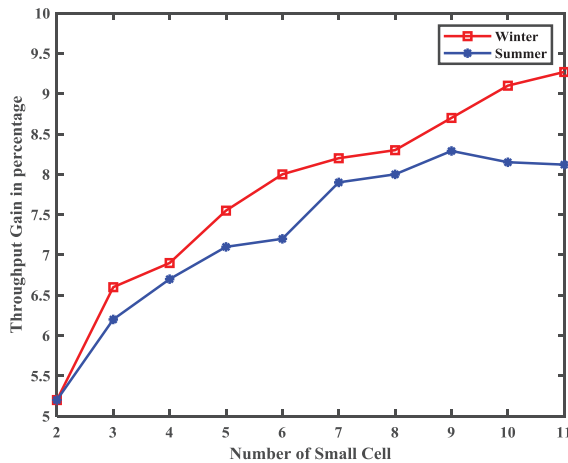


Figure 3. Throughput gain [%] of QL with number of small cell

Fig. 3 shows the average throughput gain of Q-learning as a function of number of small cells. The system throughput gain by Q- learning is upto 9.5% (during the winter). Furthermore, it rises with the number of the small cells as more users get more traffic.

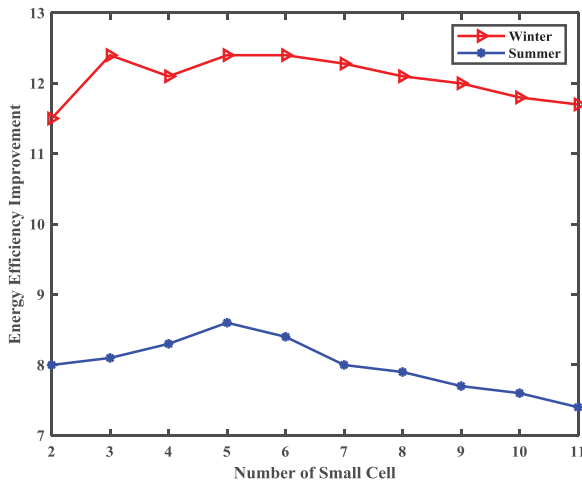


Figure 4. Energy efficiency improvement by QL method

Fig.4 represents the energy efficiency improvement of Q-learning algorithm with the number of small cell. QL significantly gain, up to 14% in the winter months. In the summer, the algorithm is not showing saved energy, since the harvested energy is sufficient for the entire day. Therefore, Q-learning has nearly similar performance.

V. CONCLUSION

We employed Q learning approach to formulate the proposed algorithm for managing the energy harvesting for cellular radio networks. We proposed the algorithm and reduced power consumption at the base station applying switching operations under varying traffic loads . Our simulated results show the encouraging and viable approach. The proposed algorithm considers the design goals at maximum and enhances the energy efficiency appreciably. However, there are certain aspects that need to be further highlighted, such as the impact of cellular network on the decisions made for careful synchronization of the common goals. Further exploration of various functions is needed to achieve the gains in performance objectives for a large number of smaller cells by using the energy efficiency into the learning.

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Time-Frequency Image-based Speech Emotion Recognition using Artificial Neural Network

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Abstract. Automatic Speech Emotion Recognition (ASER) is a state-of-the-art application in artificial intelligence. Speech recognition intelligence is employed in various applications such as digital assistance, security, and other human-machine interactive products. In the present work, three open-source acoustic datasets, namely SAVEE, RAVDESS, and EmoDB, have been utilized (Haq et al., 2008, Livingstone et al., 2005, Burkhardt et al., 2005). From these datasets, six emotions namely anger, disgust, fear, happy, neutral, and sad, are selected for automatic speech emotion recognition. Various types of algorithms are already reported for extracting emotional content from acoustic signals. This work proposes a time-frequency (t-f) image-based multiclass speech emotion classification model for the six emotions mentioned above. The proposed model extracts 472 grayscale image features from the t-f images of speech signals. The t-f image is a visual representation of the time component and frequency component at that time in the two-dimensional space, and differing colors show its amplitude. An artificial neural network-based multiclass machine learning approach is used to classify selected emotions. The experimental results show that the above-mentioned emotions' average classification accuracy (CA) of 88.6%, 85.5%, and 93.56% is achieved using SAVEE, RAVDESS, and EmoDB datasets, respectively. Also, an average CA of 83.44% has been achieved for the combination of all three datasets. The maximum reported average classification accuracy (CA) using spectrogram for SAVEE, RAVDESS, and EmoDB dataset is 87.8%, 79.5 %, and 83.4%, respectively (Wani et al., 2020, Mustaqeem and Kwon, 2019, Badshah et al., 2017). The proposed t-f image-based classification model shows improvement in average CA by 0.91%, 7.54%, and 12.18 % for SAVEE, RAVDESS, and EmoDB datasets, respectively. This study can be helpful in human-computer interface applications to detect emotions precisely from acoustic signals.

Keywords: Time-Frequency Image; Neural Network; Automatic Speech Emotion Recognition; Acoustic Signal; Grayscale Image Feature

Introduction

Emotions are an individual's feelings about a situation. It is the body's physical and emotional response to a person's thoughts and feelings. People express emotions in identical situations differently. People's expressions on their faces and their voices usually reflect their feelings. For effective communication, emotion is essential. Different emotions can be expressed as happiness, sadness, anger, anxiety, cheerfulness, excitement, lonely, helplessness, annoyance, etc. Additionally, it can be categorized as positive and negative emotions. The primary emotions are classified into six categories: happy, sad, anger, fear, disgust, and surprise (Ekman et al., 2013). Human uses many types of gestures, including speech, as a means of communication. Speech is the most common, easiest, and natural form of communication. Communication can be done in other ways as well, but it lacks emotions such as text messages, without proper emotions, can induce misunderstanding. So, emojis were introduced, which replicated the emotions. Using emojis in text messages conveys our emotions. When people speak, their emotions are reflected in their voices, facilitating better

communication. One of the unique physiological processes is speech generation. Therefore, the inherent emotional state in the speech can also help to detect the mental and physical health of human (Akçay and Oğuz, 2020).

Automatic Speech Emotion Recognition (ASER) is the process of recognizing emotions in speech. ASER uses speech analysis and machine learning to create an automated system that can detect the emotions of human beings from their voice for various purposes. Acoustic feature extraction plays a prominent role in the ASER system to analyze a speaker's voice and determine the speaker's emotional state. A variety of methods are used to classify emotions from the acoustic signal, such as Prosodic features, Mel-frequency cepstral coefficients, Pitch Frequencies, vocalization duration, and spectrogram. ASER-based systems can be applied to make supportive tools for some areas such as healthcare, digital assistant-based customer service, marketing and other human-machine interactive services.

The main challenge in ASER is extracting hidden features embedded in the acoustic signal. For this, various methods are applied to extract features. Prosodic features, voice quality features, spectral features, and Teager energy features are the different types of speech features (Akçay and Oğuz, 2020). Time domain, as well as frequency domain feature extraction techniques for acoustic signals, were reported by many researchers. Some researcher uses spectrogram of the acoustic signal. The present method extracts emotional features from time-frequency images (spectrogram). The t-f image is a visual representation of the time component and frequency component at that time in the two-dimensional space, and differing colors show its amplitude.

Literature Review

Some recent studies using spectrogram-based emotion recognition with various datasets and classifiers are reported briefly below.

Wang (2014) extracted texture image information from a spectrogram of the speech signals to sense emotions embedded in speech. Two open-source emotional datasets have been used in their work, namely EmoDB and eNTERFACE, along with their self-recorded dataset (KHUSC-EmoDB) for the cross-corpus method. Firstly, the speech signals of the dataset mentioned above are converted into a spectrogram; after that, it is transformed into a normalized grayscale image, and then a cubic curve is used to enhance the image contrast. The features were extracted by Laws' Masks, based on the principle of texture energy measurement and SVM is used as a classifier. Their experimental results show that the correct classification rates range from 65.20% to 77.42%.

Badshah et al. (2017) proposed a model for SER using a spectrogram with the deep convolutional neural network. The EmoDB dataset has been utilized in their work, and the acoustic signals have been converted to spectrogram images. They used three convolutional layers and three fully connected layers to extract suitable features from spectrogram images. The Softmax layer performs the final classification for seven emotions embedded in acoustic signals of the EmoDB dataset. They achieved an overall classification accuracy of 83.4% for all seven emotions.

Özseven (2018) investigated the effects of texture analysis methods and spectrogram images on speech emotion recognition. In their work, four different texture analysis methods were used to obtain features from the spectrogram images of the speech signals. Also, acoustic features were studied to compare texture analysis methods with acoustic analysis methods. They achieved 82.4%, 60.9%, and 64.6% success rates for texture analysis method and 82.8%, 56.3%, and 74.3% success rates for acoustic analysis methods for EMO-DB (Berlin Database of Emotional Speech), eNTERFACE'05 and SAVEE (Surrey Audio-Visual Expressed Emotion) databases, respectively

using SVM classifier. When comparing SER performance based on approach, the acoustic analysis outperforms the texture analysis by 0.4% for EMO-DB and 9.7% for SAVEE and underperforms by 4.6% for eNTERFACE'05.

Hajarolasvadi and Demirel (2019) extracted 88-dimensional vectors from acoustic signals of SAVEE, RML, and eNTERFACE'05 databases. They also obtained each signal's spectrogram and then applied k-means clustering to all the extracted features to get keyframes. Then, the corresponding spectrogram of keyframes is encapsulated in a 3-D tensor form, which works as an input of 3-D CNN. The 3-D CNN consists of 2 convolutional layers and a fully connected layer for classifying six emotions, anger, disgust, fear, happy, sad, and surprise, in the dataset mentioned. They achieved 81.05%, 77% & and 72.55% overall classification accuracy using SAVEE, RML(Ryerson Multimedia Laboratory), and eNTERFACE'05 datasets, respectively.

Mohammed and Hasan (2020) have been used MELBP variants of spectrogram images to recognize emotion from the acoustic signal. They converted the emotional acoustic signals into 2D spectrogram images, and then four forms of Extended Local Binary Pattern (ELBP) were generated to extract the emotional features from spectrogram images. ELBP provides information about direction and variation in amplitude intensities for the given emotions; as a result, more effective feature vectors were captured. In this paper, a Multi-Block of ELBP (MELBP) using the histogram is proposed to highlight the important features of the spectrogram image. Here, Deep Belief Network (DBN) is used to classify the emotions from extracted features. For the well know SAVEE dataset, they achieved 72.14% accuracy.

Sönmez and Varol (2020) developed a lightweight, effective speech emotion recognition method called multi-level local binary pattern and local ternary pattern abbreviated as 1BTPDN. This method first applied a one-dimensional local binary pattern (1D-LBP) and a one-dimensional local ternary pattern (1D-LTP) on the raw speech signal. Then 1D discrete wavelet transform (DWT) with nine levels was utilized to extract the features. Out of 7680 features, 1024 features are selected using neighbourhood component analysis (NCA). Using a third-degree polynomial kernel-based support vector machine as a classifier, they obtained success rates of 89.16%, 76.67%, and 74.31% for EMO-DB, SAVEE, and EMOVO (an Italian emotional speech database) databases, respectively.

Padi et al. (2021) proposed transfer learning and spectrogram augmentation based automatic SER model. In this work, they used spectrogram images as input for ResNet layer. Statistics Pooling layer, fully connected layers, and softmax layer were other consecutive layers of proposed model. Three experimental setups were prepared for evaluation of this model. Each experimental setup contained data of four emotions only. The emotions namely angry, happy, neutral, sad, and excited were selected from the IEMOCAP (Interactive emotional dyadic motion capture) database. High classification accuracy of 71.92 % was achieved using this model.

Yalamanchi et al. (2022) proposed architecture that utilizes CapsuleNets with Time distributed 2D-convolution layers to accurately predict emotions from speech samples. This paper highlights the importance of time distributed layers in handling time series data and capturing crucial cues for emotion recognition. The proposed model is trained and evaluated on two datasets, RAVDESS and IEMOCAP for Speech Emotion Recognition (SER) and achieved an accuracy of 92.6% on the RAVDESS dataset and 93.2% on the IEMOCAP dataset. The CapsuleNets architecture with Time distributed 2D-convolution layers outperformed the architecture without Time distributed layers. Class-wise accuracies were used to evaluate the model's performance in predicting each emotion class. Precision, recall, and F1 score were also calculated to assess the model's performance. The results showed that the proposed architecture effectively classified emotions.

Zhang et al. (2023) proposed speech emotion recognition (SER) model based on dual global context attention and time-frequency features achieves competitive performance on three public datasets: IEMOCAP, RAVDESS, and EMO-DB. The model demonstrates recognition accuracies of 70.08%, 86.67%, and 93.27% on these datasets, respectively. The utilization of time-frequency features in the model leads to improved performance compared to using either time-domain or frequency-domain features alone. Their proposed model outperforms most of the baseline methods on the RAVDESS and EMO-DB datasets, achieving accuracies of 86.67% and 93.27%, respectively. Additionally, their proposed model achieves high recognition accuracy on the EMO-DB dataset, with an accuracy of 93.27%. The results show the effectiveness of the model in addressing the misuse of features and improving recognition accuracy in speech emotion recognition tasks.

Contributions of the present paper

1. We have implemented and evaluated t-f image-based multiclass emotional state classification model using the BPANN classifier.
2. We have also validated the proposed SER model's performance using various datasets for the emotions namely anger, disgust, fear, happy, neutral, and sad only.

The rest of the paper is arranged in the following section: The material and Methods section includes a brief discussion about datasets, time-frequency images, feature extraction, BPANN classifier, and multiclass ASER model. The next section is results and discussions, followed by the conclusion.

Materials and methods

Dataset

For this study, we have selected three benchmarked database of different native speakers and different languages, which includes male and female speakers. The datasets used in this paper are discussed briefly below:

SAVEE :

Surrey Audio-Visual Expressed Emotion (SAVEE) is a well-known dataset of emotional speech. It contains an audio-visual signal with seven emotions, anger, disgust, fear, happiness, neutral, sadness, and surprise, a total of 480 speech signals in .wav format of four male actors. Each subject's audio-visual signal was recorded for seven emotions, 30 utterances for neutral emotions, and 15 sentences for each remaining emotion. The speech signals were recorded in a visual media lab with 16-bit encoding and a 44.1 kHz sampling rate. All subjects were British English speakers (Haq et al., 2008).

RAVDESS:

Ryerson Audio-Visual Database of Emotional Speech and Song (RAVDESS) is an open-source dataset that contains speech and song, audio, and video signals of 24 actors (12 male, 12 female). All actors were native North Americans, and their speech signals contained anger, disgust, fear, calm, happiness, neutral, sad, and surprise emotions. The speech signals were recorded in a studio with 16-bit encoding and a 48 kHz sampling rate. RAVDESS dataset contains 60 sentences per actor, i.e., $60 \times 24 = 1440$, and all files are in .wav format (Livingstone et al., 2005).

EmoDB:

The EmoDB dataset (Berlin Database of Emotional Speech) is created by the Institute of Communication Science, Technical University, Berlin, Germany, which can be openly accessed on

their website. This dataset contains speech signals from 10 speakers (5 male, 5 female) on seven emotions: anger, fear, boredom, disgust, happy, sad, and neutral. A total of 535 utterances were recorded with a 48 kHz sampling rate (Burkhardt et al., 2005).

In the present work, only six common emotions in the above dataset have been selected, and speech signals of emotions, namely anger, disgust, fear, happy, neutral, and sad are used. The number of utterances for each emotion is listed in Table 1. A total of 1870 utterances, i.e., 360, 1056 and 454, are utilized from SAVEE, RAVDESS and EmoDB datasets, respectively.

Table 1 — Emotion and number of utterances selected from the various dataset

S. No.	Dataset → Emotion ↓	SAVEE	RAVDESS	EmoDB
1.	Anger	60	96	127
2.	Disgust	60	192	46
3.	Fear	60	192	69
4.	Happy	60	192	71
5.	Neutral	60	192	79
6.	Sad	60	192	62
	Total =	360	1056	454

Time-Frequency Image

The time-frequency image is a visual representation of the time component and frequency component at that time in the two-dimensional space, and differing colors show its amplitude. Dark blue shows low amplitude, and bright colors yellow to red show high amplitude (Fig.1). It is also known as a spectrogram, and when used in acoustic signals, it is called voicegram or voiceprints. The speech signal represents a 1-D signal and provides information such as speech rate, amplitude, and space between each sample, giving information about emotions. Similarly, the t-f image represents a 2-D image with color-coded amplitudes, which gives information about emotions embedded in them. The t-f image is usually obtained by applying Fast Fourier Transform (FFT) on the acoustic signal. It begins with the decomposition of the acoustic signals into small time frames. Each frame is converted to the frequency domain from the time domain by applying windowed Short-Time Fourier Transform (STFT), as shown in (eq.1). Here, hamming window with 50% overlapping is used.

$$X(k,t) = \sum_{n=0}^{N-1} x(n)w(n-t) e^{\frac{-2\pi jkn}{N}} \quad k=0,1,2,\dots,N-1 \quad (1)$$

Where X(k,t) is the time-frequency representation of acoustic signal x(n), x(n) is preprocessed Acoustic signal, w(n) represents the Hamming window function, N represents the length of the window function, k represents the corresponding frequency, $f(k) = kfs/N$, where fs is the sampling frequency

The following equation (eq.2) generates the coefficients of a Hamming window:

$$w(n)=0.54-0.46\cos(2\pi nN), \quad 0 \leq n \leq N \quad (2)$$

The time-frequency image is a very reliable form to extract features for ASER. It holds rich information which can't be extracted in the time domain or frequency domain alone (Mustaqeem and Kwon, 2019). Due to this reason, time-frequency image has been used to improve the study in various fields. In many applications, the time-frequency image has been used to classify sound events, speech recognition, speech emotion recognition, and speaker recognition (Mao et al., 2014,

Yu et al., 2013, Dennis et al., 2010, Lee et al., 2009). In this paper, MATLAB © R2021a has been used to replicate acoustic signal into a t-f image. (Fig.1) shows the acoustic signal and their t-f image for six emotions.

Feature Extraction from Grayscale Image

Once the t-f image is obtained for every acoustic signal, it is converted into a 400x400 grayscale image. The grayscale image is represented by gray colors with binary values between 0-255. 0 shows the black color, and 255 shows the white color. Using various statistical methods, 472 features are extracted such as First Order Statistics (FOS), Haralick Spatial Gray Level Dependence Matrices (SGLDM), Gray Level Difference Statistics (GLDS), Neighborhood Gray Tone Difference Matrix (NGTDM), Statistical Feature Matrix (SFM), Spectral Texture of Images (STI), Gray Level Run Length Matrix (GLRLM), etc. (see Table 2). Next, these features were given to the back propagation artificial neural network (BPANN) classifier to train and test emotions embedded in acoustic signals (Singh et al., 2015).

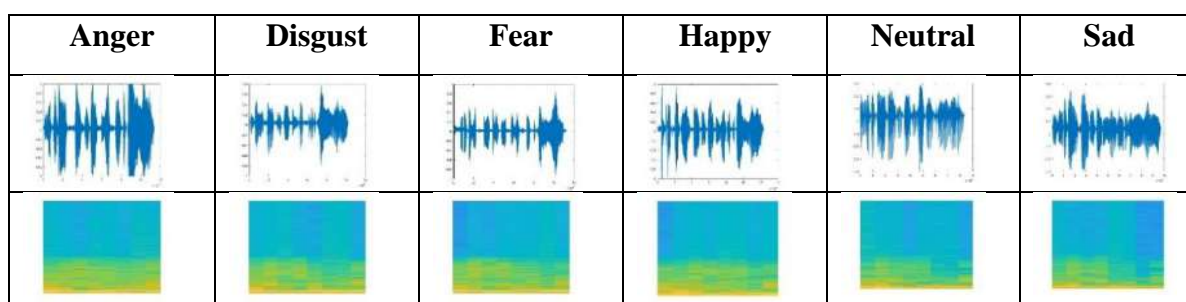


Fig.1— Acoustic signal and t-f image of 6 emotions

BPANN

The neural network is one of the most broadly used classifiers. In neural networks, there are two algorithms: feedforward and backpropagation. In the present work, backpropagation artificial neural network (BPANN) is utilized to classify emotions. This type of neural network needs supervised learning; it contains one input layer, one output layer, and some hidden layer. The goal of backpropagation is to minimize the error between the predicted output of the neural network and the actual target output. This is achieved by adjusting the weights of the network through a process of iterative optimization. This process is repeated for multiple iterations (epochs) until the network converges to a set of weights and biases that minimize the error on the training data (Goh, 1995).

The main terminology and annotations that explain the BPANN method is denoted by following terms:

- L : The total number of layers in the neural network (including the input and output layers).
- $W^{(l)}$: The matrix of weights connecting layer l to layer $l + 1$. The superscript (l) indicates the layer index.
- $b^{(l)}$: The vector of biases for layer $l + 1$.
- $a^{(l)}$: The vector of activations in layer l after applying the activation function.

- $z^{(l)}$: The vector of inputs to the activation function in layer l .
- $\delta^{(l)}$: The error term for layer l .

The backpropagation algorithm consists of two main steps: the forward pass and the backward pass.

1. Forward Pass:

Compute the activations $a^{(l)}$ for each layer using the weighted sum of inputs and the activation function.

$$z^{(l+1)} = W^{(l)}a^{(l)} + b^{(l)} \quad (3)$$

$$a^{(l+1)} = f(z^{(l+1)}) \quad (4)$$

This process will be repeated for each layer until we reach the output layer.

2. Backward Pass:

Compute the error term $\delta^{(L)}$ for the output layer:

$$\delta^{(L)} = \nabla_a J \odot f'(z^{(L)}) \quad (5)$$

where J is the cost function, $\nabla_a J$ is the gradient of the cost function with respect to the activations, \odot denotes element-wise multiplication, and $f'(\cdot)$ is the derivative of the activation function.

Propagate the error backward through the layers to compute the error terms for each layer:

$$\delta^{(l)} = ((W^{(l)})^T \delta^{(l+1)}) \odot f'(z^{(l)}) \quad (6)$$

Compute the gradients of the cost function with respect to the weights and biases:

$$\frac{\partial J}{\partial W^{(l)}} = \delta^{(l+1)} (a^{(l)})^T \quad (7)$$

$$\frac{\partial J}{\partial b^{(l)}} = \delta^{(l+1)} \quad (8)$$

Update the weights and biases using a gradient descent optimization algorithm:

$$W^{(l)} = W^{(l)} - \alpha \frac{\partial J}{\partial W^{(l)}} \quad (9)$$

$$b^{(l)} = b^{(l)} - \alpha \frac{\partial J}{\partial b^{(l)}} \quad (10)$$

where α is the learning rate.

Table 2 — List of grayscale image features(Singh et al., 2015)

Feature Category	Feature Name	No. of Features
Statistical Features	Mean, Variance, median, mode, skewness	5
Haralick textural features	Mean and range values are calculated for features, namely angular second moment, contrast, correlation, a sum of squares, homogeneity, sum average, sum variance, sum entropy, entropy, difference variance, difference entropy, information measures of correlation-1, information measures of correlation-2	26
Gray level difference statistics (GLDS)	Homogeneity, contrast, energy, entropy	4
Neighbourhood gray-tone difference matrix (NGTDM)	Coarseness, contrast, busyness, complexity, strength	5
Statistical feature matrix (SFM)	Coarseness, contrast, periodicity, roughness	4
Texture energy measures (TEM)	LL, EE, SS, LE, ES, and LS kernel-based TEM features	6
Fractal dimension texture analysis (FDTA)	FDTA-H1, FDTA-H2, FDTA-H3, FDTA-H4	4
Shape	Area, perimeter, perimeter square per unit area	3
Spectral texture of images (STI)	199 features of spectral energy distribution as a function of radius, 180 features of spectral energy distribution as a function of angle	379
Invariant moments of image (IMI)	MI1-IMI7	7
Statistical measures of texture (SMT)	Average gray level, average contrast, measure of smoothness, third moment, uniformity, entropy	6
Gray-level run length matrix-based properties (GLRLP)	SRE, LRE, GLN, RLN, RP, LGRE, HGRE, SRLGE, SRHGE, LRLGE, LRHGE	11
Texture feature using Segmentation based fractal texture analysis (SFTA) algorithm	SFTA1-SFTA12	12
Total		472

Experimental analysis of the multiclass SER model

In the present work, three benchmark datasets of the emotional speech signal, namely SAVEE, RAVDESS, and EmoDB, have been utilized to recognize six emotions, i.e., anger, fear, disgust, happy, neutral, and sad. The speech signals of each dataset are firstly preprocessed to remove noise and unwanted signals. It is a necessary part before feature extraction. Here, the preprocessing method abides by two stages. The first stage is noise removal using a bandpass filter with a 20 Hz to 20 kHz frequency range. In the second stage, the silence part of the speech signal has been

removed to decrease the frame length and unwanted signals. After that, speech signals are transformed into 2-D time-frequency images using the FFT method. The t-f image is then converted into a 400x400 grayscale image using MATLAB ©R2021a software. The t-f image-based multiclass SER model is shown in (Fig.2). 472 features have been extracted from these grayscale images. Using these features as input and ground truth the BPANN classifier is trained. The trained network contains the learning parameters that will help the BPANN to take decision during testing. The testing part is almost similar to the training part. Here only relevant features are extracted from the unknown preprocessed speech signals. The trained BPANN classifier takes the decision on the signals based on the learning during the training process. Here, we studied and evaluated the performance of the multiclass SER model using each dataset separately and with the mixed dataset. Each dataset is divided using a 5-fold data division protocol. This method divides the whole data into 5 equal parts, 4 used for training purposes, and 1 for testing. It repeats itself process 5 times with different validation data (Browne 2000).

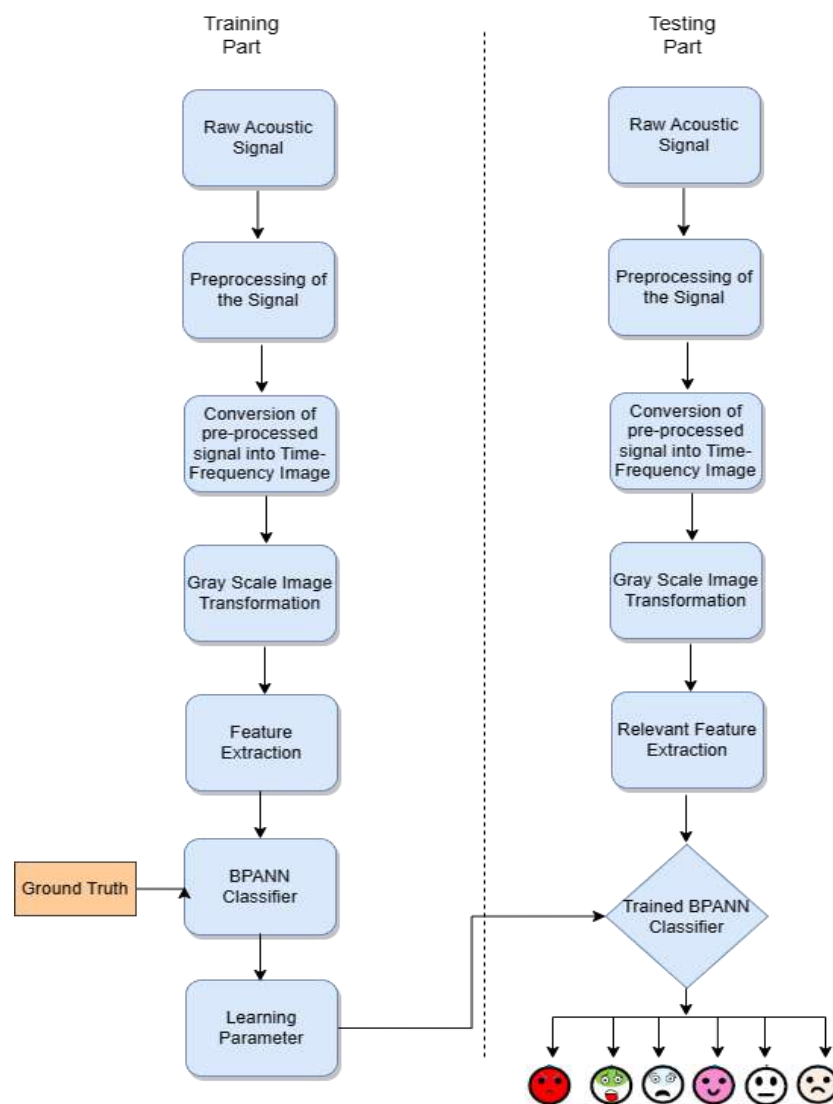


Fig.2 — A t-f image-based Speech Emotion Recognition (SER) model

Result and discussion

In the present work, we proposed the t-f image-based SER model for classifying six common emotions (i.e., anger, disgust, fear, happy, neutral, and sad) from SAVEE, RAVDESS, and EmoDB

datasets. The average accuracies of the classifier using grayscale features with 5-fold BPANN are shown in (Fig.3). We got the highest average classification accuracy (CA) of 93.56 % for the EmoDB dataset, followed by the SAVEE dataset with 88.60% and for RAVDESS dataset it is 85.5%. Also, the average CA of 83.44% is obtained for the mixed dataset.

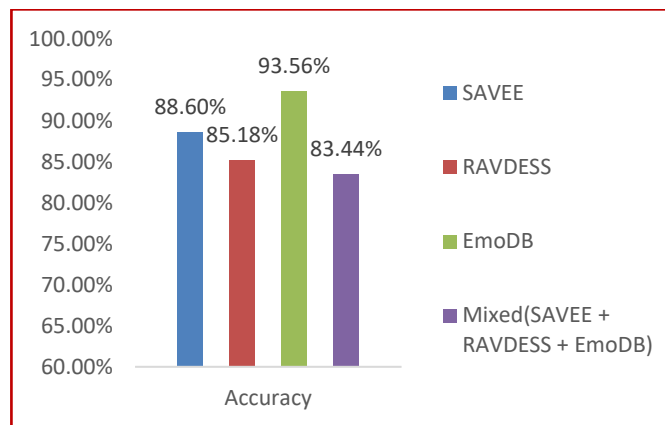


Fig.3 — Classification accuracy of BPANN-based SER model for various datasets

The true positive rate (TPR) and false positive rate (FPR) of six emotions of all three datasets used in the present work are shown in Table 3. The TPR represents the correct positive results during the test among all positive samples. While the FPR gives the amount of incorrectly positive results out of all the negative samples during the test, the FPR tells you how frequently those results occur. TPR should be high, and FPR should be low. Here, the highest TPR of 100% is obtained for the sad

Table 3 — TPR & FPR for six emotions of SAVEE, RAVDESS, EmoDB

Dataset	Emotion	TPR (%)	FPR (%)
SAVEE	Anger	90.00	3.00
	Disgust	85.00	4.00
	Fear	88.33	1.67
	Happy	88.33	2.00
	Neutral	91.67	1.67
	Sad	88.33	1.39
RAVDESS	Anger	87.13	3.72
	Disgust	86.11	3.02
	Fear	84.24	3.13
	Happy	82.65	3.12
	Neutral	85.26	1.88
	Sad	87.37	3.00
EmoDB	Anger	95.20	2.18
	Disgust	93.33	1.50
	Fear	85.71	1.87
	Happy	88.57	1.60
	Neutral	94.67	0.81
	Sad	100.00	0.53

emotion of the EmoDB dataset. For the RAVDESS dataset, sad emotion also shows the highest TPR of 87.37%, while for the SAVEE dataset, a TPR of 91.67% is the highest for neutral emotion. The lowest FPR is obtained for the sad emotion of the EmoDB dataset, which is 0.53%. For other

datasets, the lowest FPR is 1.39% for the sad emotion of SAVEE and 1.88% for the neutral emotion of RAVDESS. In overall analysis, the EmoDB dataset gives the highest CA and TPR, and lowest FPR from all three datasets utilized in this work.

Table 4 — Performance comparison with other research works

Author Name & Year	Dataset	Feature & Classifier	Accuracy
Wang, 2014	EMO-DB	Texture image information (TII) from	65.20% to
	eNTERFACE05	Spectrogram with SVM classifier	77.42%.
Zheng et al., 2015	IMOCAP	Deep Convolutional Neutral Network using the spectrogram segment as input	40%
Fayek et al., 2015	eNTERFACE'05	Deep Neutral Network, Spectrogram as input	60.53
Badshah et al., 2017	SAVEE		59.7
	EmoDB	Convolutional Neutral Network, Spectrogram as input	83.4%
Sönmez and Varol, 2017	EMO-DB	global optimum features with Third-degree polynomial kernel-based SVM classifier	89.16%,
	SAVEE		76.67%,
	EMOVO		74.31%
Özseven, 2018	EmoDB	Spectrogram-based features with SVM classifier	82.8%,
	SAVEE		74.3%
	eNTERFACE'05		60.9%
Hajarolasvadi and Demirel, 2019	SAVEE	3D CNN with tensors as an input consists of Mel Frequency Cepstral Coefficients (MFCC), pitch, intensity, and spectrogram	81.05%
	RML		77%
	eNTERFACE'05		72.55%
Mustaqeen and Kwon, 2019	RAVDESS	deep stride convolutional neural network (DSCNN) with a spectrogram as input	79.5%
Mohammad and Hasan, 2020	SAVEE	Spectrogram features with ELBP and Deep Belief Network(DBN)	72.14%
Wani et al., 2020	SAVEE	Deep Stride Convolutional Neural Networks (DSCNN), spectrogram as input	87.8%
Shuzhen Li et al., 2021	IEMOCAP	Spatiotemporal and Frequential	80.47%
	EMO-DB	Cascaded Attention Network consist of CNN	83.30%
	eNTERFACE05		75.80%
	SAVEE		56.50%
Proposed Method	SAVEE	Gray scale image features of spectrogram with BPANN classifier	88.60%
	RAVDESS		85.50%
	EmoDB		93.56%
	SAVEE+		83.44%
	RAVDESS+		
	EmoDB		

Table 4 shows the performance comparison of different works done on spectrogram features for speech emotion recognition. In this table, many researchers worked on different datasets of emotional signals viz. EmoDB, eNTERFACE, IMOCAP, SAVEE, EMOVO and RAVDESS. Here, only three datasets are participating in the comparison i.e., SAVEE, RAVDESS and EmoDB.

Using Deep Stride Convolutional Neural Network (DSCNN) Wani's work show the highest average classification accuracy (CA) for the SAVEE dataset with 87.8% (Wani et al., 2020). The highest average classification accuracy (CA) of 79.5% for the RAVDESS dataset using Deep Stride Convolutional Neural Network (DSCNN) is reported by Mustaqeem and Kwon (2019). The highest average classification accuracy (CA) for the EmoDB dataset is 83.4%, reported by Badshah (Badshah et al., 2017). using a convolutional neural network. The proposed t-f image-based model with Back Propagation Artificial Neural Network(BPANN) shows better results with average classification accuracy (CA) of 88.6%, 85.5%, and 93.56% for SAVEE, RAVDESS, and EmoDB datasets, respectively. This shows improvement in maximum reported average CA by 0.91%, 7.54%, and 12.18 % for SAVEE, RAVDESS, and EmoDB datasets, respectively.

Conclusion

This study's proposed model is based on time-frequency images of acoustic signals to recognize emotions. This model shows improvement by 0.91%, 7.54%, and 12.18 % for SAVEE, RAVDESS, and EmoDB datasets, respectively, as compared to the maximum reported accuracies for the same datasets. The proposed model is also validated with various dataset and combination of the datasets. The proposed method is efficiently works on the combination of datasets as well and shows the classification accuracy of 83.44%. These out performances are also the evidence of efficiency of the proposed model.

Future Scopes and Challenges

The time-frequency image-based study is the most prominent in the area of ASER. Much research has already been done in the ASER application area for human-computer interfaces. Still, it needs more improvement for much more perfection and accuracy and a less complex structure so it can be used widely at a low cost. The emotion recognition model validation and test with emotion database of Indian context is also new path for further research.

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Abstract:

In the modern communication world, capacity of future mobile networks will continuously rise for enhanced data traffic and high reliability. The current evolution trends in 5G networks and beyond impose drastic increase in energy consumption and therefore, a high level of carbon footprint by industry network infrastructures. Modern 5G wireless communication can be a potential driver for machine learning (ML) and artificial intelligence architecture at network edge. Herein, we investigate the performance and evaluation analysis of cellular radio access networks (RAN) simulated and based Q-learning approach by turning on-off some base stations (BSs) to achieve enhanced energy savings in a cellular RAN. In this work, we study the BS switching actions, considering traffic load variations. We formulate the network models as action state, environment and reward. It was shown that the proposed learning scheme results in efficient energy saving under varying workloads.

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Sziklai Pair based Small Signal Amplifier with BJT-MOSFET Hybrid Unit at 180nm Technology

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Sziklai Pair based Small Signal Amplifier with BJT-MOSFET Hybrid Unit at 180nm Technology

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ABSTRACT

Two circuit models of Small Signal amplifier, constituted with BJT-MOSFET hybrid unit under Sziklai pair topology are designed and analyzed using ‘PSpice’ and ‘Cadence Virtuoso and Spectre simulation tool (at GPDK 180nm technology)’ respectively. First amplifier (Circuit-1) uses PSpice user-defined model of BJT and MOSFET whereas the second amplifier (Circuit-2) consists of transistors available at GPDK 180nm technology. Circuit-1 can amplify the AC signals of 1mV-1nV range with optimum voltage gain 389.532, 137.570 current gain, 14.464MHz bandwidth and 2.43% THD. However, Circuit-2 can amplify AC signals of 0.1mV-10nV range with 164.018 voltage gain, 32.775 current gain, 11.906 MHz bandwidth, and 13.608E-6% THD. Both the proposed amplifier circuits remove narrow band problem and generate better results than earlier announced small signal Sziklai pair amplifier with BJT-MOSFET hybrid unit in respect of voltage and current gains, bandwidth, THD, and power consumption. Proposed amplifiers successfully address the problem of poor frequency response of small signal Darlington pair amplifier in higher frequency range and narrow bandwidth limitations of small-signal PNP Sziklai pair amplifier. Dependency of the proposed amplifiers at various biasing resistances and performance with temperature variation, noise variation, DC supply variation, and phase variation are also discussed herein. Proposed Circuits display strong dependency over ideal maximum forward beta ‘ β ’ of NPN transistor, Transconductance ‘ V_{TO} ’ of P-MOS transistor and additional biasing resistances ‘ R_A ’. Layout of Circuit-2 is found to cover 96.3898 μm^2 area with 11.32 μm length and 8.515 μm breadth. Minor percentage variation between pre-layout and post-layout simulation results of Circuit-2 validates the proposed design at GPDK 180nm technology. Monte Carlo and Process Corner analysis are also performed to test the robustness and insensitivity of Circuit-2 against mean value of the parameters and process and mismatch variations respectively. Performance summary of the proposed circuits and comparison with the recently reported designs shows effectiveness of the proposed circuits in terms of power gain, THD, voltage gain, current gain, input referred noise and power gain. Qualitative analysis of the proposed Circuits recommends its usability as Low Noise Amplifier in the portable RF noise measurement system.

Key Words: Sziklai pair, Small signal amplifier, compound pair

INTRODUCTION

For a variety of electronics and communication system applications, the preferred device configurations are the Darlington and Sziklai Pairs [1]-[4]. Due to the identical ranges for input impedance, output impedance, voltage gain, and current gain factor ‘ β ’, Darlington and Sziklai pairs are regarded as complementary to one another in many applications [4]-[5]. But now-a-

days, Sziklai pair gradually replacing the Darlington pair in small-signal amplifiers, power amplifiers and digital circuits because of its half base turn-ON voltage, low power dissipation, and better switching speed than Darlington pair [5].

In order to combine the required qualities of JFETs and BJTs, Aina *et al.* (1993) first ever used a JFET-BJT hybrid unit based small-signal amplifier under Darlington pair topology [6]. They concurrently obtained high input impedance and high current gain. These coordinated efforts have resulted in the usage of a number of devices in hybrid combinations under Darlington pair and Sziklai pair topology by many researchers [6]-[13]. The BJT and MOSFET hybrid unit based Sziklai pair amplifier had been reported by Shukla *et al.* in 2015 which crops high voltage gain, moderate current gain with low THD [7].

This manuscript reports modified version of two small-signal amplifiers circuits with BJT-MOSFET hybrid unit under Sziklai pair topology. These circuits not only resolve the narrow band problem found in [7] and PNP Sziklai pair Small Signal Amplifier but also resolves the poor response problem of small signal Darlington pair amplifier at higher frequency [12], [14]-[15]. The key merits of the reported circuits are their high voltage and current gains, wide bandwidth, low power consumption, and low input referred noise.

CIRCUIT DETAILS

Circuit designs of Proposed amplifiers, as sketched in Fig.1(a) and Fig.1(b), are referred herein as Circuit-1 and Circuit-2 respectively. Circuits of Fig.1(a) and Fig.1(b) accommodate NPN type BJT at driver position and P-type MOSFET at follower position under Sziklai pair topology. Respective circuits of proposed amplifiers are analyzed with the aid of PSpice (Student Version 9.2), and Cadence Virtuoso and Spectre Simulation (at GPDK 180nm technology) tools [16]-[17]. Proposed amplifier (Circuit-1) accommodates user defined PSpice model of BJT (QMODN with $\beta=300$) at driver position and P-type MOSFET (PMOSD with $V_{TO}=-2$) at follower position under Sziklai pair topology [16].

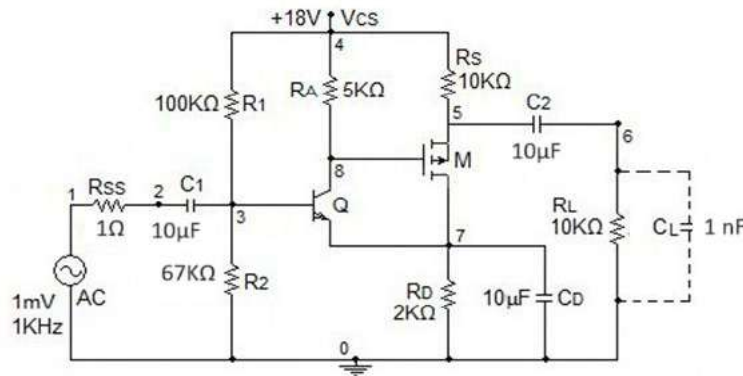


Fig.1(a). Proposed Amplifier (Circuit-1) under PSpice Simulation tool

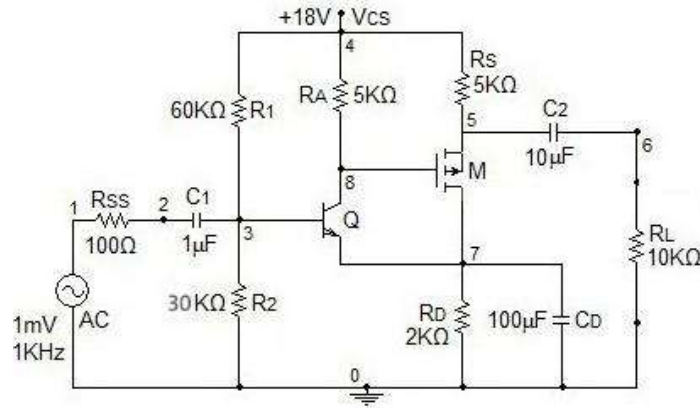


Fig.1(b). Proposed Amplifier (Circuit-2) under Cadence Virtuoso and Spectre Simulation tool at GPDK 180nm technology

Similarly, at GPDK 180nm technology under Cadence Virtuoso and Spectre simulation tool, proposed amplifier (Circuit-2) uses lateral type of BJT (*nnp* with $\beta=100$) at driver position and P-type MOSFET (*pmos* with $V_{TO}=-3.67$) transistor at follower position under Sziklai pair topology (Fig.1(b)) [18]. Moreover, amplifier with commercial BJT Q2N2222 ($\beta=255.9$) at driver position and P- type MOSFET IRF9140 ($V_{TO}=-3.67$) at follower position in the design of Fig.1(a) is referred throughout the present manuscript as *Reference Amplifier* [7]. Model parameters used in PSpice User-defined and Cadence system defined, BJTs and MOSFETs, are listed in Table-1 and Table-2 respectively.

Qualitative performance of the proposed amplifiers is observed with 1mV, 1KHz AC input signal source. However, the Circuit-1 and Circuit-2 produce undistorted output for 1mV-1nV and 0.1mV-10nV range of AC input at 1KHz respectively.

Table 1: Model Parameters of NPN BJT for Circuit-1 and Circuit-2 amplifiers

Model Parameters for BJTs	QMODN (Circuit-1)	nnp (Circuit-2)
IS (p-n saturation current)	200E-21A	3.26E-16A
BF (Ideal maximum forward beta)	300	100
NF (Forward current emission coefficient)	1	Default
BR (Ideal maximum reverse beta)	1	6
NR (Reverse current emission coefficient)	1	Default
RB (Zero-bios (maximum) base resistance)	5Ω	Default
RC (Collector ohmic resistance)	1Ω	1Ω
RE (Emitter Ohmic resistance)	---	Default
TF (Ideal forward transit time)	200E-12S	25E-12S
TR (Ideal reverse transit time)	5.00E-12S	Default

Table 2: Model Parameters of P-type MOSFET for Circuit-1 and Circuit-2 amplifiers

Model Parameters for MOSFETs	PMOSD (Circuit-1)	pmos (Circuit-2)
LEVEL (Model type 1,2, or 3)	3	3
L (Channel Length)	100μm	2μm
W (Channel Width)	100μm	1.9μm
VTO (Threshold Voltage)	-2V	-3.67V
KP (Transconductance)	4.54 Amp/V	10.15 μ Amp/V
PHI (Surface Potential)	0.6V	0.6V
RD (Drain ohmic resistance)	5Ω	60.66mΩ
RDS (Drain Ohmic Shunt Resistance)	1E+6Ω	444.4KΩ
RS (Source Ohmic Resistance)	--	70.6mΩ
IS (Gate p-n saturation current)	10E-15A	52.23E-18A
PB (Gate p-n potential)	0.8V	0.8V
CBD (Bulk-drain zero bias p-n capacitance)	5E-12F	2.141nF

RESULTS AND DISCUSSIONS

A. PERFORMANCE PARAMETERS

Comparative values of the performance parameters of the Proposed amplifiers (Circuit-1 and Circuit-2) with Commercial transistor based BJT-MOSFET Sziklai pair amplifier (Reference Amplifier) are listed in Table-3. Circuit-1 describes the PSpice user-defined BJT-MOSFET based Sziklai pair amplifier whereas Circuit-2 designates the similar amplifier design with Cadence system defined transistors at GPDK 180nm technology [17]-[18].

Table 3: Qualitative features of Proposed Amplifiers

Performance Parameters	Reference Amplifier	Circuit-1	Circuit-2
Maximum Voltage Gain (A_{VG})	347.995	389.532 (51.81 dB)	164.018 (44.29 dB)
Unity Gain Bandwidth, (B_U)	8.1438 MHz	2.438 GHz	1.7957 GHz
Maximum Current Gain (A_{IG})	71.519	136.570	32.775
Band Width (B_W) Corresponds to A_{VG}	47.926KHz	14.464 MHz	11.906 MHz
Lower Cut-off Frequency (f_L)	300.787Hz	2.5038 KHz	1.595 KHz
Higher Cut-off Frequency (f_H)	48.227KHz	14.467 MHz	11.908 MHz
Power gain (P_W in Watt)	24888.25	53198.385	37.3043
Device Current Gain (A_{IGD})	143.099	20701	108.636
Device voltage Gain (A_{VGD})	367.213	389.632	172.659
Peak Output Voltage (V_{RL})	336.537mV	145.812 mV	91.845 mV
Peak Output Current (I_{RL})	33.654 μ A	14.581 μ A	9.15 μ A
Input Current across R_{SS}	456.009nA	109.714nA	271.076nA
Output Phase Difference θ°	-163.479 $^\circ$	-112.173 $^\circ$	-123.245 $^\circ$
Total Harmonic Distortion THD	1.33%	2.43%	13.608E-6%
Total Power Consumption, (P_C)	55.2 mW	55.2 mW	47.865 mW
Phase Margin of Voltage Gain (θ_M)	---	---	52.4371 $^\circ$
Slew Rate of Output Voltage, (S_R)	---	---	5.06 V/ μ s
Power Spectral Density, (P_D)	---	---	26.705 pV ² /Hz
Transfer Function, (T_F)	---	---	164.011 V/V

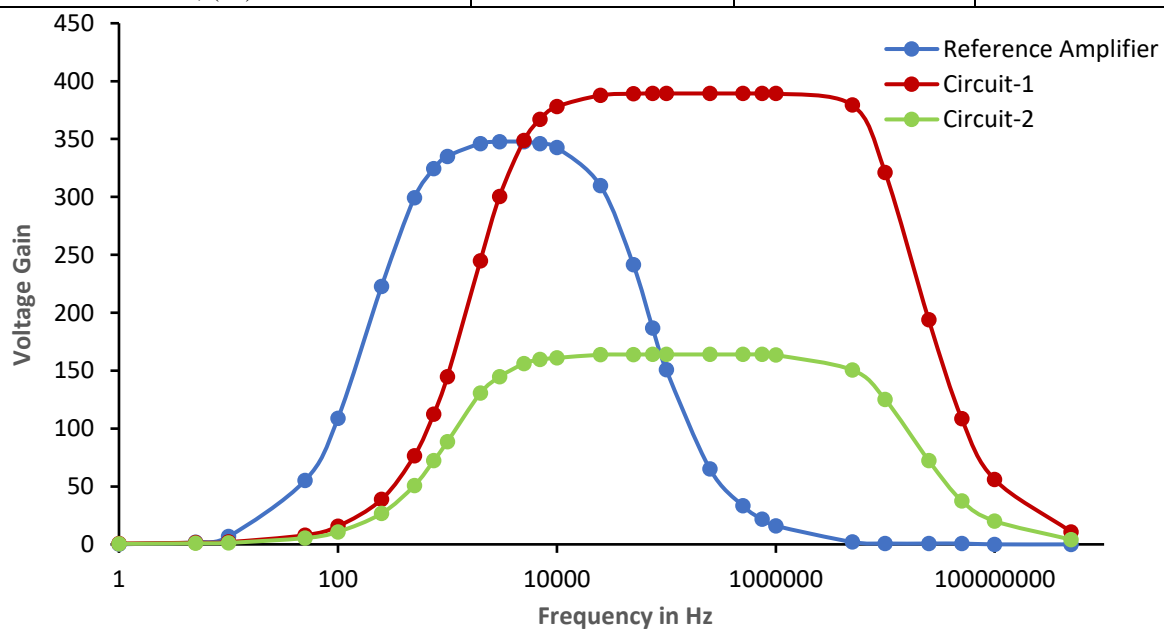


Fig.2. Distribution of Voltage gain on Frequency Scale

Refer Table-3. Circuit-1(with PSpice user-defined BJT and MOSFET) carries significantly improved voltage and current gains, wider bandwidth, wider unity gain bandwidth, higher

power consumption, and higher device voltage and current gain than Reference Amplifier on the cost of enhanced THD [18]. However, Circuit-2 (at GPDK 180nm technology) generates wider bandwidth, wider unity gain bandwidth, lower power consumption, and lower THD, than Reference Amplifier with the compromise over voltage and current gains. In spite of this, phase difference of the Circuit-1 and Circuit-2 is found lower than the Reference Amplifier. Moreover, due to typical CE-CD configuration, nearly 180° phase reversal output is observed for all the amplifier circuits under consideration [19].

Fig.2 represents the voltage gain of all the amplifiers with respect to frequency. It is evident from Fig.2 that the Proposed amplifiers (Circuit-1 and Circuit-2) removes the narrow bandwidth restrictions of the Reference Amplifier and PNP driven Sziklai pair amplifier [7], [12]. These amplifiers are also found free from the poor-response-problem of small-signal Darlington pair amplifier at higher frequencies. Performance parameters observed in Table-3 suggests that proposed amplifiers may be used to design Cascadable gain blocks for radio and TV receiver stages and 1KHz-14MHz frequency range power sources [15], [20].

It must be mentioned that the performance of Circuit-1 strongly depends on Ideal maximum forward beta ‘ β ’ of user-defined BJT and Transconductance ‘ V_{TO} ’ of user-defined MOSFETs in PSpice [14]. It is found that voltage gain increases with increasing value of β and becomes saturated at higher β value whereas it decreases with increasing value of V_{TO} . In addition, meaningful amplification with β is received for $4 \leq \beta \leq 500$ whereas for V_{TO} , the range for faithful amplification is $-12 \leq V_{TO} \leq +3$. The voltage gain of Circuit-1 increases with rising β because increasing β of the NPN transistors beyond $\beta=4$, causes increment in Small Signal transconductance, g_m and collector current I_C which perhaps increases the voltage gain of Circuit-1. In contrast, voltage gain of Circuit-1 decreases with increasing V_{TO} because small signal transconductance g_m decreases when the value of V_{TO} is varied beyond -12 to +3 range.

Proposed amplifiers may be used as Low Noise amplifier (LNA) in RF noise measurement system, shown in Fig.3 [21]. In this set-up, a biconical antenna is fed to bandpass filter through coaxial wires. The output of this filter is, then, applied to the LNA (having gain $\approx 30\text{dB}-60\text{ dB}$ in radio frequency region). The recording of the noise phase and quadrature data is performed with the help of spectrum analyser.

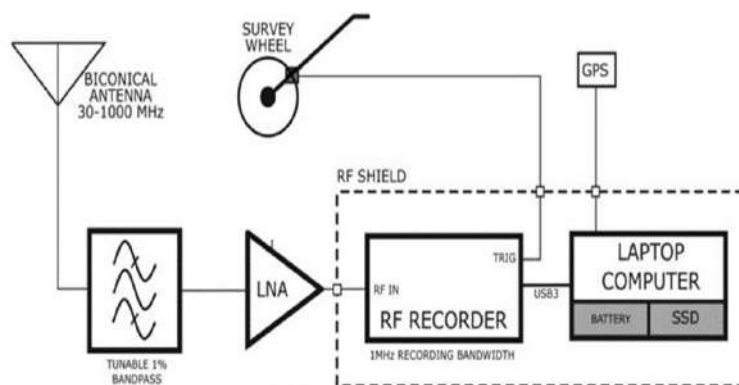


Fig.3. Block Diagram of Portable Noise Measurement System

B. SMALL SIGNAL AC ANALYSIS

Small-signal AC equivalent circuit of Proposed amplifiers is depicted in Fig.4(a). With $R_X=r_o||R_A$ and $R_Y=r_d||R_S$ and $R_B=R_1||R_2$, the reduced version of Fig.4(a) is sketched in Fig.4(b).

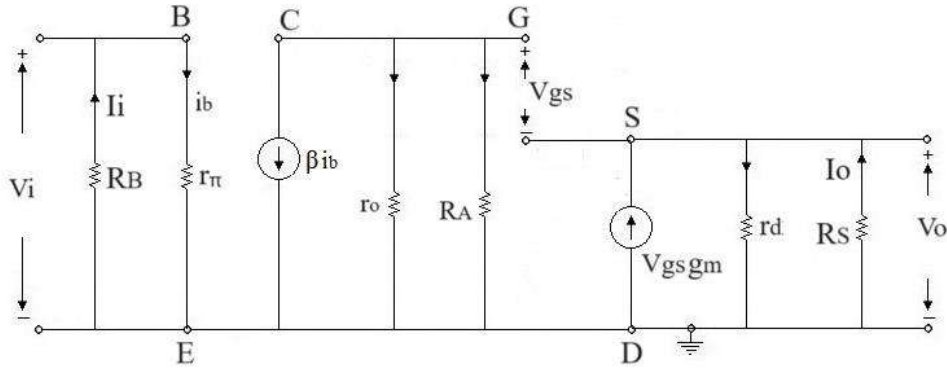


Fig.4(a). Small-signal AC Equivalent of the Proposed amplifier

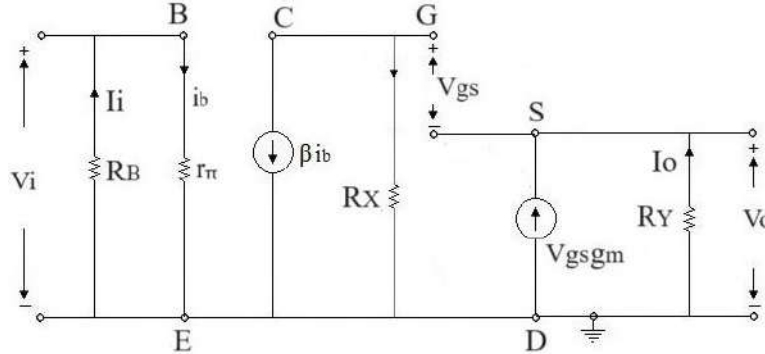


Fig.4(b). Small-signal AC Equivalent of the Proposed amplifier

Based on simulation results of Circuit-1, BJT of the Sziklai unit consists base-emitter resistance $r_{\pi}=3.69\text{K}\Omega$, collector-emitter resistance $r_o=1\times 10^{12}\Omega$, AC current gain factor $\beta=300$ whereas MOSFET consists $g_m=87.7\times 10^{-3}$, drain-source resistance $r_d=4.19\text{K}\Omega$ [15].

Analysis of Fig.4(b) suggests that

$$V_O = -V_{gs}g_mR_Y$$

$$V_{gs} = -\frac{V_O}{g_mR_Y} \quad (1)$$

Now voltage across register R_X would be

$$V_{RX} = V_{gs} + V_O$$

Hence,

$$\beta i_b R_X = -\frac{V_O}{g_m R_Y} + V_O \quad (2)$$

Now, the voltage at input half

$$V_i = i_b r_{\pi} = I_i R_B \quad (3)$$

$$i_b = \frac{V_i}{r_{\pi}} \quad (4)$$

Now by Equation (2) and Equation (4)

$$\frac{\beta V_i R_X}{r_{\pi}} = -V_O \left(\frac{1}{g_m R_Y} - 1 \right) \quad (5)$$

Now, by Equation-5, small-signal AC voltage gain of the proposed amplifier may be expressed as-

$$A_{VG} = \frac{V_o}{V_i} = \frac{-\beta R_X}{r_\pi \left(\frac{1}{g_m R_Y} - 1 \right)} \quad (6)$$

Now by Equation (6)

$$\frac{V_o}{V_i} = \frac{I_o R_Y}{I_i R_B}$$

$$\frac{I_o}{I_i} = \frac{R_B V_o}{R_Y V_i}$$

$$\frac{I_o}{I_i} = \frac{-\beta R_X R_B}{r_\pi R_Y \left(\frac{1}{g_m R_Y} - 1 \right)}$$

$$\frac{I_o}{I_i} = \frac{-\beta R_X R_B}{r_\pi \left(\frac{1}{g_m} - R_Y \right)}$$

Small-signal AC current gain of the proposed amplifier may be defined as-

$$A_{IG} = \frac{I_o}{I_i} = \frac{-\beta g_m R_X R_B}{r_\pi (1 - g_m R_Y)} \quad (7)$$

C. PERFORMANCE WITHOUT R_A

Performance of the proposed circuits significantly depends on R_A which is to be necessarily included in circuit structure to retain amplification status [3], [16]. Table-4 summerizes the status of the parameters of the proposed circuits without R_A.

Table 4: Qualitative features of Proposed Amplifiers without R_A

Performance Parameters	Reference Amplifier	Circuit-1	Circuit-2
Maximum Voltage Gain (A _{VG})	0.208	0.447	0.463
Maximum Current Gain (A _{IG})	0.009	0.120	0.076
Band Width (B _w) Corresponds to A _{VG}	5.2762 MHz	---	13.5523 Hz
Lower Cut-off Frequency (f _L)	1.0334 MHz	---	1.0943 Hz
Higher Cut-off Frequency (f _H)	6.3096 MHz	---	14.6466 Hz
Power gain (P _w in Watt)	-27.447	-12.705	-14.559
Device Current Gain (A _{IGD})	0.697	15.103	0.260
Device voltage Gain (A _{VGD})	0.850	0.838	0.559
Peak Output Voltage (V _{RL})	4.7249 μA	86.874 μA	42.302 μV
Peak Output Current (I _{RL})	472.490 pA	8.6892 nA	4.2309 nA
Input Current across R _{SS}	2.4944 μA	3.2383 μA	1.7732 μA
Output Phase Difference θ°	-61.640°	-83.300°	-86.912°
Total Harmonic Distortion THD	1.75%	2.47%	22.13E-15%
Total Power Consumption, (P _C)	23.8 mW	26.2 mW	38.44 mW
Slew Rate of Output Voltage, (S _R)	---	---	0.347 V/us
Power Spectral Density, (P _D)	---	---	11.036 nV ² /Hz
Transfer Function, (T _F)	---	---	463.085 mV/V

Refer Table-4. Exclusion of R_A causes reduction in voltage and current gains of the proposed circuits (both A_{VG} and A_{IG} goes below unity). However, power consumption of both the proposed circuit reduces in the absence of R_A. In addition, THD of Circuit-1 remains constant whereas for Circuit-2, THD significantly reduces in the absence of R_A. This happens because

of the fact that when R_A is detached from the Circuit-1, drain current I_D and drain-to-source voltage V_{DS} of P-type MOSFET decreases which consequently decreases the voltage and current gain across R_L .

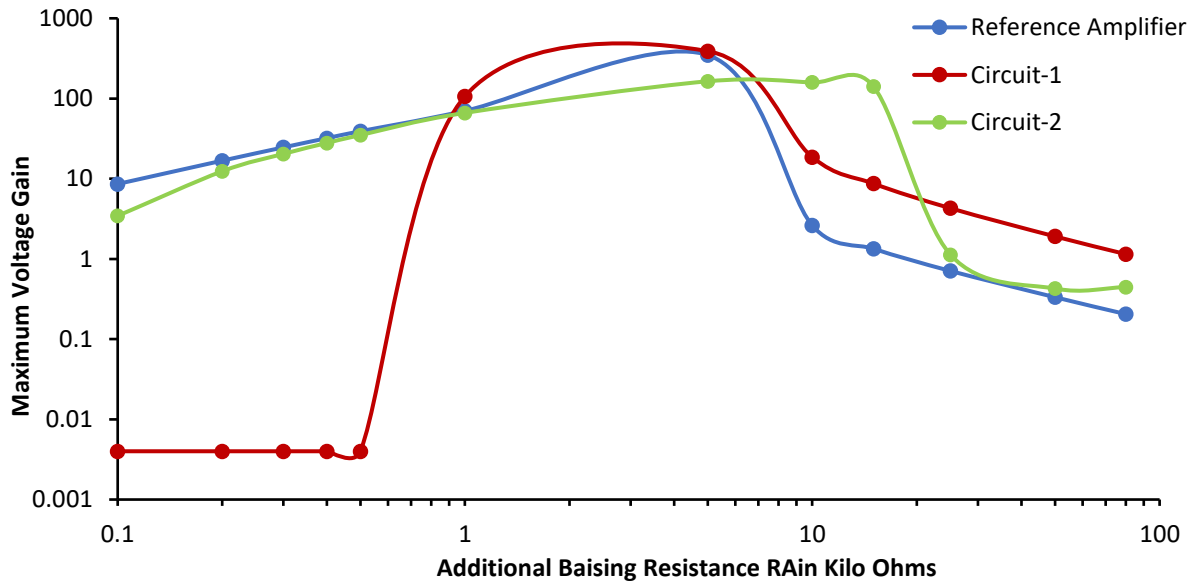


Fig.5. Effect of R_A on Voltage Gain

Fig.5 portrays the status of voltage gain of the proposed circuits as a function of R_A . Permissible range of R_A for Reference amplifier for meaningful amplification is $470\Omega < R_A < 5K\Omega$ [7]. For Circuit-1 and Circuit-2, Voltage gain increases with increasing value of R_A up to $R_A = 5K\Omega$, and starts decreasing thereafter. It is also to note that both the proposed circuits produce distortion at $R_A \geq 15K\Omega$. Hence, the purposeful range for amplification of Circuit-1, and Circuit-2 is $1K\Omega < R_A < 15K\Omega$ and $100\Omega < R_A < 15K\Omega$ respectively. Observed phenomenon is found in accordance with the deduced Equations (6) and (7).

D. EFFECT OF BAISING RESISTANCES

Fig.6. shows the variation of the voltage gain of the proposed circuits with respect to Souce resistance R_S [9].

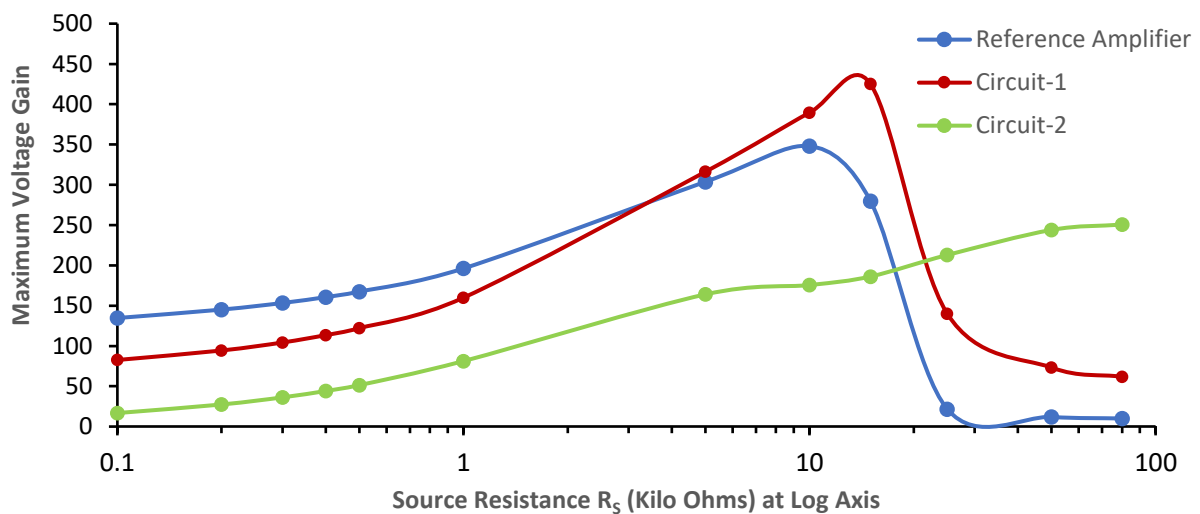


Fig.6. Effect of R_S on Voltage Gain

The Voltage gain of Circuit-1 elevates with rising value of R_S and reaches its peak value at $R_S = 15K\Omega$, and acquire decreasing trend at higher value of R_S . Similarly, in case of Circuit-2,

voltage gain goes on increasing with increasing value of R_S . However, this circuit produces distortion at $R_S \geq 25K\Omega$. Therefore, meaningful range of amplification for Circuit-1 and Circuit-2 is $100\Omega \leq R_S \leq 100K\Omega$ and $100\Omega \leq R_S \leq 25K\Omega$ respectively. For Reference Amplifier, A_{VG} increases non-linearly with source resistance R_S and reaches its maximum value at $R_S = 12K\Omega$. Thus, purposeful response is received in $1K\Omega < R_S < 12K\Omega$ range [7]. This generally happens because V_{DS} of P-type MOSFETs increases with increase in R_S (Upto $15K\Omega$) which in-turns increases the voltage gain of Circuit-1. However, beyond $R_S \geq 15K\Omega$, drain to source voltage starts to reduce which reduces the voltage gain.

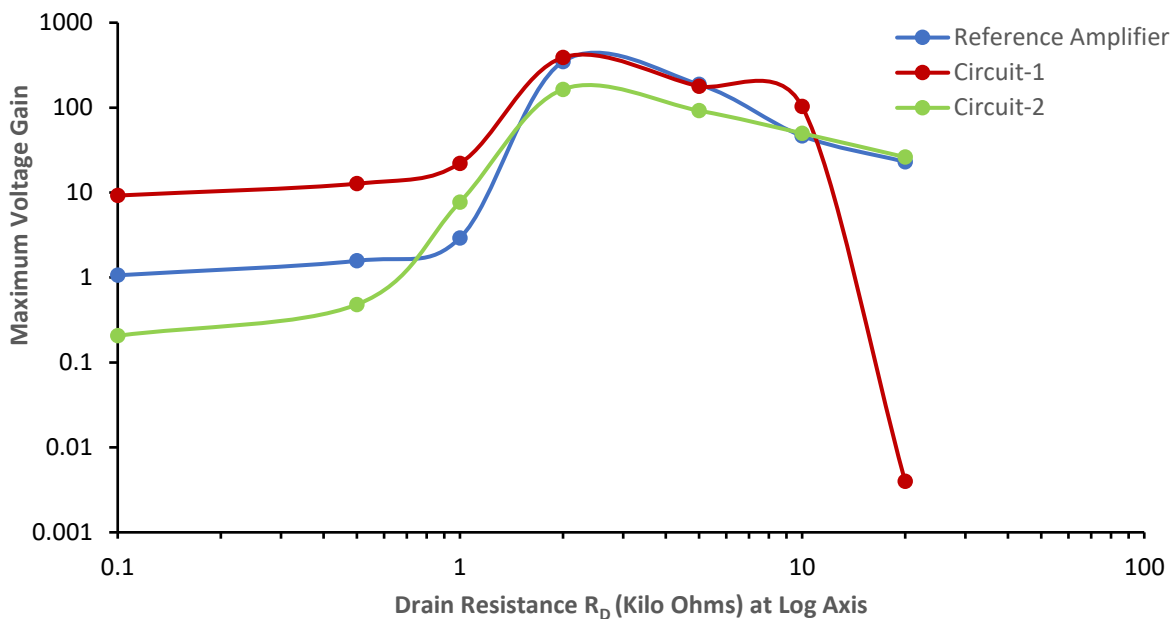


Fig.7. Effect of R_D on Voltage Gain

Fig.7 shows the variation of the maximum voltage gain with respect to drain resistance [12]. For Circuit-1, voltage gain rises with rising value of R_D and reaches to its peak value at $R_D = 2K\Omega$, thereafter starts decreasing non-linearly. It is also to note that this circuit produces distortions at $R_D \geq 10K\Omega$. Hence, meaningful range for amplification with R_D for Circuit-1 is $100\Omega < R_D < 10K\Omega$. Similarly, voltage gain for Circuit-2 increases non-linearly with increasing value of R_D and attains its maximum value at $R_D = 2K\Omega$, and starts decreasing beyond this value. Therefore, meaningful range of R_D for Circuit-2 is $1K\Omega \leq R_D \leq 40K\Omega$. However, for Reference Amplifier, voltage gain decreases with increasing values of drain resistance R_D up to $7K\Omega$ and beyond this, amplifier performance becomes poor [7]. This usually happens because beyond $2K\Omega$, drain current and drain to source voltage both starts to decrease which is probably responsible for the deterioration of voltage gain.

It is also worth mentioning that the current gain of both the proposed amplifier circuits remain more or less unaffected with the variation of R_{SS} (Figure not shown) [19]. Instead, it is found that the voltage gain increases with decreasing value of R_{SS} for both the proposed circuits. However, for the Reference Amplifier, the voltage gain A_{VG} receives its maximum value at $R_{SS} = 10\Omega$ and minimum value at $R_{SS} = 80K\Omega$ [7].

E. EFFECT OF DC SUPPLY VOLTAGE

Supply voltage scaling causes significant impact on the proposed amplifiers' performance [13]. Fig.8 depicts the variation of voltage gain of the proposed circuits with respect to Supply Voltage V_{DC} . Respective observations are recorded up to $V_{DC} = 50V$ and beyond this limiting value, the proposed amplifiers appear with distorted outcome.

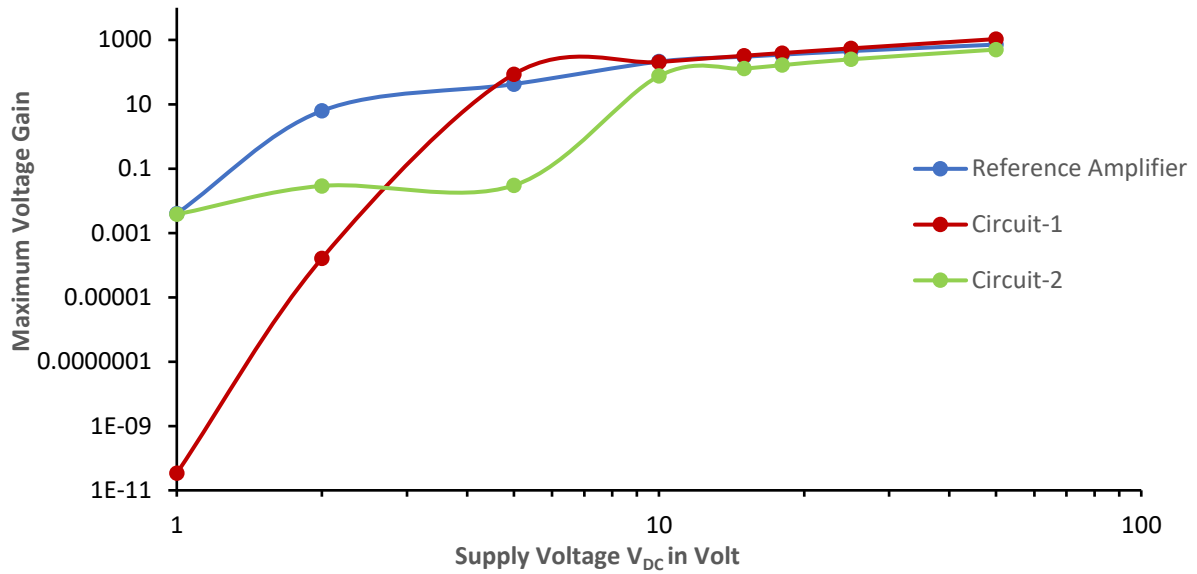


Fig.8. Effect of V_{DC} on Voltage Gain

Fruitful range for amplification for Circuit-1 and Circuit-2 are observed to be $25 \text{ Volt} \geq V_{DC} \geq 5 \text{ Volt}$ and $35 \text{ Volt} \geq V_{DC} \geq 10 \text{ Volt}$ respectively. In addition, voltage gain for both the proposed amplifiers increases with increasing V_{DC} . However, Reference Amplifiers produces meaningful amplification with V_{DC} in the 7-40V range [7].

The factor which is responsible for this behavior is the significant enhancement in drain to source voltage of the of P-type MOSFET at increasing values of V_{DC} which in-turns increases the effective voltage gain of the amplifiers.

F. PHASE VARIATION

Phase difference of output voltage with respect to frequency is shown in Fig.9 for the proposed amplifier circuits [18], [22].

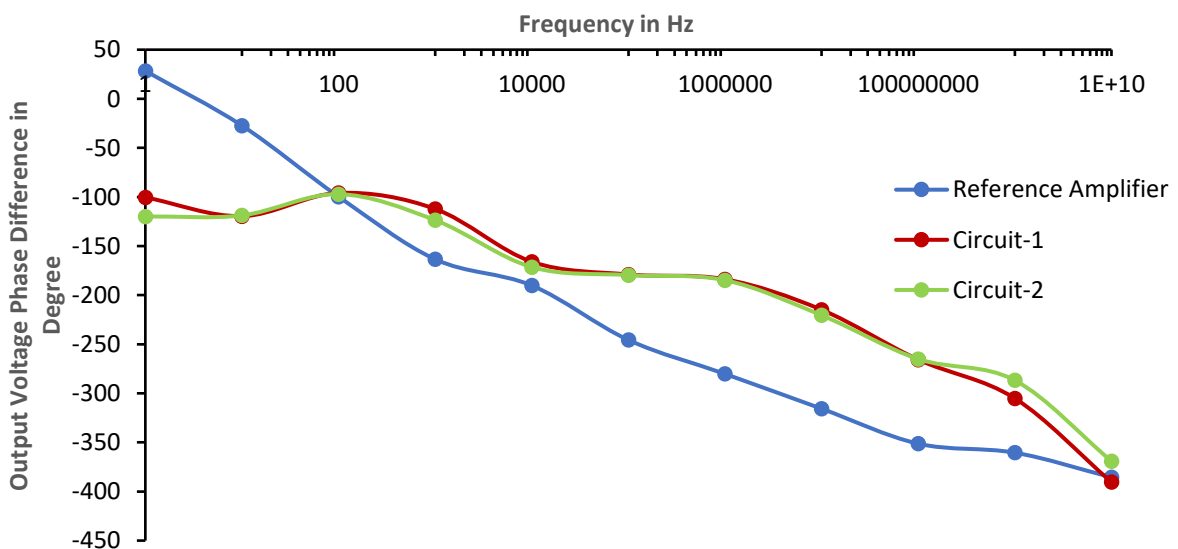


Fig.9. Phase Variation

At 1KHz of operating frequency, Circuit-2 produces higher phase reversal output (-123.624°) than Circuit-1 (-112.173°). However, Reference Amplifier generates phase reversal output close to 180° (i.e. -163.479°) [7]. With the increasing value of frequency, output phase

difference of Circuit-2 initially decreases up to 100 Hz and undergoes sudden increment at 1KHz frequency, and thereafter increases non-linearly. Similarly, for Circuit-1, output phase difference changes in zig-zag manner up to 1KHz frequency, and increases non-linearly beyond this frequency.

G. TEMPERATURE DEPENDENT PERFORMANCE

Table-5(a) and Table-5(b) refers the performance of the Circuit-1 and Circuit-2 with the variation of temperature in $-20^{\circ}\text{C} \leq T \leq +50^{\circ}\text{C}$ range [23].

Table-5(a): Temperature effect on Circuit-1 with PSpice User defined Transistors

Environmental Temperature (°C)	Voltage Gain (A _{VG})	Current Gain (A _{IG})	Bandwidth (B _w)	Total Power Consumption (P _C)
-20	457.520	138.401	16.516 MHz	55.0 mW
-10	441.102	138.006	16.122 MHz	55.0 mW
0	425.842	137.614	15.507 MHz	55.1 mW
10	411.617	137.225	15.340 MHz	55.1 mW
27	389.532	136.570	14.464 MHz	55.2 mW
50	336.227	135.696	13.725 MHz	55.3 mW

Table-5(b): Temperature effect on Circuit-2 with Transistors Available at GPDK 180nm Technology

Environmental Temperature (°C)	Voltage Gain (A _{VG})	Current Gain (A _{IG})	Bandwidth (B _w)	Total Power Consumption (P _C)
-20	197.205	34.5065	10.666 MHz	47.2631 mW
-10	189.251	34.14	10.957 MHz	47.389 mW
0	181.818	33.77	11.212 MHz	47.516 mW
10	174.863	33.403	11.400 MHz	47.645 mW
27	164.018	32.775	11.632 MHz	47.865 mW
50	151.006	31.9228	12.489 MHz	48.166 mW

Refer Table-5(a) and Table-5(b). Voltage and Current gain reduce whereas total power consumption increases for both the proposed amplifier circuits with rising temperature. However, bandwidth decreases with increasing temperature for Circuit-1, whereas for Circuit-2, it increases with temperature elevation. In addition, for reference amplifier, voltage gain goes down but current gain goes high with rising temperature [7]. This usually happens because the temperature elevation accelerates majority carrier generation process in both the proposed circuits which elevates collector and drain currents and therefore affects A_{VG}, A_{IG} and B_w [24].

This probably happens because the Drain-Source resistance of the P-type MOSFET rises with temperature which in turn reduces the drain current and the voltage and current gains [14]. Similarly, the bandwidth of proposed amplifiers also reduces with raising temperature for Circuit-1 because the effective drain to source capacitance of P-type MOSFET decreases with increasing temperature and causes reduction in the bandwidth [14].

H. NOISE SENSITIVITY

Variation of input and output noise with temperature (at different operational frequencies) for Circuit-1 and Circuit-2 is listed in Table-6(a) and Table-6(b) respectively [24]-[25].

Table 6(a): Noise Sensitivity of Circuit-1 with PSpice User defined Transistors

Temp (°C)	Noises at 10Hz		Noises at 1KHz		Noises at 100KHz		Noises at 100MHz	
	Out Noise	In Noise	Out	In	Out Noise	In	Out	In

	(V/√Hz) x 10 ⁻⁹	(V/√Hz) x 10 ⁻⁹	Noise (V/√Hz) x 10 ⁻⁹	Noise (V/√Hz) x 10 ⁻¹²	(V/√Hz) x 10 ⁻⁹	Noise (V/√Hz) x 10 ⁻¹²	Noise (V/√Hz) x 10 ⁻⁹	Noise (V/√Hz) x 10 ⁻¹²
-20	12.140	6.1389	59.553	403.402	181.320	396.416	29.613	396.900
-10	12.275	6.2081	60.985	414.776	179.849	407.823	28.534	408.293
0	12.409	6.2765	62.392	426.108	178.868	419.185	27.539	419.643
10	12.541	6.3442	63.773	437.401	177.169	430.506	26.617	430.952
20	12.672	6.4113	65.130	448.657	175.945	441.788	25.761	442.223
27	12.762	6.4579	66.066	456.515	175.130	449.664	25.197	450.091
50	13.057	6.6087	69.057	482.226	172.666	475.425	23.525	475.830

Table 6(b): Noise Sensitivity of Circuit-2 with Transistors Available at GPDK 180nm Technology

Temp (°C)	Noises at 10Hz		Noises at 1KHz		Noises at 100KHz		Noises at 100MHz	
	Out Noise (V/√Hz) x 10 ⁻⁶	In Noise (V/√Hz) x 10 ⁻⁹	Out Noise (V/√Hz) x 10 ⁻⁹	In Noise (V/√Hz) x 10 ⁻⁹	Out Noise (V/√Hz) x 10 ⁻⁹	In Noise (V/√Hz) x 10 ⁻⁹	Out Noise (V/√Hz) x 10 ⁻⁹	In Noise (V/√Hz) x 10 ⁻⁹
-20	2.0498	0.001522	269.22	2.8071	249.55	1.2655	26.078	1.2579
-10	2.133	0.001589	280.83	2.9656	244.65	1.2927	26.169	1.2838
0	2.2208	0.001662	293.08	3.1355	239.96	1.3198	26.243	1.3093
10	2.3074	0.001798	305.32	3.31034	235.49	1.3467	26.302	1.3345
20	2.396	0.001811	317.926	3.4941	231.211	1.3734	26.349	1.3593
27	2.459	0.001866	326.365	3.6283	228.329	1.3921	26.374	1.3765
50	2.676	0.002052	357.955	4.1040	219.445	1.4532	26.422	1.4320

Refer Table-6(a) and Table-6(b). Input noise of Circuit-1 and Circuit-2 at all the mentioned frequencies increases with increasing temperature. However, output noise of Circuit-1 at 10Hz, and 1KHz frequencies increases with increasing temperature whereas at 100KHz and 100MHz frequencies, it reduces with temperature elevation. Similarly, for Circuit-2, output noise at 10Hz, 1KHz, and 100MHz increases whereas at 100KHz, it decreases with rising temperature.

I. LAYOUT AND POST LAYOUT SIMULATION

Layout of Circuit-2, depicted in Fig.10, is designed at GPDK 180nm technology using Layout XL editor tool in Cadence Virtuoso and Spectre simulation [26]-[27]. Layout of Circuit-2

covers an area of 96.3898μm² having 11.32μm length and 8.515μm breadth. In this layout, first block replicates NPN transistor whereas

Table 7: Pre-Layout and Post-Layout Simulation Results of Circuit-2

Parameters	Pre layout	Post layout	Percentage variation
Voltage Gain, (A _{VG})	164.018	142.23	14.22%
Current Gain, (A _{IG})	32.775	23.12	34.54%
Total Power Consumption, (P _C)	47.465 mW	40.22 mW	16.52%

second block shows P-type MOS transistor. The P-type MOS transistor, having dimensions of 0.68μm x 0.955μm, is taken as integrated because source and substrate terminal is connected to same wire. Yellow and Violet wires represent poly and metal wires respectively. The λ rule for connecting the wires is well abided to avoid wire mismatch and overlapping [19], [28]. Minor % variation between pre-layout and post-layout simulation, recorded in Table-7, authenticate the design of Circuit-2 at GPDK 180nm technology.

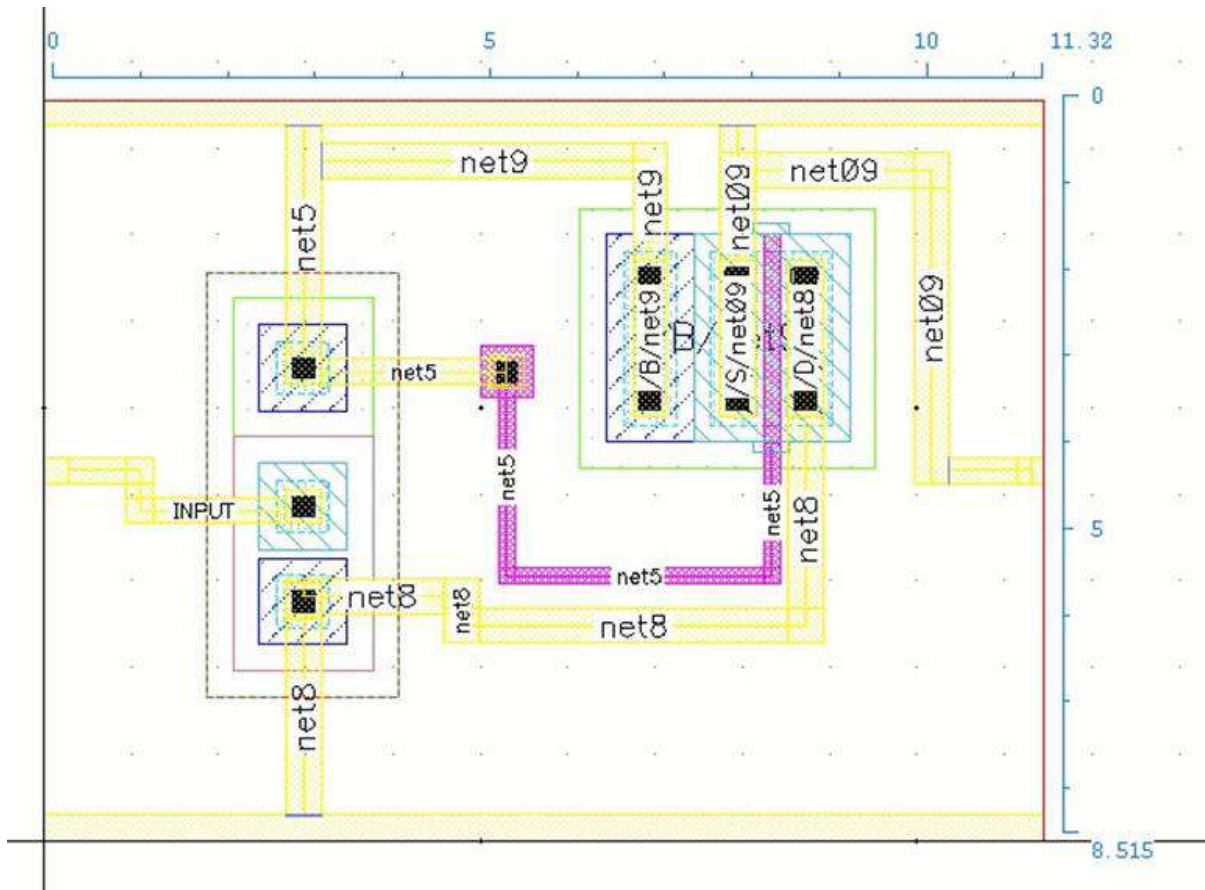


Fig.10. Layout of Circuit-2

J. MONTE CARLO ANALYSIS

For 51 samples, Monte Carlo simulation is done to check the robustness of the proposed amplifiers for Voltage gain, and total power consumption against process and mismatch [29]. Statistical representation of such variations are shown in Fig.11, and Fig.12 respectively.

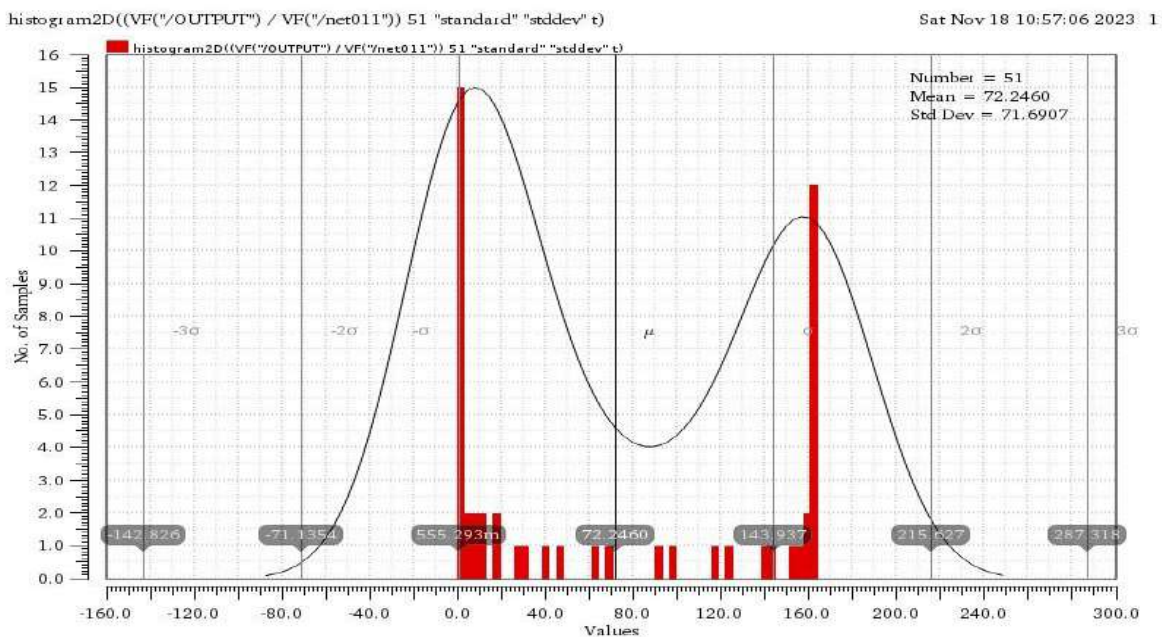


Fig.11. Monte Carlo Simulation of Voltage gain

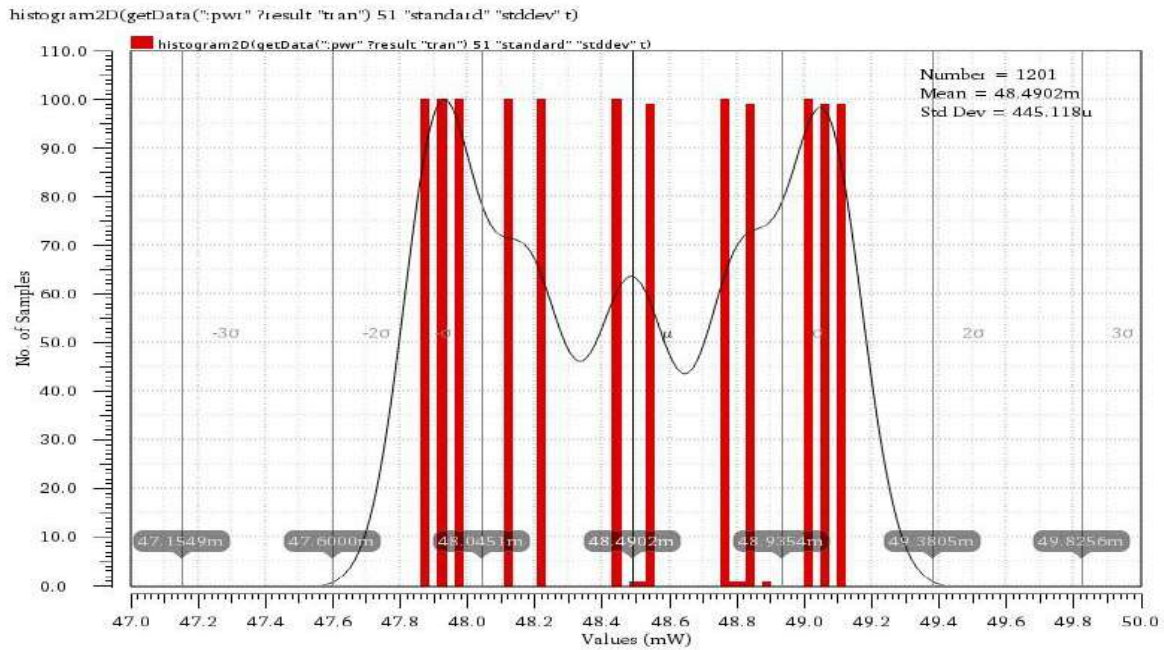


Fig.12. Monte Carlo Simulation of Total Power Consumption

Table-8 shows the deviation of the Voltage gain, and total power consumption from their mean value. It is found that the measured parameters shows small deviation against their respective mean value which shows the robustness against the process and mismatch variations [11].

Table 8: Monte Carlo Simulation of Circuit-2

Parameters	Mean (μ)	Deviation (σ)
Voltage Gain	72.2460	71.7907
Total Power Consumption	48.4902mW	445.118 μ W

K. PROCESS CORNER SIMULATION

Fig. 13, and Fig. 14 represents the five-corner simulation (TT, FF, SS, FNFP, SNFP) of voltage gain and total power consumption at 27°C, where TT, FF, SS, FNFP, and SNFP stands for typical-typical, fast-fast, slow-slow, fast-NPN-slow-PMOS, and slow-NPN-fast-PMOS [30].

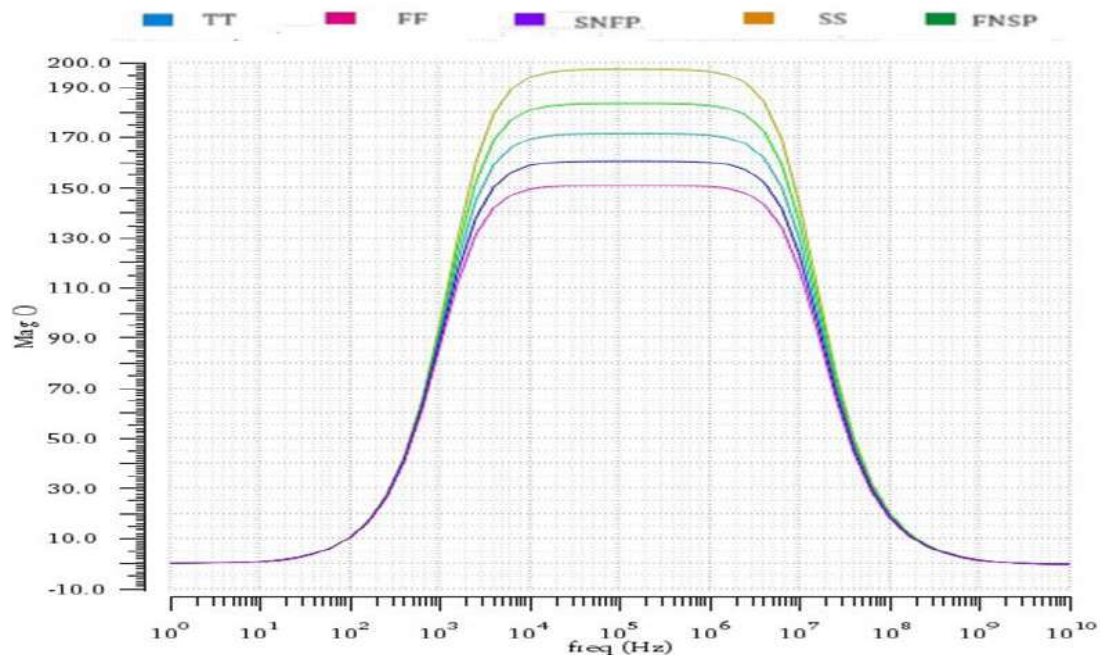


Fig.13. Corner Analysis of Voltage gain

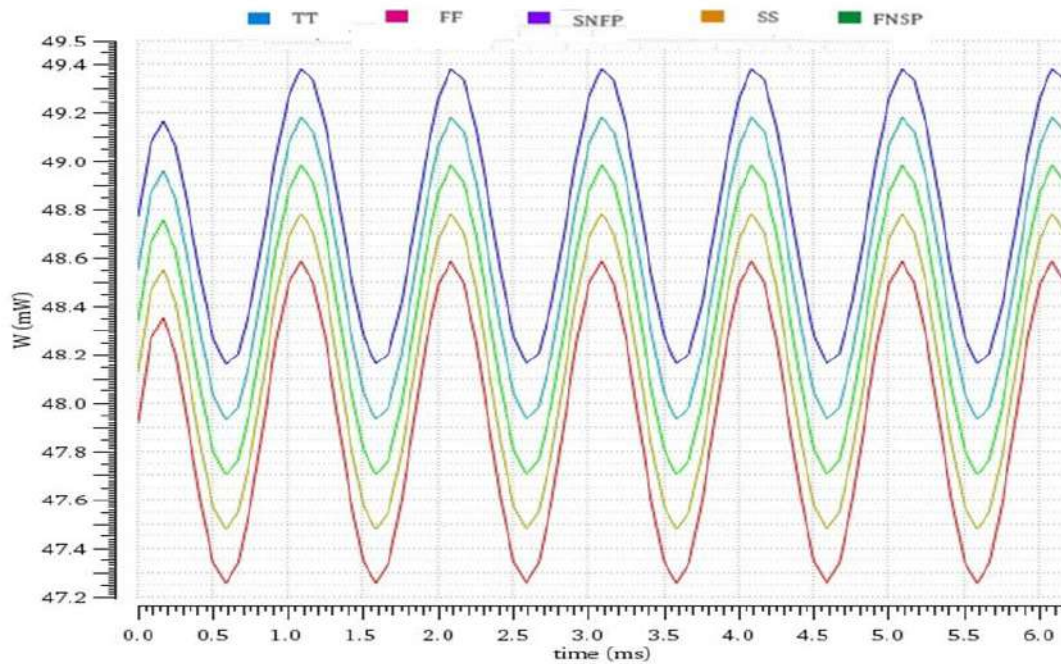


Fig.14. Corner Analysis of Total Power Consumption

The SS corner simulation produces the largest Voltage gain, measuring 195.21 whereas the SS consumes lowest power consumption, measuring 47.1mW. In addition, all the corners have almost similar values of parameters at different corners which shows that the Circuit-2 is insensitive against the process and mismatch variations.

L. TUNING PERFORMANCE OF CIRCUIT-1

The Load capacitor C_L is included in Circuit-1 as an essential circuit component which help the amplifier to tune at a specific frequency to match the frequency of a particular channel [30]. It is achieved under two conditions, first by keeping the C_L constant at 1nF and varying C_D (Table-9(a)), and second by varying C_L and keeping C_D constant at 10 μ F (Table-9(b)).

Table-9(a): Performance parameters at Varying C_D and keeping C_L constant

C_D ($C_L=1nF$)	A_{VG}	A_{IG}	F_L	F_H	B_w
1 μ F	288.243	132.514	18.476 KHz	19.602 MHz	19.599 MHz
10 μ F	389.532	136.570	2.5038 KHz	14.467 MHz	14.464 MHz
100 μ F	403.718	136.990	263.770 Hz	14.030 MHz	14.029 MHz
1mF	405.194	137.031	30.758 Hz	13.943 MHz	13.942 MHz
10mF	405.342	137.036	7.6096 Hz	13.935 MHz	13.934 MHz
100mF	405.357	137.036	5.1210 Hz	13.936 MHz	13.935 MHz

Table-9(b): Performance parameters at Varying C_L and keeping C_D constant

C_L ($C_D=10\mu F$)	A_{VG}	A_{IG}	F_L	F_H	B_w
1nF	389.532	136.570	2.5038 KHz	14.467 MHz	14.464 MHz
10nF	288.059	132.392	1.8522 KHz	1.9548 MHz	1.9544 MHz
100nF	79.903	101.340	515.633 Hz	703.398 KHz	702.883 KHz
1 μ F	9.714	30.293	65.026 Hz	582.178 KHz	582.113 KHz

Refer Table-9(a) and Table-9(b). Tuning with C_D is achieved in 10 μ F-100mF range, while the range of tuning with C_L is 1nF-10nF. Fig. 15 shows two combinations of C_L and C_D which tune at a specific frequency with varying bandwidth.

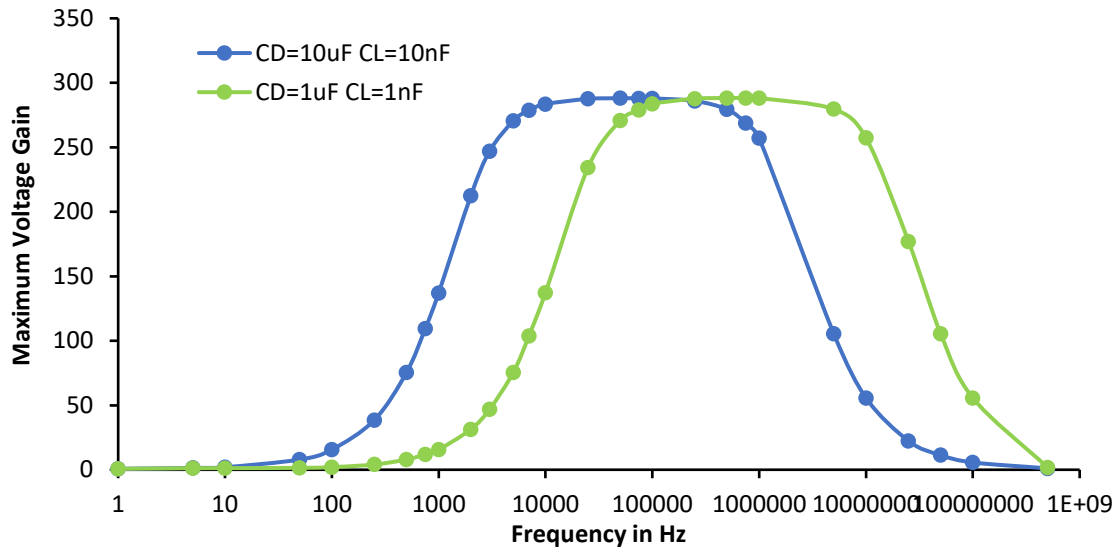


Fig.15. Tuning Performance of Circuit-1

For Reference Amplifier, bandwidth varies with drain capacitor C_D and load capacitor C_L in $10\mu\text{F}$ – $100\mu\text{F}$ and $0.001\mu\text{F}$ – 0.001F variation range respectively. However, in Circuit-2, C_L is not connected to the circuit structure hence no such type of tuning effect is recorded [9], [14].

M. PERFORMANCE SUMMARY AND COMPARISON

Table-10 compiles the comparison of proposed amplifiers, Circuit-1 and Circuit-2, with the BJT-MOSFET hybrid unit based small signal Darlington pair amplifier and small signal amplifier with BJT-MOSFET hybrid unit under Sziklai pair topology [7], [11].

Table 10: Performance Summary and Comparison

References →	Shukla <i>et al.</i> [7]	Pratima <i>et al.</i> [11]	This Work	
Design Strategy for small signal amplifiers	BJT-MOSFET in Sziklai pair Topology	BJT-MOSFET in Darlington pair Topology	BJT-MOSFET in Sziklai pair Topology (Circuit-1)	BJT-MOSFET in Sziklai pair Topology (Circuit-2)
	PSpice Commercial Transistors	At GSDK 180nm Technology	PSpice User Defined Transistor	At GSDK 180nm Technology
Year	2015	2023	2022	2022
Technology (nm)	--	180	--	180
Supply Voltage (Volt)	+18	+15	+18	+18
Maximum Voltage Gain (A_{VG})	347.995	281.331	389.532	164.018
Maximum Current Gain (A_{IG})	71.519	33.698	136.570	32.775
Band Width (Bw)	47.926KHz	22.562 MHz	14.464 MHz	11.906 MHz
Power gain (P_w in Watt)	24888.25	9480.292	53198.385	37.3043
Input Referred Noise, IRN	---	23.167 nV/ $\sqrt{\text{Hz}}$	456.515 pV/ $\sqrt{\text{Hz}}$	3.6283nV/ $\sqrt{\text{Hz}}$
Output Referred Noise, ORN	---	5.5523 pV/ $\sqrt{\text{Hz}}$	66.066 nV/ $\sqrt{\text{Hz}}$	326.365 nV/ $\sqrt{\text{Hz}}$
Total Harmonic Distortion THD	1.33%	5.296E-6%	2.43%	13.608E-6%
Total Power Consumption, (P_c)	55.2 mW	165.061 mW	55.2 mW	47.865 mW

Refer Table-10. Proposed Circuit-1 generates higher current and voltage gains, higher power gain, and lower THD than the amplifiers of Shukla *et al.* [7] and Pratima *et al.*, [11]. However, Proposed Circuit-2 holds wide bandwidth, and higher power gain than [7], lower input noise than [11], lower THD than [7], lower power consumption than [7], [11].

In addition, Circuit-2 emerges with lowest power consumption, and lowest THD whereas Circuit-1 carries highest voltage and current gain, lowest Input referred noise, and higher power gain.

CONCLUSION

Two Circuit designs of small signal Sziklai pair amplifier with BJT-MOSFET hybrid unit are studied and analysed under the purview of present manuscript.

The proposed circuits commonly use CE-CD configuration; therefore, the entire unit produces 180° phase shift in the output. In spite of this, proposed circuits provide solution to the poor frequency response of Darlington pairs at higher frequencies and narrow bandwidth limitations of small-signal PNP Sziklai pair amplifier. Additionally, these circuits also remove the narrow band problem of Reference Amplifier with comparatively high voltage and current gain as well as wider bandwidth.

The value of the additional biasing resistance R_A , as an essential circuit component, must be taken in the range $1K\Omega < R_A < 15K\Omega$ and $100\Omega < R_A < 15K\Omega$ for Circuit-1 and Circuit-2 respectively. In addition, for Circuit-1, meaningful amplification with ideal maximum forward beta β is received for the range $4 \leq \beta \leq 500$ whereas for transconductance V_{TO} , the range for faithful amplification is $-12 \leq V_{TO} \leq +3$. It is also to be noted that load capacitor C_L acts as an essential circuit element for Circuit-1 to provide tuning whereas Circuit-2 does not require any load capacitor. Tuning performance of Circuit-1 can be availed with $C_L=1nF$, $C_D=1\mu F$ and $C_L=10nF$, $C_D=10\mu F$. Comparison of proposed circuits with the similar small signal amplifiers design reported recently suggests voltage gains, current gains, input referred noise, bandwidth, THD, power consumption, and power gain as their prominent features.

Analysis of the proposed circuit suggests its use as Low Noise Amplifier in Street-scale Mapping of Radio frequency Noise at VHF and UHF region.

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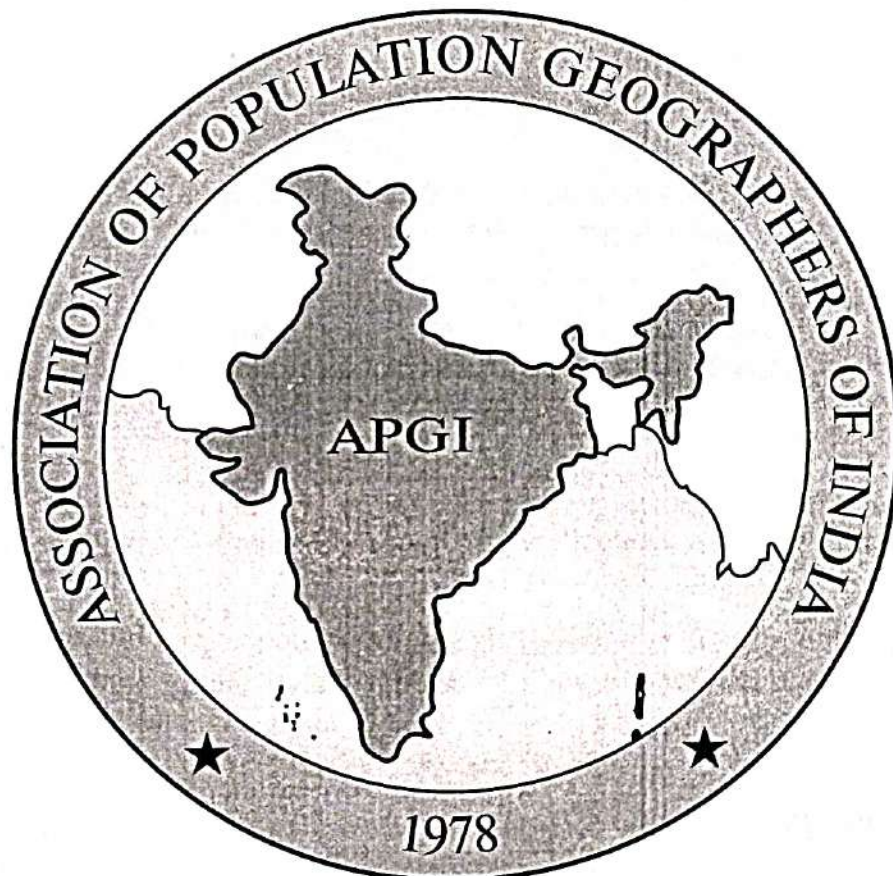
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Educational Level and Infant Mortality in Scheduled Tribes Population in Surguja District, Chhattisgarh

Utkesh Singh¹ & Anusuiya Baghel

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Abstract: This study aims to assess the status of infant mortality in the Scheduled Tribes population in the Surguja district and to compare the IMRs of Scheduled Tribes with that of Scheduled Castes and other Castes. The present study is based on the primary data. The study is based on 2691 individual mothers selected from 38 villages of 19 development blocks in Surguja district. Two types of schedules have been prepared for the data collection. The first one is based on information about the family, whereas the second one is based on that of an individual woman who has given birth to children within five years before the survey date or whose issues have died. In the Surguja district, IMR found among illiterate mothers is 77.4 per thousand, whereas that of literate mothers is 54.9 per thousand. The study reveals that the educational level is a main factor influencing the IMR.

Keywords: mortality, education, society, family

Mortality forms a basic component in population studies. To determine mortality in any region, the age structure makes the most significant demographic factor. The age-specific mortality is found to be higher for infants and old. However, infant mortality plays a key role in determining the mortality of any region.

Any region's infant mortality rate (IMR) makes a sensitive index in determining the region's development. The Geographers take a keen interest in infant mortality studies because it reflects the socioeconomic development of the region, in addition to its demographic significance. It is found that the mortality rate declines with the increase in age. It is the highest for infants. It gradually decreases with the age of persons due to several factors. The factors influencing mortality can

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मत उनके अपने हैं। उनसे संपादक का
सहमत होना आवश्यक नहीं।

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Soil Erosion Risk Estimation by using Semi Empirical RUSLE model: A case study of Maniyari Basin, Chhattisgarh

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Abstract

Soil is the protective skin of our earth's surface, but today's numerous population pressures on land, along with industrialization, climatic variability such as a vigorous increase in temperature, acid rain, and deforestation, definitely degrade the quality of land. It should have to evaluate the quality of the land and find out the nutrition status as well as the soil health. The present study is employed in a Geographic Information System (GIS) environment to predict erosion risk using the Semi-Empirical Revised Soil Loss Erosion Model (RUSLE). The physiographic soil map has been prepared by visual interpretation of the Sentinel 2 satellite image, from which the soil erodibility factor has been derived. The digital elevation model (DEM) has been prepared from a contour map and used as the base map for the topographic-related analysis. In this model, the slope length (LS) factor has been prepared from the DEM. The crop conservation and management factor (C) and support practice factor (P) factors have been derived from the LULC map. It has been found that 4.45% of the watershed comes under very high erosion, 3.50% under high erosion, 7.80% under moderate erosion, 11.37% under low erosion, and 51.36% under a very low erosion-prone zone.

Keywords: Digital Elevation Model, Erosion, Geographical Information System, RUSLE, Vigorous.

1. Introduction

Today, soil erosion is a vital concern for landscape conservation and management due to climatic factors that, in the form of temperature or rainfall, act as agents of soil erosion. The soil erosion process involves various contributory factors related to the climate land use and soil. It is necessary to investigate various contributory factors to finally assess soil erosion. Rainfall and temperature are the major factors temperature has the power to reduce the moisture level of the soil, so dry soil particles are detached from one another, and finally, the dynamic transportation agent is determined by the slope. Soil erosion estimation is very helpful for sustainable land evaluation. Where soil erosion is the main obstacle to sustainable agriculture, horticulture, livestock farming, etc., in order to mitigate the impact of land degradation, the Geographical Information System (GIS) and Remote Sensing (RS) are very powerful tools to monitor the present scenario. An attempt has been made to prepared a soil loss (soil erosion) map of the study area using various physical and climatic parameters.

The Land use landcover change detection analysis has been prepared using IRS remote sensing satellite LISS III and LANDSAT-8 satellite data (Saha et al., 1992). IRS 1D LISS IV satellite data used to prepare land use and land cover to assessed the risk of erosion-prone of Sukha Lake catchment, north India (Shirmali et al. 2001). Almost half of all terrestrial land suffers from land degradation as a result of various landcover land use parameters such as geology, slope, soil, drainage, etc. to determine the land degradation of the Silabati River in west Bengal (Mahala, 2020). There are different methods to determine the soil erosion such as Universal soil loss erosion (USLE), Revised Universal soil loss erosion (RUSLE), Morgan



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3.4.5

3.4.5 Number of research papers per teacher in the Journals notified on UGC website during the year [2023-24]

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Insights into the petrogenetic evolution of the Khallari layered intrusion and coeval granites of the Paleoproterozoic Dongargarh Supergroup, Bastar Craton, India	M.P.Manu Prasanth, Alora Sweta Padma Sharma, M Santosh, Cheng-Xue Yang and K.R.Hari	Geology & WRM	Precambrian Research Volume 391, 1 July 2023, 107040	2023	Print ISSN: 0301-9268 Online ISSN: 1872-7433	https://www.sciencedirect.com/journal/precambrian-research
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Insights into the petrogenetic evolution of the Khallari layered intrusion and coeval granites of the Paleoproterozoic Dongargarh Supergroup, Bastar Craton, India

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ABSTRACT

Several layered igneous complexes around the globe host ultramafic-mafic lithologies at the base to more evolved lithologies at the roof sections. In this study, we report U-Pb zircon ages and geochemistry of Paleoproterozoic granites and Khallari layered intrusion from the Dongargarh Supergroup of Bastar craton, central India. The Khallari layered intrusion hosts pyroxenites at the base to more evolved lithologies including gabbro, layered gabbro and anorthositic gabbros towards the roof section of the magma chamber. The estimated weighted mean U-Pb zircon ages of granites (2443 ± 13 Ma) and layered intrusion (2494 ± 19 Ma and 2469.2 ± 5.2 Ma) are in conjunction with the major Siderian crust building peak identified at the craton. The granitic plutons of the Dongargarh Supergroup are chemically similar to post-collisional/anorogenic granitic rocks, in which the rapakivi granites exhibit a fractional crystallization relation with the Khallari layered intrusion. The Dongargarh granites and enclaves were derived by a combination of fractional crystallization and mixing of partial melts from the pre-existing crust of the Bastar craton. Petrogenetic modeling indicates Khallari layered intrusion is formed by the fractional crystallization of lithospheric mantle melt followed by crystal accumulation. The parental melt also experienced localized crustal contamination (up to 10%) during its evolution. The layered intrusion and the granites formed in a post-collisional rift setting where magmatism postdates the proposed subduction and collisional orogenesis at 2.5 Ga involves cratonic domains of Eastern and Western Bastar cratons.

1. Introduction

Layered-mafic ultramafic intrusions are among the largest magmatic complexes on earth; however, their petrogenesis remains debated (Cawthorn, 1996; Charlier et al., 2015). Though layered igneous suites have been investigated for several decades, no single model can completely explain the complexity of their magmatic characteristics (Smith and Maier, 2021; Yao et al., 2021). From studies on the major layered intrusions, a wide range of magmatic layers and cryptic layering features have been identified, hence it is unlikely that a single layer-forming process can explain all the features of layered igneous complexes (Irvine, 1987; Charlier et al., 2015). Most layered igneous suites

are formed through multiple injections of mantle-derived magma emplaced into the crust over a short period (<1 myr) (Zeh et al., 2015). The magmas of the layered intrusions are originally sourced from the mantle, likely via lithospheric and/or sub-lithospheric upwellings and interacted with the overriding lithosphere during its ascent and emplacement on crust. Multiple magma pulses from the mantle to the crust result in different magmatic layers and zones, that exhibit complex macroscopic and microscopic and compositional layering, which manifest various petrogenetic processes such as magmatic differentiation, cumulate formation, and/or crustal contamination (Cawthorn, 1996; Charlier et al., 2015; Maier et al., 2000). However, the physical attributes of the layered intrusions, like their form, associated magmatic

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Petrogenesis of ultramafic rocks with abyssal peridotite affinity from the Central Bundelkhand Craton, India

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ABSTRACT

The Bundelkhand craton in India preserves important records of Archean geological evolution, where several ultramafic rocks belonging to the Babina Greenstone Belt (BGB) occur as isolated and oval shaped bodies. These rocks are composed of olivine, orthopyroxene, amphiboles, and serpentine along with accessory mineral phases like chromian spinel and ilmenite. Here we present the major and trace element geochemistry of these ultramafic rocks that are characterised by low SiO₂ (45.16–49.00 wt%), high MgO (24.41–29.15 wt%) and moderate Fe₂O₃ (5.82–9.95 wt%) with high Ni (1164–1674 ppm), Cr (1532–3477 ppm) and Cu (14.7–39.5 ppm) suggesting primary magmatic nature. The rocks show low rare earth element (REE) content (Σ REE 2.1–3.5 ppm) with depleted LREE pattern and flat to slightly fractionated HREE pattern similar to abyssal peridotite signature. The Nb/Yb ratio ranges between 0.01 to 0.20 (average = 0.03), similar to that of N-MORB, suggesting magma derivation from a depleted mantle source, further substantiated by the Th/Yb vs. Ta/Yb plot. Trace elements like Ta and Pb show positive spikes, whereas La, Nb, Pr and Ce show depleted nature. The rocks generally have low platinum group elements (PGE) content (<150 ppb) except one sample where it goes up to 388 ppb. The Σ PPGE concentration is higher than Σ IPGE for all the samples and the high Pd/Ir ratio (7.55–20.98) indicating the derivation of these ultramafic rocks from low degree of partial melting. Our data suggest that the ultramafic rocks were derived from a depleted mantle source at a shallow depth with affinity towards abyssal peridotite. These rocks might represent residue after extraction of low degree melt (~2–10%) in a mid-oceanic ridge (MOR) setting, which were captured and brought to shallow levels and subsequently exposed on the surface.

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1. Introduction

Mafic-ultramafic rocks are the significant entities of greenstone belts in Archean cratons (Anhaeusser, 2014; Condie, 2000; Verma et al., 2016), and provide important insights into the geodynamics and crustal evolution of the greenstone belts (Windley, 1995; Jayananda et al., 2013; Anhaeusser, 2014; Hölttä et al., 2014; Patra et al., 2020) in addition to offering crucial record of early lithospheric history of the earth (De Wit and Ashwal, 1995). The Archean greenstone belts are mainly composed of meta-volcanic sequences, sediments (greywackes, quartzite, chert,

and banded iron formations (BIFs)), surrounded by Tonalite-Trondhjemite-Granodiorite (TTG) gneisses, whereas the plutonic ultramafic-mafic rocks show genetic relationship with high Mg-magma (Rollinson, 1997). Systematic investigations of the ultramafic rocks yield important information on Earth's geodynamic history, as well as clues to the formation of important mineralisation such as chromite, magnetite and platinum group elements (PGEs; Rollinson, 1997; Arndt et al., 1998; Mondal et al., 2006; Barnes et al., 2013; Santosh and Groves, 2022).

The ultramafic rocks of peridotitic composition that underwent serpentinization as results of sea-water interaction, are referred to as abyssal peridotite, which are commonly found beneath mid-oceanic ridge setting (Dick and Bullen, 1984; Johnson et al., 1990). They are widely exposed at slow-to-intermediate spreading ridges (Dick et al., 1984; Cannat et al., 1995) and are believed

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DISCREPANCIES IN LAND GOVERNANCE IN THE STATE OF CHHATTISGARH: A FIFTH SCHEDULE AREA OF THE CONSTITUTION

Dr. Alekh Kumar Sahu* & Swarnika Tirkey**

Abstract

This article made an endeavor to analyze the Fifth schedule of the Constitution and its different arrangements and exceptional provisions made for regions occupied by Scheduled tribes and the law connecting with local self-governance here. It unites different legislative protections accessible to the tribals communities relating to the land and administrative governance in the scheduled areas and the role of various institutions to accomplish the objectives cherished in the Constitution.

It likewise caused a short assessment of how these statutory and legal protections convert into reality with focus on some key challenges to the privileges of tribals over their areas, assets, livelihoods, and homeland and whether the legal system provided the expected protections. It introduced relative analysis of the state of Chhattisgarh, Bastar division essentially; and attempt to highlight the lacuna in land governance in the state.

INTRODUCTION

Scheduled areas are those regions which are dealt with differently in contrast to other regions in a state as in entire of the managerial and administrative working in the state isn't stretched out to these regions and the central Government has to some degree more noteworthy obligation regarding these Regions.

Chhattisgarh, is a state in central India, having several areas designated as Scheduled Areas, primarily inhabited by tribal communities. Scheduled Areas are regions identified under the Fifth Schedule of the Indian Constitution, which provides for the administration and control of Scheduled Areas and Scheduled Tribes. The purpose is to safeguard the rights and interests of tribal communities residing in these areas. In Chhattisgarh, the Scheduled Areas cover a significant portion of the state, given the substantial tribal population. Some of the districts in Chhattisgarh that have Scheduled Areas include:

Bastar Division: This division comprises several districts with a substantial tribal population, including Bastar, Kanker, Dantewada, Bijapur, and Narayanpur.

Surguja Division: Surguja is another region in Chhattisgarh with Scheduled Areas. The districts in this division include Surguja, Jashpur, and Korea.

The administration of Scheduled Areas involves special provisions and protective measures to preserve the cultural, social, and economic rights of the tribal communities.

THE LAW

5th Schedule of Indian Constitution deals with the administration and control of certain areas called Scheduled and Tribal Areas in ten Indian states, which come under the category of 5th schedule states. The ten states included in this list are Himachal Pradesh, Odisha, Chhattisgarh, Madhya Pradesh, Andhra Pradesh, Gujarat, Telangana, Jharkhand, Rajasthan, and Maharashtra. The scheduled areas in Mizoram, Meghalaya, Tripura, and Assam are excluded from the 5th schedule of Indian Constitution and covered in the 6th schedule. The scheduled and tribal areas are inhabited by economically and socially backward people.

According to the 5th Schedule of Indian Constitution, an area is declared as a Scheduled Area if it fulfils the following criteria-

- Economic backwardness of the area (in comparison to its neighboring areas),
- a viable entity for administration such as taluk, block, or district,
- the Area's reasonable size and compactness,
- tribal population's preponderance.

Though the Indian Constitution does not spell out this criterion. Still, there are principles for declaring the partially excluded and excluded areas under the Government of India Act 1935.

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AMBEDKAR'S ADVOCACY FOR TRIBAL RIGHTS: A LEGAL ANALYSIS

Dr. Alekh Kumar Sahu* & Yuvraj Singh**

ABSTRACT:

This research study delves into the legal analysis of Dr. B.R. Ambedkar's advocacy for tribal rights in India. Dr. Ambedkar, a visionary leader and the chief architect of the Indian Constitution, had a profound commitment to promoting social justice and the empowerment of marginalized communities, including tribal populations. Through a comprehensive legal analysis of Ambedkar's writings, speeches, and contributions to the Constitution, this research aims to understand the core principles of his advocacy for tribal rights and evaluate their impact on shaping the legal landscape for tribal communities. The study also seeks to assess the challenges faced by tribal populations in the realization of their rights, and the potential gaps and areas for improvement within the Indian legal framework.

KEY WORDS: Marginalized, Advocacy, Communities, Tribal

INTRODUCTION:

Dr. B.R. Ambedkar, an eminent jurist, social reformer, and the chief architect of the Indian Constitution, dedicated his life to fighting for social justice and the rights of marginalized communities. Among the various communities he advocated for, the cause of tribal rights held a prominent place in his mission to create an equitable and inclusive society. Ambedkar's unwavering commitment to the upliftment of tribal communities resonated deeply with his vision of a democratic India founded on principles of equality, liberty, and fraternity.

The plight of tribal communities, historically marginalized and disenfranchised, became a focal point of Ambedkar's advocacy for social transformation. These indigenous peoples, often living in remote and geographically challenging areas, faced myriad challenges, including land dispossession, discrimination, lack of access to basic amenities, and limited participation in decision-making processes. Their rights to land, culture, and self-governance were frequently disregarded or subjugated, leading to their perpetual state of vulnerability and deprivation.

This research paper delves into Ambedkar's comprehensive and multifaceted advocacy for tribal rights and seeks to present a legal analysis of his contributions. It endeavors to shed light on Ambedkar's juridical principles, examining how he envisioned the legal framework as a powerful tool for the empowerment of tribal communities. Through an in-depth study of Ambedkar's speeches, writings, and legislative efforts, we aim to explore the profound impact of his ideas on shaping tribal rights and justice in the context of the Indian legal system.

The paper will explore the key principles of Ambedkar's juridical thoughts and their application to address the historical injustices faced by tribal communities. We will critically evaluate the legislative measures proposed and championed by Ambedkar to safeguard the rights and welfare of tribal populations. Additionally, we will examine landmark legal cases that have influenced the interpretation and implementation of tribal rights, highlighting the role of Ambedkar's ideas in shaping these precedents.

Furthermore, this research will seek to assess the effectiveness and limitations of Ambedkar's legal approach concerning tribal rights. By analyzing the contemporary relevance of his principles and their impact on the socio-economic and political status of tribal communities, we aim to understand the extent to which his vision has been realized and identify areas where further progress is needed.

In conclusion, this research paper seeks to contribute to the growing body of knowledge surrounding Ambedkar's advocacy for tribal rights. It endeavors to provide a nuanced legal analysis of his work, demonstrating how his ideas continue to shape the discourse on tribal justice and empowerment in India. By shedding light on Ambedkar's contributions, we hope to inspire continued efforts to address the challenges faced by tribal communities and realize his vision of a just and equitable society for all.

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** (B.A.LL.B, LL.M)

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[ग्रन्थालय एवं शोध लेख लिखने के लिए चैटजीपीटी के उपयोग का वर्णन करता है। चैटजीपीटी एक भाषा आधारित मॉडल है, जिसका उपयोग शोधार्थी अपने शोध लेख, लेख लिखने और ग्रन्थालयाध्यक्ष संदर्भ सेवाओं के लिए करते हैं। शोधार्थी द्वारा मुक्त कृत्रिम बुद्धिमत्ता (Open Artificial Intelligence) उपकरण चैटजीपीटी का उपयोग कर अपनी शोध उत्पादकता की वृद्धि का वर्णन करता है।]

1. परिचय (Introduction)

चैटजीपीटी (ChatGPT) का पूरा नाम चैट जेनेरेटिव प्री-ट्रेन्ड ट्रांसफार्मर (Chat Generative Pre-trained Transformer) है। सन् 2020 में पहली बार मुक्त कृत्रिम बुद्धिमत्ता (OpenAI) ने जीपीटी-3 मॉडल को लाया गया था, यह मॉडल गहन अध्ययन और ट्रांसफार्मर आर्किटेक्चर पर आधारित है। इस मॉडल में लगभग 175 अरब पैरामीटर हैं, जिनकी सहायता से मॉडल की भाषा को समझने और समझाने में सहायता होती है। चैटजीपीटी एक बड़े स्तर पर डेटा से सीखने वाले (Data-driven) भाषा मॉडल हैं। इसमें बड़ी संख्या में डेटा को प्रशिक्षित किया गया है जिससे वह वाक्यांशों को समझ सके और और उनका सार्थक उत्तर प्रदान कर सके। यह विभिन्न भाषाओं में अनुवाद करने, सारांश तैयार करने, प्रश्नों के उत्तर देने और अन्य भाषा से संबंधित कार्यों के लिए भी उपयुक्त है।

चैटजीपीटी के दो सबसे महत्वपूर्ण भाषा मॉडल वर्तमान में उपलब्ध है, पहला जीपीटी 3.5 और दूसरा जीपीटी-4। यह ज्ञान के कई क्षेत्रों में प्राकृतिक भाषा के पाठ को तैयार कर सकता है। अकादमिक लेखन, वैज्ञानिक लेखन और प्रकाशनों में चैटजीपीटी का उपयोग करना अन्य कृत्रिम बुद्धिमत्ता (Artificial Intelligence) उपकरणों से अपेक्षाकृत और भी आसान है। वर्तमान में चैटजीपीटी का उपयोग शिक्षा के क्षेत्र में, स्वास्थ्य के क्षेत्र में, लेखन के क्षेत्र में व्यावसायिक क्षेत्र में, विज्ञान एवं तकनीकी क्षेत्र में किया जा रहा है।

2. उद्देश्य (Objectives)

चैटजीपीटी (ChatGPT) के निम्नलिखित उद्देश्य हैं :

1. सार्थक उत्तर प्रदान करना : चैटजीपीटी (ChatGPT) का मुख्य कार्य वाक्यों को समझकर सार्थक उत्तर प्रस्तुत करना है, यह उपयोगकर्ताओं के विभिन्न प्रकार के प्रश्नों का उत्तर देने में सक्षम बनाता है।

2025

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उप सम्पादक: डॉ. अरविन्द कुमार शर्मा

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डॉ. (श्रीमती) नीति ताम्रकार

पं. रविशंकर शुक्ल विश्वविद्यालय, रायपुर के कला एवं सामाजिक
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Pt. RaviShankar Shukla University, Raipur)

तोरन लाल खुटे
डॉ. हरीश कुमार साहू

[ई-संसाधनों का अर्थ स्पष्ट करते हुए इनकी विशेषताओं का वर्णन करता है। पं. रविशंकर शुक्ल विश्वविद्यालय, रायपुर के कला एवं सामाजिक विज्ञान के स्नातकोत्तर छात्रों द्वारा ई सूचना संसाधनों उपयोग एवं लाभ का वर्णन करता है।]

1. प्रस्तावना (Introduction)

समय के बदलते परिवेश में हमारे द्वारा उपयोग किये जाने वाले संसाधनों में अब मुद्रित संसाधनों का उपयोग कम होने लगा है तथा इसका स्थान ई-संसाधन ले रहे हैं। आधुनिक शैक्षणिक वातावरण में शिक्षण एवं शोध की प्रत्येक गतिविधि को ई-सूचना स्रोतों ने प्रभावित किया है। जिससे सूचना के स्थानांतरण एवं संचार प्रक्रिया में तेजी से परिवर्तन आया है। सूचना एवं संचार प्रौद्योगिकी के त्वरित विकासों ने सूचना स्रोतों की एक नई पीढ़ी को जन्म दिया है, जिसे हम ई-संसाधन कहते हैं। ई-संसाधन के द्वारा डिजिटल ग्रन्थालयों, संस्थागत रिपोजिटरी, ई-लर्निंग एवं कनसोर्टिया जैसी आधुनिक सेवाओं एवं गतिविधियों को बढ़ावा मिला है। आज के आधुनिक ग्रन्थालय न केवल महत्त्वपूर्ण दौर से गुजर रहे हैं, बल्कि उनकी सेवाओं और तकनीकों में भी बदलाव आ चुका है। प्रस्तुत अध्ययन में ई-संसाधनों से तात्पर्य उन संसाधनों से है, जिनके द्वारा किसी भी विषयवस्तु की जानकारी क्षणों में प्राप्त की जा सकती है, जिसके अन्तर्गत ई-डेटाबेस, ई-जर्नल, ई-पुस्तकें, ई-थीसिस एवं ई-पत्रिकाएँ सम्मिलित हैं।

ई-संसाधन ऐसे स्रोत हैं, जिनमें सूचना इलेक्ट्रॉनिक माध्यम में पाई जाती है, इसमें सूचना प्राप्त करने के लिए इलेक्ट्रॉनिक संयंत्रों जैसे-कम्प्यूटर, लैपटॉप इत्यादि की आवश्यकता पड़ती है। इलेक्ट्रॉनिक संसाधन को ही ई-संसाधन के रूप में जाना जाता है। आज शिक्षा में भी अपनी पारंपरिक शिक्षा से ई-संसाधन की ओर स्थानांतरित होना पड़ रहा है। अतः अब ग्रन्थालयों द्वारा भी ई-डेटाबेस का उपयोग कर उपयोगकर्ताओं की मांगों को पूरा किया जा रहा है।



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Research Productivity of Central University of Chhattisgarh and Madhya Pradesh

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Abstract

This paper analysis on the research output of two renowned Universities in India. A comparative Bibliometric study of the Guru Ghasidas University of Chhattisgarh and Hari Singh Gour the University of Madhya Pradesh. The GUN Ghasidas Vishwavidyalaya in the State of Chhattisgarh and Doctor Harisingh Gour Vishwavidyalaya in the State of Madhya Pradesh, established under the Madhya Pradesh Adhiniyam, 1973 under the university act 2009. Both Central Universities were analyzed with different parameters. This study attempted to analyze the publication trend and growth and pattern of published documents of Guru Ghasidas Vishwavidyalaya, Bilaspur, and Harisingh Gour Vishwavidyalaya, Sagar which were indexed in Web of Science by analyzing them with the help of bibliometric techniques from the period 1991-2022. The data shows that the total number of retrieved documents from Guru Ghasidas University was 1458 and data retrieved from Harisingh Gour University was 2805. This paper includes themes like relative growth rate, compound annual growth rate, degree of collaboration, and doubling time. This paper indicates that both universities work well in all the parameters. However, the result shows that the compound annual growth rate of Guru Ghasidas University is 19.33 and Harisingh Gour University is 3.04. Doubling time (Dt) shows that Guru Ghasidas University Maximum Dt was recorded in the year 2005 (11.60), and Harisingh Gour University Maximum Dt was recorded in the year 2022 (15.85).

Keywords: Research productivity, growth rate, doubling time, degree of collaboration and relative growth rate.

1. Introduction

Research productivity may often be considered a key role in achieving quality knowledge and disseminating knowledge worldwide. Research is a core part of every university it enables the generation of intellectual property, discoveries, and innovations with values. 'Bibliometric' and 'Scientometric' are two such words that are used simultaneously. The term 'Bibliometric' was first used by Alan Pritchard in 1969. Bibliometric means quantitative analysis of publication by application of mathematics and statistical methods. The term 'scientometric' was first used by Nalimov and Mulchenko in the same year of origin the term bibliometric 1969. Scientometric means quantitative analysis of science, technology, and innovation.



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Research Productivity of the Journal of Ravishankar University (Part-A) from 2016-2023

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ABSTRACT

The Purpose of the Study is to explore the Journal "Journal of Ravishankar University (Part-A)" and the relationship between measuring and analyzing Articles, Authorship, The subject of distribution, Growth Ratio, Relative Growth Rate etc. The paper analyzes a bibliometric study of 88 articles were published during the period 2016-2023 in the Journal of Ravishankar University (Part-A). The paper covers bibliometric analyses of the year-wise distribution of articles, subject-wise distribution of articles, authorship patterns, and Relative Growth Rate.

KEYWORDS: Bibliometrics, Authorship pattern, Growth Ratio, Journal of Ravishankar University (Part-A), Doubling time.

INTRODUCTION

Bibliometrics is a research method used in library and information science. It is a quantitative study of various aspects of the literature on a topic and is used to identify the pattern of publication, authorship, and secondary journal coverage to gain insight into the dynamics of the growth of knowledge in the areas under consideration. This can lead to better organization of information resources, which is essential for effective and efficient use. Bibliometrics has attained sophistication and complexity with a national, international, and interdisciplinary character. (Thanuskodi)

The terms Bibliometrics and Scientometrics were introduced simultaneously by Pritchard, Nalimov, and Mulchenko in 1969. Pritchard defined the term 'Bibliometrics' as the application of mathematical and statistical methods to books and other communication mediums'. "Nalimov and Mulchenko" defined 'Scientometrics' as 'the application of those quantitative methods which are dealing with the analysis of science viewed as an information process'. So, Scientometrics is the measurement of science communication, and Bibliometrics deals with more general information processes. Bibliometrics is a quantitative evaluation of publication patterns of all macro and micro

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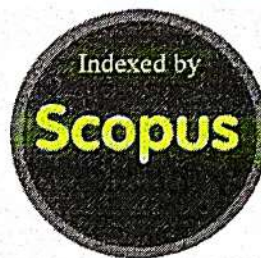
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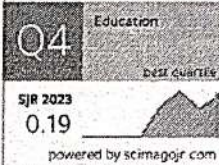
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The study Assessed with Extent and Utilization of E-Resources at Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

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ABSTRACT

The study unveils the diverse array of e-resources and services utilized by research scholars at Indira Gandhi Krishi Vishwavidyalaya, Raipur. Data collection employed a well-structured questionnaire, and descriptive inquiry was employed for analysis. Out of the 290 researchers surveyed, 247 responses were received. The study findings highlight that the most frequently accessed e-resources are e-books 137 (55.47%), e-journals 117 (47.37%), and e-magazines 91 (36.84%). Additionally, the study explores the challenges faced during the utilization of e-resources, with the highest reported issues being server downloads or system problems 77 (31.17%) and the least being poor connection 75 (30.36%). The results indicate that libraries play a crucial role in facilitating the effective use of e-resources.

Key Words: E-resources, e-books, e-Journals, IGKV, Raipur, Research Scholar, Library, Server.

INTRODUCTION

Every library is the heart of educational institutions and aids in fulfilling the objectives of educational institutions. The main purpose of libraries and information science is to provide satisfaction to the intellectual community around the world. Dr. Ranganathan, a pioneer in Indian library science, coined the term "Library Trinity" for books, users, and library staff. The evaluation of a library and its identification are based on the development and management of its resources; therefore, there is a significant emphasis on the collection, development, and management of resources in the library. Library experts have contributed to the development and management of collections in libraries.

As a result of the explosion of knowledge and the development of new technologies, library resources are transforming into electronic formats in the present time. With the rapid development of electronic publications, libraries are not only acquiring printed books and periodicals but also obtaining library resources in electronic form. In the 21st century, electronic resources have witnessed rapid development and popularity. E-resources come in various forms, including e-books, e-journals, e-research papers, e-databases, CDs/DVDs, e-newsletters, e-conference proceedings, e-reports, e-manuscripts, e-newspapers, and Internet/websites, among others. The library is not just a repository of books but the center of knowledge.

INDIRA GANDHI KRISHI VISHWAVIDYALAYA, RAIPUR

Situated in the capital of Chhattisgarh, Raipur, Indira Gandhi Krishi Vishwavidyalaya is the sole Agricultural University in the state, entrusted with the responsibilities of agricultural education, research, and the extension of technologies. With a distinguished and extensive history of service to the tribal farming community in the region, the university has been a pivotal institution. Its primary objectives encompass providing education in agriculture and allied sciences, conducting research in these domains, implementing field extension programs, and enhancing the standard of living in rural areas. Recognized as a significant biodiversity repository globally, particularly for rice and lathyrus, the university plays a major role. Education is delivered through 28 constituent and 11 affiliated colleges within the faculties of agriculture and

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(Study of Research Productivity of Agriculture Scientists
on the subject of Horticulture with Special Reference to
Indira Gandhi Krishi Vishwavidyalaya, Raipur)

श्रवण यादव*

डॉ. हरीश कुमार साहू**

[उद्यान विज्ञान कृषि संकाय का आधार स्तम्भ है, इंदिरा गांधी कृषि विश्वविद्यालय, रायपुर में सन् 2004 से 2021 तक उद्यान विज्ञान विषय में कुल 67 शोध हुए हैं, जिसमें 44 पुरुष एवं 23 महिला शोधार्थी हैं। उद्यान विज्ञान में सबसे अधिक सन् 2021 में 15 शोध तथा डॉ. जितेन्द्र सिंह द्वारा सबसे अधिक 09 शोधार्थियों को शोध हेतु निर्देशित किया है। उद्यान विज्ञान में सर्वाधिक शोध आलू फसल का अध्ययन कर निष्कर्ष प्रस्तुत करता है।]

1. परिचय (Introduction)

उद्यान विज्ञान कृषि के महत्वपूर्ण विषयों में से एक है, जिसमें फल, फूल, सब्जियां, मसाले, कंद फसलें, मशरूम, बांस, वृक्षारोपण फसलें और औषधीय एवं सुगंधित पौधे शामिल हैं। उद्यान विज्ञान शब्द आंग्ल भाषा के शब्द Horticulture से मिलकर बना है। Horti शब्द लैटिन भाषा Hortus means garden तथा Culture शब्द Cultura means Cultivation से लिया गया है। उद्यान विज्ञान की प्रमुख शाखाएं फलोत्पादन विज्ञान, शाकोत्पादन विज्ञान, पुष्पोत्पादन विज्ञान व अलंकृत वागवानी एवं फल परीक्षण विज्ञान हैं। फल विज्ञान— इसमें फल उत्पादन के विभिन्न पहलुओं जैसे पौध प्रबंधन एवं नर्सरी प्रबंधन, उत्पादन तकनीक क्रियाओं, तुड़ाई एवं उसके उपरांत प्रबंधन एवं विकास के उपायों आदि के सैद्धांतिक एवं व्यावहारिक पहलुओं का अध्ययन करते हैं। शाकोत्पादन विज्ञान— इसके शाक-सब्जी के उत्पादन के सिद्धांत तथा तकनीकों का अध्ययन किया जाता है। पुष्पोत्पादन विज्ञान— इसमें सभी फूलों, शोभाकारी पौधों एवं बागवानी के सिद्धांत एवं तकनीकों का अध्ययन किया जाता है। फल परीक्षण विज्ञान — इसमें फसलों के उत्पादन को खराब होने से बचाने, उनके लम्बे समय तक उपलब्धता को सुनिश्चित करने तथा विभिन्न प्रकार के खाद्य

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Manuscript assessment:



Utilization of E-Resources by Research Scholar of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur: A Study

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Abstract

The presented research article is related to the use and awareness of e-resources by research scholars of Jawaharlal Nehru Agricultural University, Jabalpur. Main objective of the study is to find out the awareness and use of e-resources among the Research Scholars, to explore the purpose for which the research scholar uses the e-resources, to find out the frequency of usage of e-resources, assessing satisfaction with the use of e-resources among research scholars, to examine the various problems faced by the research scholar, and to give suggestions for improvement. The purpose of the study is based on primary data collected from Research Scholars of Jawaharlal Nehru Agricultural University, Jabalpur. The study found that users were aware of e-resources, e-journals being used the most by 79 (24.92%) users. Research scholars 84 (29.89%) are using e-resources the most for their research. 66 (18.54%) respondents are facing the problem of Poor connectivity (Low bandwidth) and also 45 (12.64%) are facing Server down or system problem. Researchers are saving time for their research by using e-resources 81 (24.55%).

Keywords: E-resources, JNKV, Research Scholar, e-books, e-Journals, database.

Introduction

The field of information and communication technology has progressed significantly, leading to revolutionary changes in all fields of knowledge. Libraries often referred to as storehouses of knowledge, have also kept pace with this development. With the explosion of information, users now have access to vast amounts of information, and the library plays a crucial role in preserving and serving their information needs. In the current context, libraries are the main facilitators in the scholarly communication system. In simple terms, libraries select, acquire process, store and retrieve information for current use, making them a place where books and other sources of information are available for teaching, research, and extension activities. The new generation of users prefers online resources as they want all the information at their fingertips. Electronic information resources have reduced the role of traditional libraries. Librarians must accept their

Application of Lotka's Law in the field of Congestive Heart Failure in India – A Scientometric Analysis

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ABSTRACT

This study examines Lotka's law of authorship distribution in the field of Congestive Heart Failure from 1989 to 2023. The data were retrieved from the Web of Science database. A total of 2565 documents were retrieved and analyzed through Histcite and Bibexcel software. Graphs and Charts are made through Microsoft Excel. The data were examined by type of document, year-wise distribution, journal-wise distribution, and Prolific author. The applicability of Lotka's law and Kolmogorov-Smirnov (K-S) test has been analyzed to find out the scientific productivity. The findings of the study revealed that congestive heart failure articles gradually increasing and the highest publications are recorded in the year 2021. Journal articles have the highest impact on types of documents. The most productive journals are the European Journal of Heart Failure and the International Journal of Cardiology with 124 and 63 articles on Congestive Heart Failure. The most productive author is Kumar A with 73 contributions followed by Yusuf S with 56 contributions. The study reveals that Lotka's law applies to the authors of congestive heart failure where the Dmax value is lower than the critical value.

KEYWORDS: Heart attack, Congestive Heart failure, Scientometrics, Lotka's law, Productivity, K-S test, Prolific author.

INTRODUCTION

A heart attack, also called myocardial infarction, occurs when the blood flow that supplies oxygen to part of the heart muscle is suddenly blocked. Your heart isn't getting enough oxygen. If blood flow is not restored quickly, the heart muscle begins to die. A heart attack is not the same as cardiac arrest, which occurs when the heart suddenly and unexpectedly stops beating. A heart attack can lead to sudden cardiac arrest. Most heart attacks are caused by coronary heart disease. Age, lifestyle, and other health conditions can increase the risk of a heart attack. Symptoms of a heart attack include chest and upper body pain, shortness of breath, dizziness, sweating, and nausea. Women often experience various heart attack symptoms.

Lotka's Law and Authorship patterns in Urinary tract infections and Diabetes: A Scientometric analysis

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ABSTRACT

An infection that can occur in any part of the urinary system is known as a urinary tract infection (UTI). The urinary system comprises the bladder, urethra, ureters, and kidneys. The majority of infections affect the lower urinary system's bladder and urethra. This study presents a scientometric analysis of authorship patterns in Urinary Tract Infection (UTI) and Diabetes. The study focuses on Lotka's law to understand the productivity and impact of authors in the field. For this study, 1149 documents were retrieved from the Web of Science database from 2009 to 2023. The USA leads in publications on UTIs and diabetes among all countries. Among all authors, Kuku K has been the most productive author. K-S test reveals that the current data set does not support Lotka's law's applicability to research on urinary tract infections and diabetes. The findings of the study suggest that there is a need for more research to be done to improve the understanding of the relationship between UTI and Diabetes.

KEYWORDS: Urinary Tract Infection, Diabetes Mellitus, Lotka's Law, Authorship pattern, Scientometric, Author productivity, Diabetes.

INTRODUCTION

A urinary tract infection (UTI) is an infection in any part of the urinary system. The urinary system includes the kidneys, ureters, bladder, and urethra. Most infections affect the lower urinary tract – the bladder and urethra. Women have a higher risk of developing a urinary tract infection than men. If an infection is limited to the bladder, it can be painful and annoying. However, if a urinary tract infection spreads to the kidneys, it can cause serious health problems. (*Urinary Tract Infection (UTI) - Symptoms and Causes - Mayo Clinic*, n.d.). Type 2 diabetes mellitus is a heterogeneous group of disorders characterized by variable degrees of insulin resistance, impaired insulin secretion, and increased glucose production. Patients with type 2 diabetes mellitus are at increased risk of infections, with the urinary tract being the most frequent infection site. The increased risk of UTI among diabetic patients, coupled with the increase in the incidence of type 2 diabetes mellitus worldwide in recent years, may impose a substantial burden on medical costs. (Nitzan et al., 2015). Due to several circumstances, the likelihood of



Effect of Air Pollution on Respiratory System: A Scientometric Analysis

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Abstract

Air pollution is a significant health risk factor all over the world. Air pollution has a very bad effect on the respiratory system. The term scientometrics originated as a Russian term for the application of quantitative methods of the history of science, which studies the quantitative aspects of science. This applied study was done using scientometric techniques and software. The data collection was performed on June 2, 2023 from the Web of Science (WoS) database. The search period was from 1991 to 2023. Data has been analyzed with the help of HistCite Software, charts & graphs have been made with the help of Microsoft Excel. In this study, the most productive authors, top journals, year-wise distribution, and country-wise distribution of publications has been analyzed. The highest number of scientific outputs belongs to USA, China and UK followed by other countries which extensively had a lower rate of publication. Science of the Total Environment journal has been ranked first among the journals published the most articles i.e. 111 out of 2805 articles. The result shows that Bradford's law of scattering does not fit well when analyzing the collected data of research articles of air pollution on the respiratory system.

Keywords: Scientometric analysis, Bradford Law, Air pollution, Respiratory system, Publication output.

1. Introduction

Air pollution is a significant health risk factor in Europe, and all over the world. A global study of diseases risk factors. Approximately 7 million people in the world and 400,000 people in the European Union (EU) experience early death due to air pollution. (Unver)

Air pollution is a complex mixture of different gaseous and particulate components and can cause several health effects. Both long and short-term exposure to air pollution can cause cardiovascular diseases, respiratory diseases (e.g. asthma, chronic obstructive pulmonary disease) and mortality. (Bergstra et al.)

Four adverse effects of air pollution on the respiratory system that is Asthma, COPD, lung cancer and respiratory infections all seem to be exacerbated due to exposure to a variety of environmental air pollutants with the greatest effects due to particulate matter (PM), ozone and nitrogen oxides. New publications reviewed reaffirm these findings. (Kurt Kar et al.)

Scientometrics

Since the development of scientometrics and bibliometric techniques they are proved to be the most dynamic tools to evaluate the productivity of universities, research institutes and individual researchers, as well as to map the growth of the research field. Scientometrics is a study of quantitative aspects of information in any form, not just records or bibliographies and

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Awareness and use of KrishiKosh
(Institutional Repository of Indian
National Agricultural Research System)
by the Research Scholars of IGKV,
Raipur: A Study

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ABSTRACT

The objective of this study is to investigate the level of awareness, utilization, and impact of the KrishiKosh Institutional Repository. It is an online repository established by the Indian Council of Agricultural Research (ICAR) to centralize agricultural research outputs and knowledge from ICAR institutes and affiliated organizations. The repository provides access to agricultural research literature and resources for researchers, academics, and professionals in the agricultural field. The study focused on research scholars from Indira Gandhi Krishi Vishwavidyalya, Raipur, and employed a questionnaire as the primary data collection tool. The results of the study revealed that a significant proportion (96.80%) of research scholars are aware of KrishiKosh, and the main source of their awareness is the university library and faculty/department. The majority of scholars reported using KrishiKosh for their research purposes. Additionally, the scholars expressed a need for more training programs and improved infrastructure to enhance their reading experience.

Key Words: KrishiKosh, User Awareness, Institutional Repository, Indian National Agricultural Research System, User Satisfaction, IGKV, ICAR.

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From the Desk of Editor

The editorial board of journal of Ravishankar University (JRU) Part A [Social-Science], would like to extend a very warm welcome to the readership of JRU Part A [Social-Science]. I would like to offer a word of thanks to our readers, our author and contributors and editors for their support of the journal and its mission to promote original research papers and reviews in all branches of Social Science, including Management, Law, Psychology, History, Economics, Sociology and Social work, Library and Information Science, Literature and Languages, Philosophy and yoga, Ancient Indian history, Physical education, Education, Hindi, and English.

The editorial board has put significant efforts to digitize the back issues of the journal (which are available in Print Media). However, if any discrepancy or typographical errors are found in any of the manuscript in this issue, please refer to the PDF version of the corresponding manuscript.



A Study on Use of Electronic Resources and Services by Users of Pt. Sundarlal Sharma Library, PRSU Raipur, Chhattisgarh

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Abstract:

This paper aims to propagate the pivotal role of e-resources in the academic environment, particularly focusing on the postgraduate students of the Science stream of Pt. Ravishankar Shukla University, Raipur. A survey method was employed and a well-structured questionnaire was designed for collecting the data from respondents. This study focused to find out various aspects related to the use of e-resources by the target respondents i.e. awareness level, purpose of using e-resources, time spent by the respondents, etc. This study will enhance the infrastructure and basic requirement of e-resources in the library uplift the teaching and learning environment in the university and offer an insight to policy makers and librarians for better use of e-resources. as a result found that the Total 219 (100%) respondent's use internet for e- resources and other purposes. The highest 182 (83.11%) of respondents use email followed by 146 (66.67%) use e-books, e-journals 85 (38.81%), e-newspaper clippings 76 (34.70%), e-pg pathshala 64 (29.22%), e-magazines 37 (16.89%), e-thesis 26 (11.87%), e-shodhganga 21(9.59%), e-repository13(5.94%),e-database 12(5.48%), and lowest 03(1.37%)by used is e-shodhsindhu. and The majority of the 163 (74.43%) respondents are satisfied with the use of e-resources,12 (5.48%) are dissatisfied, 19 (8.68%) are very satisfied and 25 (11.42%) respondents don't know the satisfaction level.

Keywords: Electronic Resources, Services, PG Students, Science, Pt. Sundar lal Sharma Library, PRSU Raipur.

Introduction

Developments in Information and Communication Technologies (ICT) have radically taken over every sphere of activity in university libraries. Academic libraries owe it a key duty to keep pace with technological advancement to cope with users' continual sophisticated information requirements. Academic libraries in the 21st century may not function properly without the existence of electronic resources. Over the years, technology has progressed significantly, leading to the development of new techniques and standards that manage and distribute content in various formats. As a result, librarians are increasingly embracing e-resources in their collections to address users' e-resource needs. Information and Communication Technology (ICT) based computers and the internet have brought about significant changes in the operations of library institutions, necessitating adaptations in internal library processes and user services. Traditional libraries are transitioning into digital and virtual libraries due to advancements in technology and web development. Information technology has not only

Anthropometric Indicators Among Adolescent Female Players After Soy Supplement in Chhattisgarh India

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ABSTRACT

Adolescence is a transitional phase from childhood to adulthood. It is a period of development as the gain of anthropometric measurements is increased over this period. India is a country with different tribal groups and Bastar district is a tribal belt of Chhattisgarh state in India. The nutritional status is a major concern among adolescent girls, which affects growth and development and forms basis of adulthood, dietary supplements can play an important role to address the concerns. The study aimed to explore the effect of soy supplement on the anthropometric measurement of tribal girls. A total of 120 female players aged 12 to 18 years from a residential school where the female players take part in sports training as well as attend the school Khel Parisar Kanker (KPK) from the tribal area and female players of Sports Authority of India (SAI) of urban area were selected for the study. Female players of KPK and SAI were divided into Experimental Group (EG) (N=30) and Control Group (CG) (N=30). Soy Supplement in form of Soy Ladoo was provided to the experimental group from August'2018 to March'2019. Before and after experimental design with control groups was used in the study. Height, Weight, Mid Upper Arm Circumference (MUAC), Waist Girth (WG) were measured and BMI was calculated. ANCOVA and trend analysis were used to analyse the data. It was found that Anthropometric measurements (MUAC, WG and BMI) increased significantly in EG than CG in KPK and SAI female players. An upward trend was observed and can be concluded that soy supplement was effective in improving anthropometric measurements.

Keywords: Soy supplement, adolescent girls, anthropometric measurement, Khel Parisar Kanker (KPK), Sports Authority of India (SAI)

INTRODUCTION

A balanced diet is an essential element in the life of one and all, it needs special attention during the adolescent period as it is the period of the growth spurt and developmental stage where physical, physiological and mental changes take place, which requires that each cell of the body is well nourished to work optimally when these adolescents take part in sports the nutritional requirement needs much more attention as per increased demand of the physical activity for optimal performance.

The “dietary supplement” means a product (other than tobacco) intended to supplement the diet that contains one or more dietary ingredients, including a vitamin, minerals, a herb or other botanical substance, an amino acid, a dietary substance, for use by man to supplement the diet by increasing the total dietary intake, or a concentrate, metabolite, constituent, extract or combination of any of aforementioned ingredients.¹ A dietary supplement is also known as a food supplement or nutritional supplement, is a preparation to provide nutrients when it is lacking in the diet.²

Soy supplement is a preparation of soybean has global importance and economic value. It has an excellent source of high quality of all 8 essential amino acid such as cysteine, tryptophan, leucine, isoleucine, lysine, valine, histidine, phenylalanine. It has soluble carbohydrates, dietary fibres, Omega 3 and Omega 6 fats. It also contains minerals such as calcium, iron, copper, zinc, magnesium, phosphorus, potassium and flavonoids which are important for growth and to build lean body mass.³

Adolescence is an intermediate phase between childhood and adulthood. According to WHO the age ranges from 10 to 19 years. It is a period of rapid growth and demand higher nutrition because up to 50% of the height and skeletal mass is gained during this period. Anthropometric measurements are used commonly to assess nutritional status. It displays health, nutritional status and anticipates performance. It also reflects the growth pattern of individuals.

In India adolescent girls aged 11 to 18 years are about 16.75% of the total female population.⁴ Their nutritional status is low and nutritional anaemia is a major health problem, The National Family Health Survey 3 (NFHS 3) data suggests that 56% of girls of 15 to 19 years were anaemic.⁵

Chhattisgarh was established on 1st November 2000 by splitting ten Chhattisgarhi and six Gondi districts of Madhya Pradesh. Bastar district is a tribal belt of Chhattisgarh. The major tribes are Gond, Batra, Muria, Abujmaria, Bison, Hornmaria, Halba, Dhurva.⁶ Almost 70% of the population are tribals. They are an important part of the state population and lives mainly in the dense forest of Bastar. They depend upon primitive agriculture practices and often face problems like scarcity of food, poverty, health problems and improper education facilities.

The plethora of studies revealed that anthropometric measurements were significantly lower among adolescent girls. Kapoor and Aneja reported that 35.5% of adolescent girls aged 11 to 18 yrs of Delhi are undernourished.⁷ Adolescent girls were found to be 3 to 10cm shorter and 3 to 15 Kg lighter than their U.S. counterparts.⁸ A study in nine states of India reported that about 42% of adolescent tribal girls were undernourished.⁹ In another study, 58.44% stunting and 72.71% wasting was found in tribal girls.¹⁰ Sharma et al. (2013) report that 42.6 % of girls were undernourished.¹¹ Venugopal et al (2016) state that weight and height, when compared with NCHS 1987, CDC 20-07-2010, ICMR 2010 growth reference and all the anthropometric measurements, were significantly lower among adolescent girls of Chhattisgarh.¹² Various other studies also revealed that the prevalence of lower nutritional status is common in adolescent girls in Chhattisgarh (C.G.). Kurrey et al. reported underweight 32.5%, stunting 22% and thinness 24% among Bihor tribal children.¹³ A Study has reported 57.1% of children to be thin in the sample.¹⁴ Low BMI was reported in Gond tribes of C.G.¹⁵ Lower weight and height were reported in Kamar children in almost all ages.¹⁶

Insufficient protein intake has been shown to have a negative association with growth indicators and performance of players. Proper nutrition is very crucial for adolescent players, to address the body composition as well as to meet the demand for training and competition load. The players in the tribal area working hard to excel in sports, hence this issue of energy requirement and specifically protein intake were taken into cognizance.

Aim of the study:

- To investigate the effect of SS on anthropometric indicators, selected under study.

MATERIAL AND METHODS:

Selection of Subjects:

A total of 120 players from Khel Parisar Kanker (KPK) and SAI were selected for the study. Participants of both groups were divided into the Experimental group (N=30) EG and Control group (N=30) CG. Soy ladoos prepared from processed soy flour, besan (Bengal gram flour), sugar, almond, cashewnut and ghee were consumed by the experimental group. They consume 50 grams per day which have 10.3gram protein. CG did not consume Soy laddoo. The experimental protocol was approved by the ethical committee (246/IEC/PRSU/2018). All the subjects were trained according to their sports for 4 hours along with their academic engagements. Before testing the written consent form was taken regarding the willingness of participation in the study.

Selection of variables:

Mid upper arm circumference (MUAC), Waist girth (WG) and Body mass index (BMI) are used to identify the status of muscle development, the proportion of abdominal fat and body composition. Height, Weight, MUAC, Waist Girth (WG) was measured with standard techniques and BMI was calculated.

Experimental design:

Experimental design before and after with control group was used. The variables were measured in the beginning and after every three months for the experimental group and control group till 9 months after the supplementation. Data collected was analysed through SPSS package 25 version.

RESULTS:

Table 1. Descriptive statistics of the effect of soy supplement on MUAC, WG and BMI between KPK and SAI girls.

		KPK GIRLS N=30		SAI GIRLS N=30	
MUAC	MEASURES	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST
EXPERIMENTAL GROUP	MEAN	7.87±10	8.98+-.14	8.59+-.17	9.95+-.21
	SD	.59	.77	.93	1.18
CONTROL GROUP	MEAN	9.01+-.17	8.85+-.19	10.07+-.21	9.33+-.17
	SD	.95	1.04	1.17	.95
WG EXPERIMENTAL GROUP	MEAN	23.74+-.32	26.91+-.33	26.36+-.38	28.11+-.40
	SD	1.76	1.83	2.12	2.20
CONTROL GROUP	MEAN	27.30+-.40	26.38+-.47	29.17+-.38	28.06+-.52
	SD	2.21	2.57	2.09	2.87
BMI EXPERIMENTAL GROUP	MEAN	18.48+-.31	0+-.27	20.40+-.50	20.79+-.37
	SD	1.72	1.48	2.74	2.03

CONTROL GROUP	MEAN	18.70+-37	18.18+-40	20.78+-46	20.23+-37
	SD	2.06	2.20	2.52	2.07

Table 1 shows the mean course of MUAC, WG, BMI before and after the soy supplement. Mean score gain in the experimental group of KPK girls and SAI girls in MUAC is 1.11 inches and 1.36 inches, in WG is 3.17 inches and 1.75 inches and in BMI is 1.32 to and 0.39 respectively whereas control groups of KPK and SAI did not show any change in any of the variable selected.

Table 2. Analysis of covariance and comparison of adjusted post-test means of soy supplement on MUAC, WG and BMI between EG and CG of KPK and SAI girls.

MUAC	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG	PARTIAL ETA SQUARED
Contrast	33.208	3	11.069	15.09	.000	0.283
Error	84.335	115	0.733	-	-	-
WG						
Contrast	127.127	3	42.376	11.10	.000	0.225
Error	438.827	115	3.816		-	-
BMI						
Contrast	57.740	3	19.247	11.51	.000	0.231
Error	192.203	115	1.371		-	-

Table 2 reported a significant difference in adjusted post-test mean scores of MUAC between EG and CG ($F(3,115) = 15.09, p < 0.00$). Lower effect (.283) after soy supplement was seen when compared with Cohen's guidelines of effect size (0.2- small effect 0.5- moderate effect, 0.8-large effect). The partial eta squared value of .283 justifies 28.3% effect of soy supplement (Independent variable) on MUAC (Dependent variable) in EG.

The significant difference in the adjusted mean score of WG was also reported between EG and CG ($F(3,115) = 11.10, p < 0.00$). Small effect (.225) after the soy supplementation was seen when compared with Cohen's guidelines of effect size. The partial eta squared justifies 22.5% effect of soy supplement on WG in EG.

Similarly, the significant difference in adjusted post-test mean score of BMI between EG and CG ($F(3,115) = 11.51, P < 0.00$). Small effect (0.231) after the soy supplementation was seen when compared with Cohen's guidelines of effect size. The partial etas squared justifies 23.1% effect of soy supplement on BMI in EG.

Table 3. Trend analysis of the effect of soy supplement on MUAC, WG and BMI of KPK and SAI girls.

Measures	Source of Variation	Type III sum of squares	Df	Mean Square	F – ratio	Sig.
MUAC	Intercept	38952.033	1	38952.033	14663.240	.000
	Group	100.185	3	33.395	12.571	.000
	Error	308.174	116	2.656		
WG	Intercept	345210.951	1	345210.951	24480.473	.000
	Group	761.065	3	253.688	17.990	.000
	Error	1635.772	116	14.101		
BMI	Intercept	185369.123	1	185369.123	11984.725	.000
	Group	367.275	3	122.425	7.915	.000
	Error	1794.185	116	15.467		

Table 3 reported statistically significant improvement in trend on MUAC after Soy Supplement ($F(1,116) = 14663.24, p < .000$) at 1% level of significance. It also shows the statistically significant difference in comparing the trend of MUAC between KPK and SAI girls ($F(3,116) = 12.57, p < .000$) at 1% level of significance.

Similar improvement in trend on WG was seen ($F(1,116) = 2448.047, p < .000$) at 1% level of significance after soy supplement. It also shows the statistically significant difference in comparing the trend of WG between KPK and SAI girls ($F(3,116) = 12.57, p < .000$) at 1% level of significance.

Likewise, improvement in trend on BMI was seen ($F(1,116) = 11984.72, P < .000$) at 1% level of significance after soy supplement. The trend on BMI between KPK and SAI girls ($F(3,116) = 7.91, P < .000$) at 1% level of significance shows a statistically significant difference.

Table 4. Trend analysis of the effect of soy supplement on MUAC, WG AND BMI among KPK and SAI girls.

Source	Factor 1	Type III sum squares	Df	Mean Square	F-ratio	Sig.
MUAC	Linear	13.054	1	13.054	27.87	.000
	Factor*Group Linear	46.723	3	15.574	33.256	.000
	Error(factor1)	54.324	116	0.468		
WG	Linear	40.119	1	40.119	17.69	.000
	Factor*Group Linear	196.439	3	65.480	28.872	.000
	Error(factor1)	263.079	116	2.268		
BMI	Linear	1.034	1	1.034	0.793	.375
	Factor*Group Linear	36.832	3	12.277	9.417	.000
	Error(factor1)	151.242	116	1.304		

Table 4 supports Linear trend $F(1,116) = 27.87, p < .000$, between independent variable (soy supplement) and dependent variable (MUAC) for EG. It also showed a statistically significant difference in linear trend $F(3,116) = 33.25, p < .000$, between KPK and SAI female players.

Similarly, the table supports the linear trend $F(1,116) = 17.69, p < .000$, between the independent variable (soy supplement) and dependent variable (WG) for EG. It also showed a statistically significant difference in linear trend $F(3,116) = 28.87, p < .000$ between both the groups.

In case of the linear trend $F(1,116) = .793, p < 0.05$, did not support between the independent variable (soy supplement) and dependent variable (BMI) for EG whereas it showed a statistically significant difference in the linear trend $F(3,116) = 9.41, p < .000$ on BMI between the KPK and SAI players.

DISCUSSION:

Anthropometric measurements are important indicators of growth and optimal growth can contribute to better performance. MUCA, WG and 8 BMI showed significant improvement in EG of KPK and SAI female players which can be considered as a factor for performance

improvement. A large number of studies indicates that players need to ingest protein two times of RDA (1.5 to 2.0 kg/d) to maintain protein balance.^{17,18,19,20} An overview that soy being a dense source of protein with all essential amino acid helps to attain protein requirements before, during and after exercise.²¹ Studies have shown that soy protein contributes to optimising muscle performance during and after exercise²² and promotes lean body mass gain.^{23,24,25,26} Munson States 20 to 25 gram of protein every 3 hours is needed to maintain muscle protein synthesis.²⁷ Low protein consumption ($0.86\text{kg}^{-1}\text{day}^{-1}$) by strength-trained athletes results in reduced protein synthesis compared with medium and high $1.4\text{g kg}^{-1}\text{day}^{-1}$ and $2.4\text{g.kg}^{-1}\text{day}^{-1}$ protein diets respectively.²⁸ Soy has antioxidant properties and similar digestibility and absorption properties like animal protein, so it is good for vegans. Thus, soy supplement is implemented to the sportsperson.

CONCLUSIONS AND RECOMMENDATIONS:

MUAC, WG and BMI are the important anthropometric indicators and significant improvement have been observed in these indicators after nine months of soy supplementation in the diet of the experimental groups. Soy supplement can be included in the diet of adolescent female players to improve body composition, which may in turn be helpful in better performance.

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Competing Interest:

Authors acknowledge that no competing interest exists.

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Growth and Nutritional Status of the Gond tribe of Chhattisgarh, India

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Abstract- Objective - To assess the growth and nutritional status of the Gond children.

Methods - A cross sectional study of the physical growth was conducted on 409 Gond children (194 boys and 215 girls), aged 12 to 17 years, in the Bastar district of Chhattisgarh. The study aimed to find out the growth pattern of the Gond children, which is considered to be a primitive tribe of Chhattisgarh, India and was compared with other Indian tribe and the official data of NCHS1987, CDC 2007-2010 & all India (ICMR 2010). Anthropometric measurements included height, weight, sitting height, and measurements of the biceps, triceps and subscapula, supraspinale and calf skinfolds.

Results - All anthropometric measurements except skinfold thickness exhibited uniform increase with age in both sexes. Gond boys showed higher anthropometric values than girls in height, weight and sitting height whereas in all the skinfolds measurements mean values of girls were higher as compared to boys. The Gond children showed lower mean values as compared to NCHS & CDC 2007-2010 where as height & weight were at par with ICMR 2010 and higher than Kamar tribe. Around 47% boys & 72% girls reported to be in various category of malnutrition.

Conclusion - Poor socio-economic status of this primitive tribe may be one of the reasons for this poor nutritional status & growth pattern as compared to NCHS 1987. However, further study can be conducted to get more insight

Key Words – Growth Status and Nutritional Status, Gond Tribe.

INTRODUCTION

The nutritional status of growing children in a population indirectly determines the standard of living. Nutritional inadequacy slows down the growth

of children and which is observable response. Therefore, determination of nutritional status may prove to be a powerful tool to identify the health status of any population.

Tribal populations are isolated from general population with their own physical, socioeconomic and cultural environment. They are the most backward section of the society, due to various factors like ignorance, poverty, lack of development in the inaccessible areas, illiteracy and exploitation. Several studies have documented a close relationship between tribal ecosystem and their health and nutritional status.¹ The habitat of the tribe has conferred certain advantages. The dietary habits and other related modes of life contributed to their better nutritional and health status in some tribal groups, while in other groups these practices are not conducive to good health. ²

Many studies based on published data have indicated patterns of anthropometric variation along ethnic, geographic, latitude, longitude and altitude, nutrition and several confounding variables.³ This work is an attempt to study the growth status through anthropometric measurement of Gond, children a primitive tribe of Bastar district, Chhattisgarh state and to compare their growth & nutritional status with other studies.

The Gonds are one of the most famous and important tribes in India, known for their unique customs and traditions. They are mainly a nomadic tribe and call themselves as Koytoria. The term 'Gond' is derived from the Telugu word 'Konda' which means hill. Gond Tribes are primarily found in Madhya Pradesh, Chhattisgarh, eastern Maharashtra, northern Andhra Pradesh and Western Orissa. With a population of over

4 millions, Gonds also form the largest tribal group in central India⁴, which is around 55% within the tribal population.⁵ In Chhattisgarh Gond population are found in Bastar, Dantewada, Kanker, Suurguja and Raipur districts. The total population of Gond is 42,98,404 consisting of 21,20,974 males and 21,77,430 females (Census of India 2011).⁶ The staple food of Gonds tribes in Bastar district are Kodo or Kutki (millet), they are usually meat consumers.

MATERIAL AND METHODS

The present study was based on cross-sectional samples of 409 apparently healthy Gond children (194 boys and 215 girls), aged 12+ to 17+ years. The subjects were selected from various tribal schools of Bastar district, Chhattisgarh. Anthropometric measurements such as body weight, height, sitting height, biceps, triceps, subscapular and calf thickness were the variable measured, according to the standard

technique (Weiner and Lourie 1981 and Singh and Bhasin 1987).^{7,8} Standing and sitting height were measured to the nearest cms. using a wall-mounted stadiometer (manufactured by Harpenden). Weight was measured with a physician’s beam balance scale to the nearest 0.5 kg. A skin fold caliper was used to measure the skinfold thickness to the nearest mm.

Height and weight are basic measurement to understand the growth pattern and the nutritional status, separately as well through BMI (WHO 2004).⁹ Skinfold thickness are indirect but authentic method of assessment of body fat percentage in body.

Data on Anthropometric measurements were analyzed using descriptive statistics. Weight and height of the present data were compared with NCHS (1987)¹⁰, ICMR (2010)^{11,12}, CDC (2007-2010)¹³ and Mitra et al.(2002).¹⁴ Analysis was done by using Windows Microsoft Excel and SPSS.

RESULT

TABLE 1. Descriptive Statistics of Weight, Height and Sitting Height of Gond Boys and Girls.

Girls							
Age group	N	Weight(kg)		Height (cm)		Sitting height (cm)	
		Mean	SD	Mean	SD	Mean	SD
12+	28	32.6	5.91	137.6	7.7	53.0	4.90
13+	39	36.0	5.59	142.7	4.9	56.6	2.71
14+	37	37.0	5.72	146.7	5.6	55.7	3.70
15+	40	39.9	4.22	148.5	5.8	58.3	3.23
16+	35	41.7	4.43	150.0	4.8	58.7	3.16
17+	36	42.3	3.57	150.6	5.0	60.7	2.69
Boys							
12+	30	36.1	7.56	147.9	9.3	57.9	9.08
13+	35	38.0	7.69	148.0	8.4	58.1	7.50
14+	30	46.6	6.01	156.5	6.7	63.5	4.49
15+	35	47.7	5.24	158.7	6.7	65.5	1.00
16+	31	51.7	4.65	161.0	6.2	64.9	6.16
17+	33	52.3	5.98	163.3	5.3	64.8	4.00

Table 1 Steady increment in mean weight was observed in the present study from 12+ to 17+ years of age. In case of girls minimum weight was 32.6 kg in 12+ year & maximum 42.3 at the age of 17+ years, difference of 9.7 kg was observed between 12+ to 17+ years. Mean weight of boys at 12+ was recorded to be 36.1 kg where as at 17+ year the weight was 52.3 kg weight gain of 16.2 kg was recorded in boys from 12+ to 17+ years. Higher weight was noted in boys as compared to girls in all the age.

Mean height of 12+ year girls was 137.6 cm which increased gradually and was 150.6 cm at the 17+ year, increase of total 13 cm was recorded. Growth spurt was noted between 12+ to 13+ years (5.14 cm). In boys the increase of height from 12+ (147.9 cm) to 17+ (163.3 cm) was 15.4 cm.

Mean value for sitting height were 53 cm (12+) & 60.7 (17+) for girls & 57.9 (12+) & 64.8 (17+) for boys. Total increment of 7.7 & 7.6 cm from 12+ to 17+ years were observed for girls & boys respectively.

TABLE 2. Descriptive Statistics of Skin fold measurement of Gond Boys and Girls.

Girls											
Age group	N	Biceps		Triceps		Sub scapular		Suprailac		Calf	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
12+	28	4.99	2.19	6.46	2.50	6.87	2.39	5.62	2.39	12.1	3.64
13+	39	4.72	2.05	9.27	3.24	8.21	2.37	7.13	2.75	12.9	3.39
14+	37	5.24	2.28	8.20	2.79	8.03	2.14	7.16	2.47	13.3	3.97
15+	40	5.11	2.33	8.70	1.98	8.42	1.68	8.05	2.59	12.9	3.39
16+	35	4.65	1.74	10.0	3.50	8.66	2.95	7.56	2.65	13.6	3.69
17+	36	4.25	1.72	9.36	2.82	8.67	2.69	8.00	2.64	13.4	4.78
Boys											
12+	30	2.63	.41	4.52	.96	5.03	1.31	3.60	1.53	8.45	2.52
13+	35	2.88	.81	5.27	1.91	5.10	1.39	3.75	1.76	8.45	2.06
14+	30	3.16	1.54	5.84	1.55	5.99	1.38	4.35	1.41	10.1	3.00
15+	35	2.68	.55	5.52	1.56	5.99	1.19	4.16	1.28	8.54	2.40
16+	31	2.83	.42	5.71	1.49	6.51	1.56	4.18	1.10	7.64	1.85
17+	33	3.04	.99	5.73	1.21	7.02	1.38	4.96	2.42	7.65	2.76

Descriptive statistics of skinfold measurement are presented in table 2 all the skin fold measurement showed increment from 12+-17+ years. Mean values of all the skin fold measurement were higher in girls as compared to boys through out 12+ to 17+ years, high SD value in measurements show greater inter

individual variability. Maximum increment observed in biceps triceps, Sub scapular, Suprailiac & Calf skinfold for boys were recorded 3.54 mm, 1.8 mm, 2.74 mm & 4.5 mm respectively, whereas in girls increment recorded to be 16 mm, 1.32 mm, 1.99 mm, 1.36 mm & 1.6 mm respectively from 12+ to 17+ years.

TABLE 3. Test of significance of various anthropometric measurement between the Gond tribe boys and girls

Age Group	Weight	Height	BMI	Sitting height	Biceps	Triceps	Sub scapular	Suprailac	Calf
12+	1.96	2.30*	7.20**	2.52*	5.79**	3.93**	3.65**	3.85**	4.46**
13+	1.23	4.44**	1.30	1.12	4.95**	6.37**	6.77**	6.19**	6.10**
14+	6.62**	5.84**	3.97**	7.73**	4.25**	4.13**	4.50**	5.53**	3.59**
15+	7.10**	5.60**	3.54**	4.30**	6.02**	7.63**	7.11**	8.02**	6.40**
16+	8.95**	6.42**	4.43**	5.27**	5.65**	6.42**	3.62**	6.60**	8.19**
17+	8.52**	8.16**	3.96**	5.02**	3.51**	6.80**	3.14**	4.97**	6.11**

SD – Standard Deviation,

*Significant at 5% and ** Significant at 1% level

Comparison of mean weight, height, sitting height & skin fold measurements between Gond boys & girls are shown in table 3. Statistically significant difference was observed in height between Gond boys & girls, boys being tall than girls at all age group (P<0.01). In case of weight higher mean values are seen in the boys in all the age group and statistically significant difference was observed in 14+,15+, 16+ &

17+ years of age (P<.01). In sitting height statistically significant difference was observed at all age group between boys & girls (P<0.01) except age group 13+. Mean values of biceps, triceps, sub scapular, suprailiac & calf skinfold measurements were higher in girls in all the age group, statistically significant difference was noted at (P<.01).

TABLE 4. Distribution of Body Mass Index value of Gond boys and girls (According to WHO 2004 Standard)

Boys				Age in Years	Girls			
Normal Range (18.50-24.99)	Mild Thinness (17.00-18.49)	Moderate Thinness (16.00-16.99)	Severe Thinness <16.00		Normal Range (18.50-24.99)	Mild Thinness (17.00-18.49)	Moderate Thinness (16.00-16.99)	Severe Thinness <16.00
4 (13.3)	7 (23.3)	2 (6.6)	17 (56.6)	12+	4(14.2)	2(7.1)	3(10.7)	19 (67.8)

7 (20)	11 (31.4)	9 (25.7)	8 (22.8)	13+	6(15.3)	10 (26.4)	5 (12.8)	18(46.1)
19 (63.3)	6 (20)	4 (13.3)	1 (3.3)	14+	12 (32.4)	5 (13.5)	8(21.6)	12(32.4)
22 (62.8)	9 (25.7)	3 (8.5)	1 (2.8)	15+	11(27.5)	13(32.5)	10(25)	6(15)
26 (83.8)	4 (12.9)	1 (3.2)	0	16+	15(42.8)	9(25.7)	6(17.1)	5(14.2)
24 (72.7)	9 (27.2)	0	0	17+	12(33.3)	15(41.6)	6(16.6)	3(8.3)
102 (52.5)	46 (23.7)	19 (9.7)	27 (13.9)	Total	60(28.0)	54(25.1)	38 (17.6)	63 (29.3)

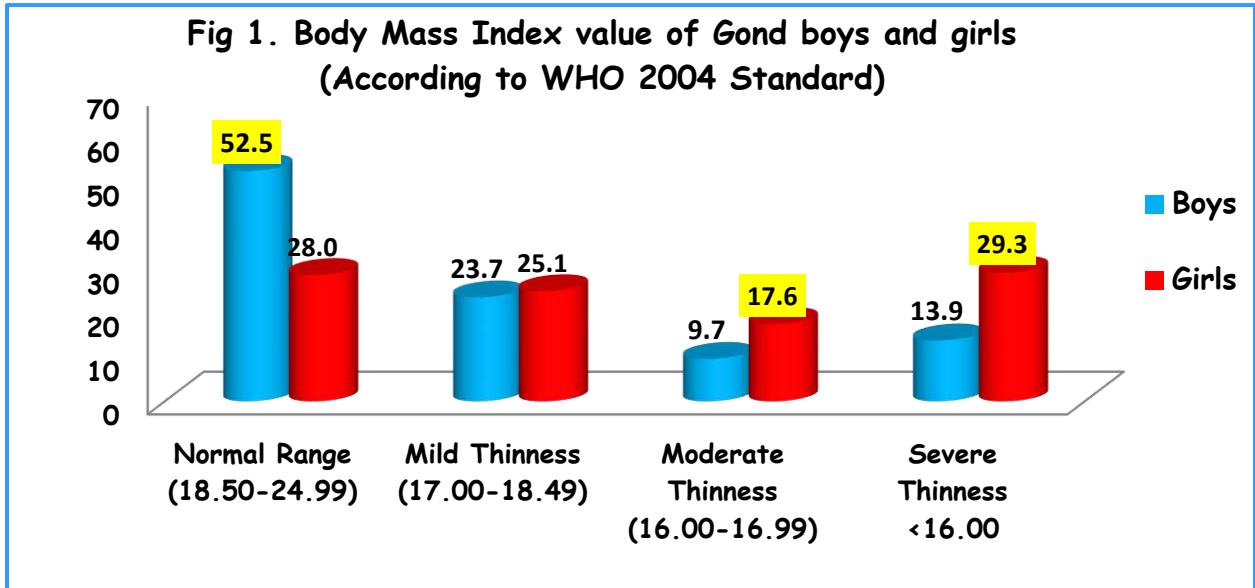


Table 4 & fig 1. shows the BMI according to WHO 2004 standard of malnutrition. BMI reveals that 52.5 % boys and 28.0% girls are classified under the normal category. 23.7 % boys and 25.1% girls suffered mild thinness 9.7% boys and 17.6 % girls suffered from moderate thinness and 13.9% boys and 29.3% girls suffered with severe thinness category of

malnutrition. Distribution of girls & boys in various nutritional categories showed different trend for different age group at age 12+ 56.6 % of boys 67.8 % of girls fell in severe malnutrition categories with increases in age malnutrition status in boys and girls improved. Which is evident from the reduced number of boys and girls in severe malnutrition categories.

TABLE 5. Comparison of mean of Weight of present Study with Other Studies

Age in Years	Present study	ICMR 2010	NCHS 1987	M.Mitra 2002	CDC 2007-2010
Boys					
12+	36.1	29.2	44.2	24.8	49.1
13+	38.0	32.6	49.6	25.7	54.0
14+	46.6	36.7	56.9	26.9	64.1
15+	47.7	41.1	61.0	31.0	66.9
16+	51.7	44.2	66.8	34.1	68.8
17+	52.3	47.1	67.5	37.2	72.9
Girls					
12+	32.6	29.6	47.10	23.60	49.0
13+	36.0	33.6	51.50	25.43	55.8
14+	37.0	37.2	54.70	27.25	58.5
15+	39.9	39.8	56.40	29.84	58.1
16+	41.7	42.0	58.20	31.82	61.3
17+	42.3	43.2	59.70	34.00	62.4

FIG 2. Comparison of mean of Weight of Boys in present Study with Other Studies

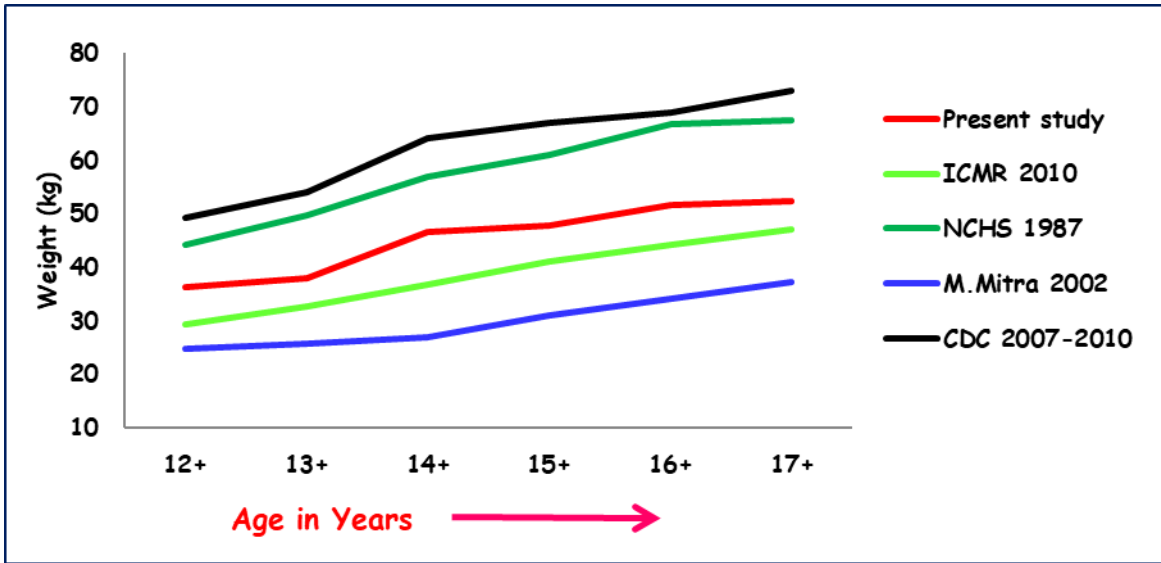


FIG 3. Comparison of mean of Weight of Girls in present Study with Other Studies

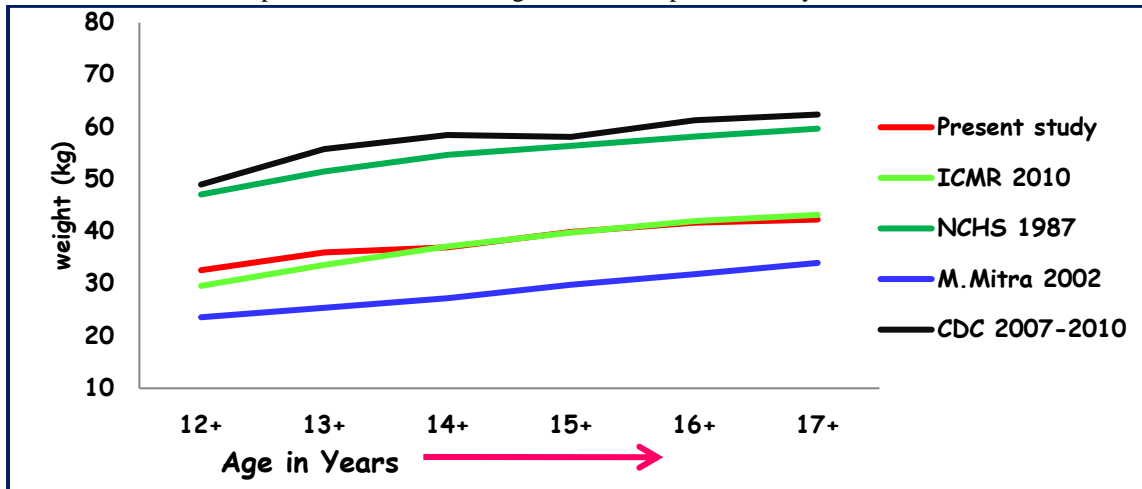


Table 5 & fig 2-3. shows the comparison of body weight of boys and girls of present study with other studies ie. reference data of NCHS (1987), ICMR (2010), CDC (2007-2010) and Mitra et al. (2002). It is

revealed from the table that present study mean were lower than NCHS (1987), and CDC (2007-2010) and higher than ICMR (2010) and Mitra et al. (2002).

TABLE 6. Comparative Analysis of Height of present Study with Other Studies

Age in Years	Present study	ICMR 2010	NCHS 1987	M.Mitra 2002	CDC 2007-2010
Boys					
12+	147.9	137.4	152.2	132.5	155.5
13+	148.0	142.7	159.2	137.1	161.6
14+	156.5	148.5	167.1	140.5	169.0
15+	158.7	153.8	170.8	144.7	172.8
16+	161.0	156.9	174.5	151.8	175.0
17+	163.3	159.7	175.5	155.9	176.5
Girls					
12+	142.7	137.6	154.6	130.6	156.1
13+	147.3	142.7	158.8	133.7	160
14+	147.7	146.7	160.9	140.3	161.6
15+	150.6	148.5	163.2	145	162.9
16+	152.1	150.0	162.2	147.9	162.2
17+	153.2	150.6	162.7	150.1	163.1

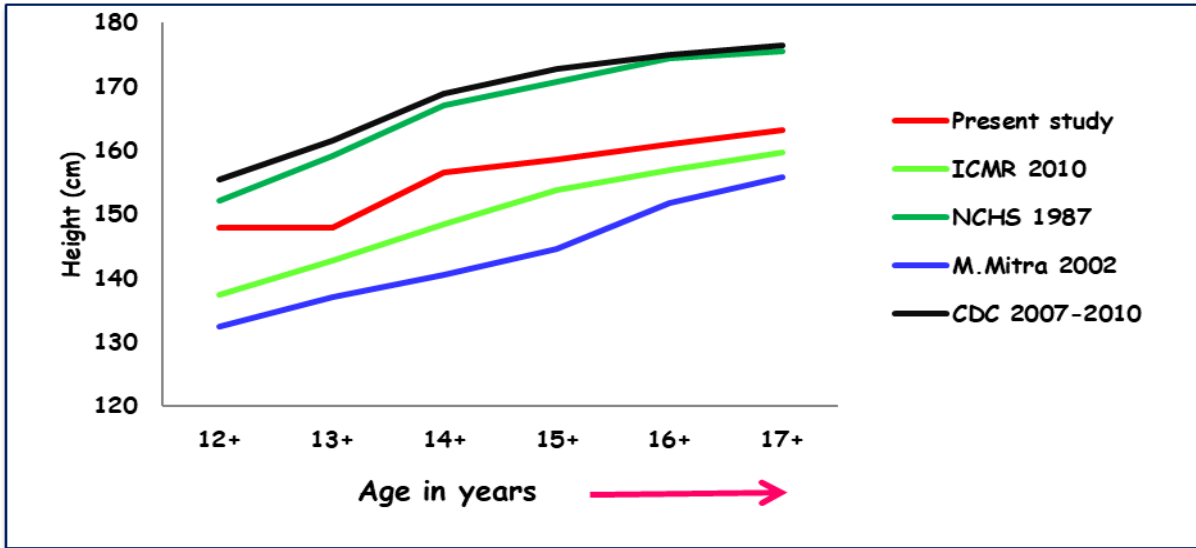


FIG 4. Comparison of mean of Height of Boys of present Study with Other Studies

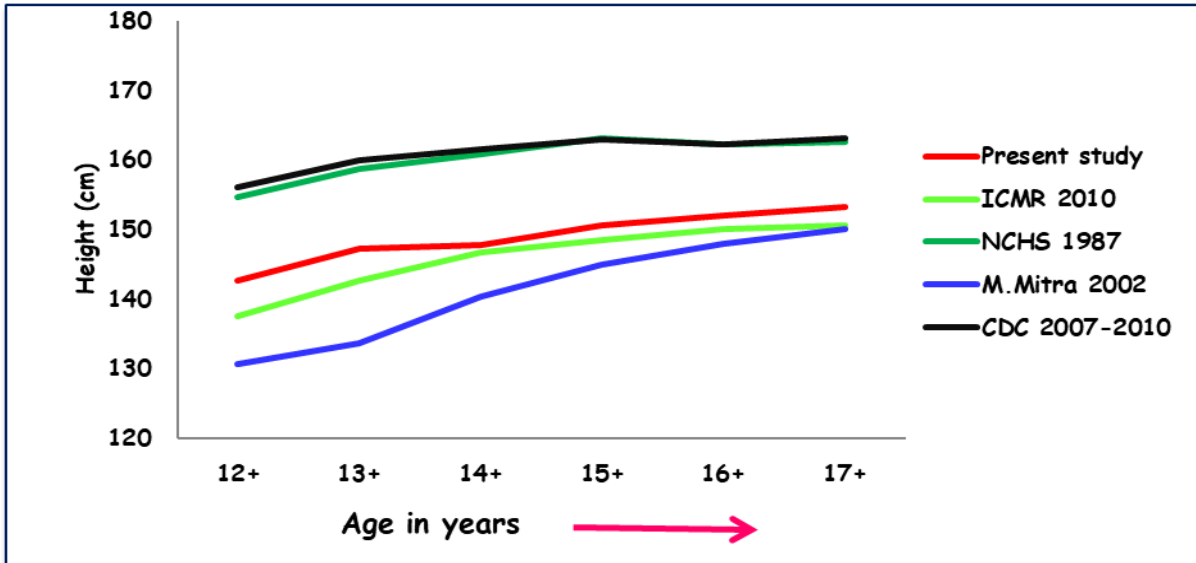


FIG 5. Comparison of mean of Height of Girls in present Study with Other Studies

Height of the boys and girls of present study were compared with reference data it was revealed that means of present study were lower than NCHS (1987), and CDC (2007-2010) and higher than ICMR (2010) and Mitra et al. (2002).

TABLE 7. Period of Occurrence of Adolescent Spurt As Indicated By »Hpv« In Different Body Measurements Among the Gond tribe of Chhattisgarh

Measurement	Boys adolescents spurt		Girls adolescents spurt	
	Age Group	HPV	Age Group	HPV
Body weight	13-14	8.6 kg	12-13	3.4 kg
Height	13-14	8.5 cm	12-13	4.6 cm
Sitting height	13-14	5.4 cm	12-13	3.6 cm
Biceps	14-15	0.48 mm	15-16	0.46 mm
Triceps	12-13	0.75 mm	12-13	2.81 mm
Sub Scapular	13-14	0.89 mm	12-13	1.34 mm
Supraspinale	16-17	0.78 mm	12-13	1.51 mm
Calf	13-14	1.65 mm	12-13	0.80 mm

HPV – Highest peak velocity

DISCUSSION

The present study examined growth and nutritional status of children from 12+-17+ years and increase in all anthropometric measurements under study was observed with increase in age. Weight and height of the Gond boys and girls were higher than Kamar boys and girls(Mitra et al 2002),¹⁴ another primitive tribe of central India where as it was lower as compared to CDC 2007-2010 & NCHS 1987 data.

The growth pattern of Gond boys and girls showed increasing trend in almost all the variables, the rate of increase showed different pattern for different variables. Highest peak velocity corresponding to the occurrence of growth spurt was observed between 12+ - 15+ years in girls and 12+ - 16+ years in boys. Among the boys out of eight body measurements five measurements (Weight, Height, Sitting height, Sub Scapular, Calf) showed the highest peak velocity between 13-14 years indicating an adolescent spurt in these measurements. Highest peak velocity was observed in the 12+ -13+ for Triceps Skinfold at 14+ - 15+ for Biceps Skinfold and at 16+ - 17+ for Supraspinale Skinfold. In case of the girls, highest peak velocity was observed in seven measurements (Weight, Height, Sitting height, Triceps, Sub Scapular, Supraspinale, Calf skinfold) out of eight, between 12+-13+ years. One measurements (Biceps skinfold) indicated highest peak velocity in the 15+-16 + years Present study shows that 28.8% girls were found to be normal. Deshmukh et al (2006)¹⁵ in their study of adolescents in rural Wardha district reported that 44% of adolescents girls to be in normal category of nutrition status. Nagamani et al (2015)¹⁶ in another study on adolescent Girls in Urban Slums of Visakhapatnam City, Andhra Pradesh State reported that 35% girls were chronic energy deficient (BMI<18.5). 80% of the girls were undernourished in a study done by Kalhan et al (2009)¹⁷ on adolescent girls of rural Haryana and 75.5% in a study done by Guduri et al (2014)¹⁸ on early adolescents girls (11-14) attending Government school of Visakhapatnam city.

Present study shows that 47.8% boys were underweight. Hunshal et al. (2010)¹⁹ in a study on subjects of 10 to 13 years in Dharwad district of Karnataka state have reported 82.6% of adolescents boys to be underweight. Similarly Prashant & Shaw (2009)²⁰ reported 42.6% & 22.9% prevalence of under

weight in girls as per NCHS & Indian standard respectively.

CONCLUSION

Height, weight, sitting height and skinfold measurement (Triceps, Biceps, Sub Scapular, Supraspinale, Calf skinfold) of Gond boys & girls were similar to ICMR 2010 and lower as compared to NCHS 1987 & CDC 2007-2010 standards. The Gond tribe when compared to other tribe Chhattisgarh it was found that the height, weight, sitting height and skinfold measurement (Triceps, Biceps, Sub Scapular, Supraspinale, Calf skinfold) of boys and girls of Gond tribes were higher. It is also concluded that 47.3% of boys 72 % girls suffered from different categories of malnutrition it was also observed that the malnutrition status improved with advancement of age.

Conflict of Interest : Authors have no conflicts of interest to disclose.

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Bibliometric Insights into Olympic Weightlifting Research Trends

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Abstract

Prologue: This research paper employs a rigorous bibliometric analysis to illuminate the evolving landscape of Olympic weightlifting research. The dynamic nature of weightlifting movements and their multifaceted impact on athletes form the backdrop of this study. The research identified key themes such as biomechanics, injury prevention, and the psychological aspects of weightlifting. Leveraging the extensive Web of Science database.

Methodology: In conducting this bibliometric analysis of Olympic weightlifting research, the database of Web of Science was selected as the primary source of data. A comprehensive search until January 8, 2024, yielded 10,103 articles, focusing on weightlifting, snatch, and clean & jerk. The first method involved utilizing specific keywords related to the subject, while the second method entailed identifying articles in selected journals. For inclusion the criteria were fixed to ensure relevance, including peer-reviewed publications in English. Data cleaning procedures addressed errors such as misspelled author names and variations in author affiliations. The VOSviewer 1.6.19 software facilitated bibliometric analysis, with a specific focus on keyword occurrences and co-occurrence mapping to unveil the intellectual structure of weightlifting research. This methodological approach ensures a systematic and comprehensive examination of the extensive body of literature in the field.

Results and Conclusions: The bibliometric analysis presents a vivid snapshot of Olympic weightlifting research trends, showcasing a steady increase in interest over the years. Visualization tools unveil the centrality of "Power" and its robust connections with key concepts like strength and performance. The co-occurrence analysis provides a nuanced understanding of the intellectual structure, emphasizing the multidimensionality of weightlifting studies. These findings underscore the growing role of bibliometric analysis in sports sciences. In conclusion, this research contributes invaluable insights into the evolving landscape of Olympic weightlifting, encapsulating biomechanics, injury prevention, and psychological aspects. The paper serves as a comprehensive resource for researchers, aligning with contemporary discourse and shaping the trajectory of future studies in the field.

Keywords: Bibliometric Analysis, Weightlifting, Snatch, Clean and Jerk, Power.

1. Introduction

Weightlifting movements are dynamic resistance exercises where the body parts move rapidly throughout the entire motion, causing the barbell to move quickly. In weightlifting there are two types of skill: the snatch (SN) and the clean & jerk (C&J), which are commonly done in weightlifting sports. Weightlifting movements are dynamic resistance exercises where there is a rapid acceleration of the body parts throughout the entire motion, leading to the barbell moving at high speeds [García-Valverde et al., 2022]. The actions in weightlifting can be broken down into catching, pulling, and pressing movement [Soriano et al., 2019]. Catching movements in weightlifting involve power clean and power snatch, done from different



positions like the floor, knee, and thigh. These can also be performed using blocks or plinths. On the other hand, pulling movements in weightlifting exclude the catching phase. Examples include snatch and clean pulls from the floor, knee, or thigh, done from a hang or using blocks/plinths. Additionally, there are variations like jump shrug, high pull, and hang high pull in this category. Evidence supports that these types of exercises are beneficial for achieving high power output and enhancing muscular power in athletes [Soriano et al., 2019]. Weightlifting is not only a standalone sport but is also crucial for training in other sports and as part of general physical exercise programs [Neumann, 2019]. Olympic weightlifting training involves doing fast and challenging resistance exercises. This type of training needs you to have good technical skills, speed, balance, coordination, and strength. Because muscles apply maximum force in just a short amount of time, the power you generate is more than what other strength athletes like bodybuilders and powerlifters can achieve [Huebner & Perperoglou, 2019]. We can measure technical skill by analysing how the barbell moves and how much it moves horizontally [Ang & Kong, 2023]. In the area of biomechanics, researchers have created tools like portable force plates and wearable force sensors. These devices aim to make it easier to measure force outside of a traditional laboratory with the progress of wearable technology and video analysis, there is a chance to create a portable solution for studying the forces and movements involved in Olympic weightlifting [Ang & Kong, 2023]. The danger of getting hurt while lifting heavy objects, whether at work or during free time, is a well-known issue. To find a balance between the total training load and recovery, direction have been provided for those who do resistance training. Some factors that increase the risk of injuries include lifting heavy weights in extreme joint positions. For instance [Faigenbaum & Myer, 2010]. found a higher risk of shoulder injuries when lifting weights in a specific way, as weightlifters do during a snatch. The squat movement might raise the risk of osteoarthritis. This could be because the knee joint undergoes high forces when doing squats. In powerlifting and weightlifting, deep squats are part of regular training and competitions [Aasa et al., 2017]. Weightlifting exercises and their variations, such as hang clean, hang snatch, power clean, power snatch, and high pull, are frequently applied widely used for training purposes to enhance physical attributes that contribute to performance in various sports [Morris et al., 2022]. Many sports training programs focus on improving strength, power, and speed. There is a connection between lower muscle strength, imbalances in strength, and slower sprint speeds, which increases the risk of injuries to the muscles and skeleton [Morris et al., 2022].

The Olympic sports gather a wide variety of human abilities, going beyond the Olympic motto of "Faster—Higher—Stronger." Achieving success on the Olympic podium demands exceptional genetic, physical, technical, and mental skills [Millet et al., 2021]. Physical activity and sports sciences have seen significant growth in recent decades, making them one of the scientific fields with the most publications each year. This surge allows for the conduction of reviews and meta-analyses, which gather the important inventions in each discipline. Due to this, various aspects of sports training and injury prevention in numerous sports, like football, basketball, or tennis, can be enhanced [Rincón et al., 2023]. Regular exercise significantly contributes to preserving muscle strength, cellular function, and supports older adults in maintaining an active and independent lifestyle [Huebner et al., 2020]. In sports, athletes often deal with mental fatigue, that may leads have negative affect on quality of their training and their success in competitions [Chen et al., 2023]. The way athletes express their psychological emotions may influence the performance in sports because of their individual personalities. Top athletes often experience ongoing challenges, both emotionally and physically. Consequently, it is crucial to comprehend their feelings and manage their emotions, as this plays an important role in their sporting achievements. Following guidelines for effective mental preparation, including building self-confidence,



maintaining focus, practicing positive visualization, and enhancing concentration, all contribute positively to athletes maintaining a suitable emotional state during training and competition [Baptistella do Nascimento et al., 2022].(Baptistella do Nascimento et al., 2022)

The popularity of this can be credited to the progress, widespread use, and easy access to tools like Gephi, Leximancer, VOSviewer, along with scientific databases such as Scopus and Web of Science. Additionally, the sharing of bibliometric analysis and methods from science to research has contributed to its widespread adoption across different fields [Donthu et al., 2021].

The study of bibliometrics is gaining more focus from the scientific community, driven by the rapid growth of computers and the internet. Bibliometric analysis has become a crucial method for examining research, originating from the field of library and information science. Numerous papers in various research areas, such as management, economics, health economics, fuzzy research, innovation, entrepreneurship, international business, and pricing research, offer comprehensive bibliometric insights [Merigó & Yang, 2017]. Bibliometric analysis is a statistical method used to study academic literature, helping us spot ongoing trends and new developments in particular fields. Unlike the conventional systematic evaluation and meta-analysis, bibliometric analysis provides a more comprehensive and intuitive understanding of the current status and the progression of research topics [Feng et al., 2022]. Bibliometric analysis has special advantages for evaluating research and creating knowledge maps. It helps us measure research productivity, impact, and collaboration through numbers, giving us a full picture of the field. Unlike other review methods like systematic reviews and meta-analyses, bibliometric analysis concentrates on studying how publications are written and cited [Wang & Xia, 2023].

2. Methodology

In this research, authors used the WoS Core Collection database. authors picked this database because it gathers important scientific papers and it is a main factor in academic decision-making [Jiménez-García et al., 2020]

In this research paper the information was taken from the data based named web of science until January 08, 2024. Authors selected web of science as the main database because it is widely used and respected in the academic community. Web of science is known for having a thorough collection of excellent research publications and is a key source of bibliographic information.

There are two ways by using that any information can be retrieved from database: 1) using specific words related to the subject, and 2) looking for articles in a few selected journals. For this study, the researcher chose the first method to include as many articles as possible about weightlifting, snatch and clean and jerk. The first step was setting important criteria for picking the articles.

This study was undertaken with a aim to find and focus on publications about weightlifting snatch and clean and jerk. To do this, the researcher used filters to specifically look for articles related to weightlifting, snatch and clean and jerk. The analysis was limited to original peer-reviewed publications found in journals listed on web of science. Only articles which are written in English language were considered. To keep the focus on academic contributions, the researchers included only articles and excluded other types of documents

The thorough investigation resulted in finding 10103 articles about weightlifting from the web of science database.



Checking and Cleaning Data

The step of cleaning of the data is a crucial step to get more accurate and trustworthy results before analysing data during working with bibliometric data. This kind of data often has problems like duplicates, mistakes, and missing information. Because bibliometric data can be changed, the researcher carefully examined and fixed it to remove possible errors and unnecessary repetitions before starting any analysis.

The study's examination identified four main types of errors: misspelling authors' names, using different formats for the same author names, presenting author affiliations in various formats, and not having publication timestamps for some articles. To fix these problems thoroughly, the researcher used thesaurus files and carefully corrected duplicate, inaccurate, and missing information in the bibliometric data.

The researcher used VOSviewer 1.6.19 software for bibliometric (scientometric) analyses. VOSviewer is a free tool that uses visualization techniques to create maps showing networks within large datasets. These networks include things like publications, authors, and keywords, along with connections like co-citations from the same publications, co-authorships, or co-occurrences.

The bibliometric analysis in this study focused on main area Analyzing the common occurrences of keywords in studies about weightlifting.

On the other hand, mapping gave a visual picture of the intellectual structure and how it evolved in our research field. It helped us see how different research elements interacted and connected, and the strength of these relationships. The researcher used a single analysis technique for mapping: co-occurrence.

3. Results & Findings

The main objective of the present study is to identify the most important keywords in the area of weightlifting. For the achievement of this, a co-occurrence analysis was carried out, emphasizing keywords that appeared together frequently specially a minimum threshold of 2 occurrence was set for keywords related to weightlifting research. This approach resulted in 45 keywords.

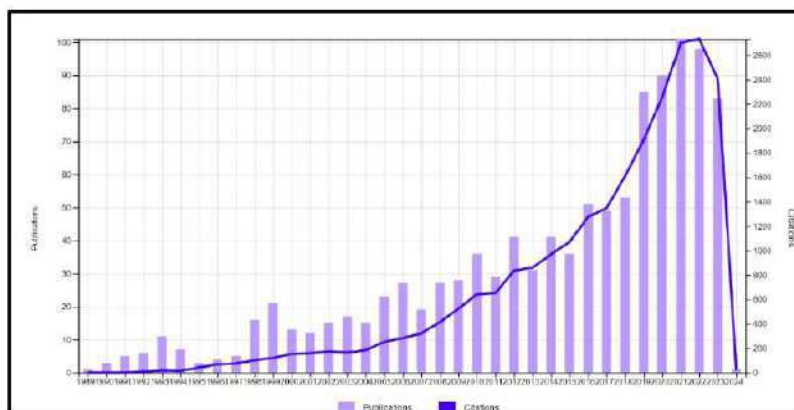


Figure:1: Publication frequency and citation metrics for weightlifting research from 1989 to 2024.



Table -1: Co-occurrence of the keywords associated with weightlifting research

S. No.	Key word	Occurrence	Total link strength
1.	Power	12	59
2.	weightlifting	19	52
3.	Strength	10	50
4.	Performance	6	35
5.	Exercise	9	26
6.	Snatch	5	24
7.	Vertical jump	5	23
8.	Periodisation	5	20
9.	Resistance Training	4	20
10.	Intensity	4	18
11.	Player	3	18
12.	Elite Male	3	17
13.	Force	2	16
14.	Position Statement	3	16
15.	Manipulating Volume	3	15
16.	Clean and Jerk	3	13
17.	Load	3	13
18.	Movement	2	12
19.	Powerlifting	3	12
20.	Snatch Technique	2	12
21.	Speed	2	12
22.	Athletic Performance	2	11
23.	Muscle Strength	4	11
24.	Peak	2	11
25.	Resistance Exercise	3	11
26.	Youth Weightlifting	2	11
27.	Association	2	10
28.	Optimal Training Load	2	10
29.	Strength Training	2	10
30.	Responses	2	9
31.	Sport Performance	2	9
32.	Men	2	8
33.	Olympic Weightlifting	2	8
34.	Weight	3	8
35.	Women	2	8
36.	Cross-Sectional Area	2	7
37.	Kinematic Analysis	2	7
38.	Maximum Strength	2	7
39.	Pain	2	6
40.	Perceived Exertion	2	6
41.	Physical -Activity	2	6
42.	Physical Activity	2	6
43.	Model	2	5
44.	Biomechanics	2	3
45.	Valsalva Maneuver	2	3
	Total	160	674



Table -1: Deals with the Co-occurrence of the keywords associated with weightlifting research. Each keyword associated with weightlifting research is assigned a serial number for reference. The "Keywords" column enumerates specific terms like "Power," "Weightlifting," and "Strength," reflecting key concepts within the weightlifting domain. The "Occurrence" column quantifies how often each keyword co-occurs with others in the analyzed literature. The "Total Link Strength" column measures the cumulative strength of connections between a keyword and all others in the dataset, reflecting the overall interconnectedness of concepts.

"Power" appears 12 times in conjunction with other keywords with a total link strength of 59.

"weightlifting" appears 19 times in conjunction with other keywords with a total link strength of 52. "Strength" appears 10 times in conjunction with other keywords with a total link strength of 50. "Performance" appears 6 times in conjunction with other keywords with a total link strength of 35. "Exercise" appears 9 times in conjunction with other keywords with a total link strength of 26. "Snatch" appears 5 times in conjunction with other keywords with a total link strength of 24. "Vertical jump" appears 5 times in conjunction with other keywords with a total link strength of 23. "Periodisation" appears 5 times in conjunction with other keywords with a total link strength of 20. "Resistance Training" appears 4 times in conjunction with other keywords with a total link strength of 20. "Intensity" appears 4 times in conjunction with other keywords with a total link strength of 18. "Player" appears 3 times in conjunction with other keywords with a total link strength of 18. "Elite Male" appears 3 times in conjunction with other keywords with a total link strength of 17. "Force" appears 2 times in conjunction with other keywords with a total link strength of 16. "Position statement" appears 3 times in conjunction with other keywords with a total link strength of 16. "Manipulating Volume" appears 3 times in conjunction with other keywords with a total link strength of 15. "Clean and Jerk" appears 3 times in conjunction with other keywords with a total link strength of 13. "Load" appears 3 times in conjunction with other keywords with a total link strength of 13. "Movement" appears 2 times in conjunction with other keywords with a total link strength of 12. "Powerlifting" appears 3 times in conjunction with other keywords with a total link strength of 12. "Snatch Technique" appears 2 times in conjunction with other keywords with a total link strength of 12. "Speed" appears 2 times in conjunction with other keywords with a total link strength of 12. "Athletic Performance" appears 2 times in conjunction with other keywords with a total link strength of 11. "Muscle Strength" appears 4 times in conjunction with other keywords with a total link strength of 11. "Peak" appears 2 times in conjunction with other keywords with a total link strength of 11. "Resistance Exercise" appears 3 times in conjunction with other keywords with a total link strength of 11. "Youth Weightlifting" appears 2 times in conjunction with other keywords with a total link strength of 11. "Association" appears 2 times in conjunction with other keywords with a total link strength of 10. "Optimal Training Load" appears 2 times in conjunction with other keywords with a total link strength of 10. "Strength Training" appears 2 times in conjunction with other keywords with a total link strength of 10. "Responses" appears 2 times in conjunction with other keywords with a total link strength of 9. "Sport Performance" appears 2 times in conjunction with other keywords with a total link strength of 9. "Men" appears 2 times in conjunction with other keywords with a total link strength of 8. "Olympic Weightlifting" appears 2 times in conjunction with other keywords with a total link strength of 8. "Weight" appears 3 times in conjunction with other keywords with a total link strength of 8. "Women" appears 2 times in conjunction with other keywords with a total link strength of 8. "Cross-Sectional Area" appears 2 times in conjunction with other keywords with a total link strength of 7. "Kinematic Analysis" appears 2 times in conjunction with other



keywords with a total link strength of 7. "Maximum Strength" appears 2 times in conjunction with other keywords with a total link strength of 7.

"Pain" appears 2 times in conjunction with other keywords with a total link strength of 6. "Perceived Exertion" appears 2 times in conjunction with other keywords with a total link strength of 6. "Physical -Activity" appears 2 times in conjunction with other keywords with a total link strength of 6. "Physical Activity" appears 2 times in conjunction with other keywords with a total link strength of 6. "Model" appears 2 times in conjunction with other keywords with a total link strength of 5. "Biomechanics" appears 2 times in conjunction with other keywords with a total link strength of 3. "Valsalva Maneuver" appears 2 times in conjunction with other keywords with a total link strength of 3. The "Total" row at the bottom provides an aggregate summary, revealing a total of 160 occurrences across all keywords, with a combined link strength of 674. This detailed breakdown facilitates a nuanced understanding of the relationships and prominence of specific concepts in weightlifting studies, by giving an idea for research scholars in the area of weightlifting.

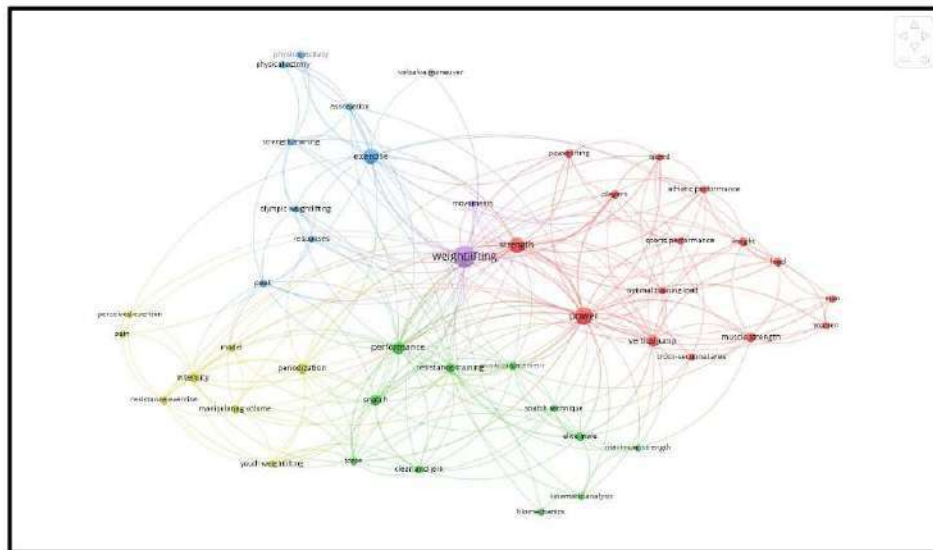


Figure-2: Network visualization of weightlifting Research: A Network Analysis of Co-Occurring Keywords (Source: Prepared by Author using VOSviewer 1.6.19 software, 2023)



4. Discussion of Findings

The bibliometric analysis presented in the present research paper gives insights regarding the trends and focus areas within Olympic weightlifting research. The publication frequency and citation metrics illustrate the timely growth of weightlifting research from 1989 to 2024. Graphical and visual representation indicates an increasing interest in weightlifting-related studies over the years. The trend aligns with the broader growth observed in the field of sports sciences [Rincón et al., 2023]. Co-occurrence of keywords associated with weightlifting research, offering a Comprehensive knowledge and understanding of the interconnectedness of concepts in the area. The keyword "Power" appears frequently and is strongly linked to other keywords such as "Strength," "Performance," and "Exercise." This suggests a consistent focus on power-related aspects in weightlifting studies, which is supported earlier conducted study [García-Valverde et al., 2022]. On the impact of weightlifting training on jumping ability and squat strength. Results also represent the intellectual structure of weightlifting research, showing how different research elements interact and evolve. The network analysis highlights the key concepts and their relationships, providing a useful tool for researchers for the identification of central themes within area. The density visualization, reveals the strength and density of connections between keywords, emphasizing the key areas of focus in weightlifting research. The literature review highlights the integration of technology, such as portable force plates and wearable force sensors, in biomechanical analysis of weightlifting movements [Ang & Kong, 2023]. This reflects a trend toward leveraging advancements in technology for a more detailed and portable assessment of forces and movements involved in Olympic weightlifting. The research underscores the importance of considering injury prevention in weightlifting, especially in relation to extreme joint positions and heavy lifting [Faigenbaum & Myer, 2010]. Guidelines for effective training load and recovery balance are crucial for the minimization of the risk of injuries, emphasizing the required need in related to a holistic approach to weightlifting training. The discussion integrates findings related to the psychological aspects of weightlifting, emphasizing the challenges athletes face in terms of mental fatigue and emotional management [Chen et al., 2023]. Effective mental preparation, including building self-confidence and maintaining focus, is highlighted as a crucial factor in athletes' sporting achievements [Baptistella do Nascimento et al., 2022]. The research paper emphasizes the increasing use and importance of bibliometric analysis in sports sciences, facilitated by tools like Gephi, Leximancer, and VOSviewer [Donthu et al., 2021]. The methodology section provides a detailed account of how the WoS Core Collection database was utilized for this study, ensuring a comprehensive and systematic approach to data collection.

5. Conclusions

1. The findings of this research provide a nuanced understanding of the trends and focus areas in Olympic weightlifting research.
2. The integration of technology in biomechanical analysis, emphasis on injury prevention, and recognition of psychological aspects underscore the multidimensional nature of weightlifting studies.
3. The bibliometric analysis highlights the growing role of bibliometric analysis as a methodological tool to assess research trends and contribute to the evolving landscape of sports sciences.



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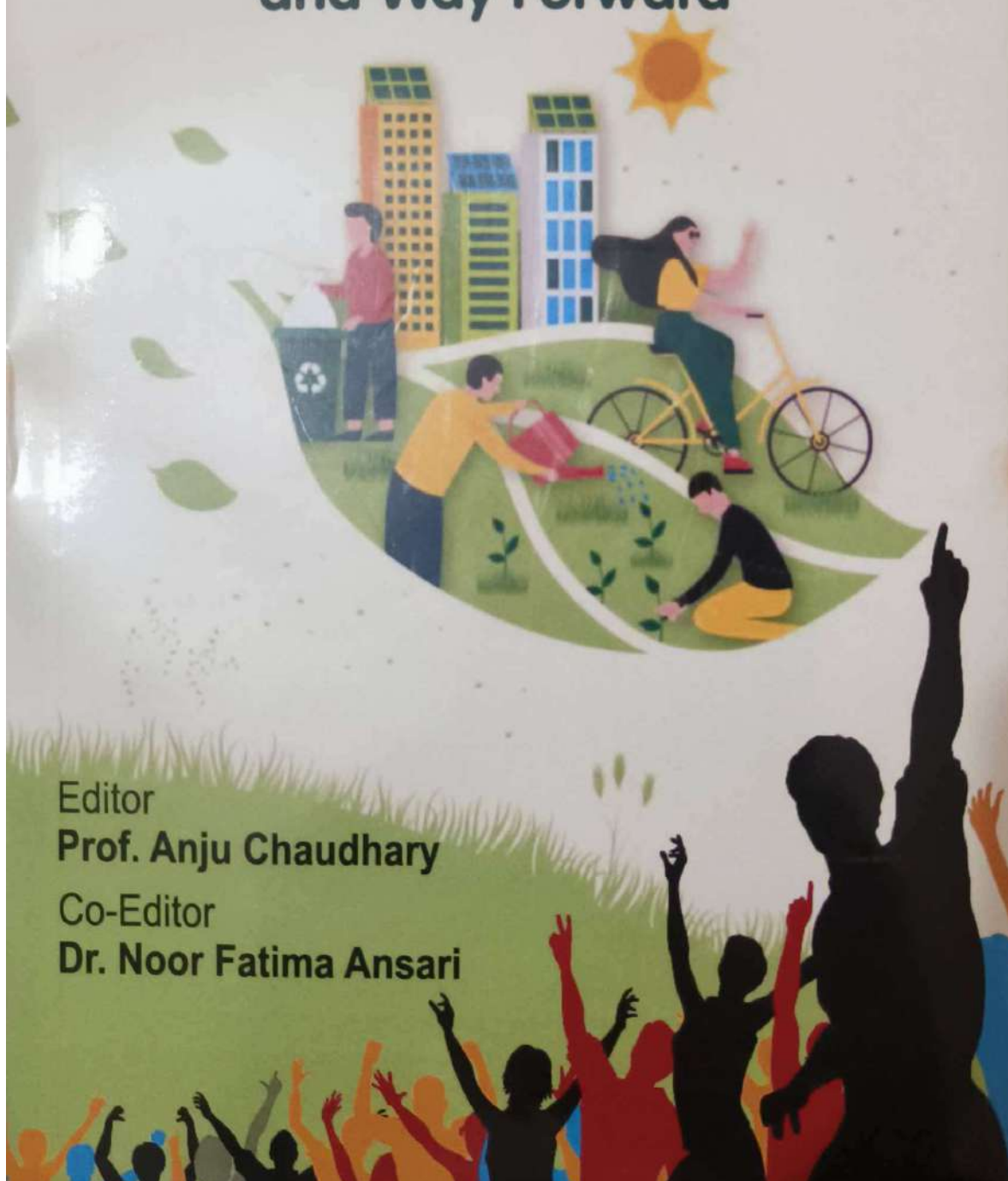
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Youth-20 India

**Emerging Issues, Challenges
and Way Forward**



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2

Youth & Mental Health: Challenges and Prevention

Dr. Rajeev Choudhary

Introduction:

The mental health (MH) of young individuals occupies a central position not only related to personal well-being but also significantly affects the broader societal context, shaping the trajectory of societal progress. Adolescence and the transition into adulthood constitute transformative phases marked by growth, exploration, and development. However, amidst the excitement and opportunities inherent in this period, young people also confront a plethora of challenges that also significantly influence their mental well-being. This crucial stage of life is characterized by a myriad of different types of stressors and pressures, spanning from academic demands and social expectations to the intricacies of personal identity formation and relationship dynamics. Moreover, the rapid changes occurring in physical, emotional, and cognitive domains contribute to feelings of confusion, uncertainty, and vulnerability. External factors, such as socioeconomic disparities, cultural influences, and systemic inequalities, further shape the landscape of mental health (MH) for young individuals.

This article endeavours to delve deeply into the multiple challenges encountered by youth in maintaining expected mental health (MH) status throughout this transitional phase. By adopting a holistic perspective and examining the diverse factors influencing youth mental health, we aim to gain a comprehensive and meaningful understanding and vision of the underlying dynamics at play. Furthermore, by proposing actionable strategies for prevention and intervention, we

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seek to empower individuals, communities, and institutions to effectively address these challenges. Through meticulous examination and analysis, we aspire to illuminate the intricate interplay of biological, psychological, social, and environmental variables and attributes that significantly contribute to youth mental health (MH) outcomes.

Recognizing the complex web of influences shaping young people's mental well-being allows for developing identified interventions that explore underlying root causes and promote resilience, coping skills, and support networks. Ultimately, our objective is to contribute to endeavours aimed at promoting mental well-being among young individuals and nurturing a society, especially youth, where each and every individual has the opportunity to thrive mentally, emotionally, and socially. Investment in the field of mental health (MH) of our youth has a significant positive effect on youth's health status and life quality as well as lays the groundwork for a healthier, holistic, and prosperous future.

In today's rapidly evolving world, the mental health (MH) of young individuals has significant attention, requirements, and needs due to its profound implications for various facets of life. As society undergoes rapid transformations propelled by technological advancements, globalization, and evolving social norms, youth find themselves operating an increasingly intricate and demanding landscape. This complexity is particularly evident in the realm of mental health, where young individuals confront a myriad of stressors, uncertainties, and pressures that can profoundly impact their well-being.

A nuanced exploration of the complexities surrounding youth mental health reveals a multitude of factors contributing to its prevalence. These factors encompass a wide spectrum of influences, including biological, psychological, social, and environmental elements. Biological characteristics such as genetics and neurobiology predispose individuals to certain mental health conditions, while psychological traits such as coping mechanisms and resilience shape their responses to stressors. Social factors, including family dynamics, peer relationships, and cultural influences, exert a significant impact on youth mental health. Additionally, environmental characteristics such as socioeconomic status, access to resources, and exposure to

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trauma further shape youth's outcomes related to mental health.

Despite the growing importance of youth's mental health, this demographic continues to encounter numerous challenges that hinder access to care. Stigma surrounding mental illness remains pervasive, leading many young men to feel ashamed or hesitant to seek help. Moreover, structural barriers like limited access to the services of mental health, particularly in underserved communities, exacerbate the challenges faced by young individuals in accessing appropriate care. Financial constraints and lack of awareness about available resources, contribute a lot to the different barriers obstructing access to care for young people.

In addition, in response to these pressing issues, innovative strategies are emerging to face the complex challenges of youth mental health. These strategies encompass a range of approaches, including technological innovations, community-based interventions, and policy initiatives aimed at promoting mental well-being among young people. Mobile health applications, online support groups, and teletherapy services are just a few examples of the desired solutions that help to overcome barriers to care and reach young individuals where they are. Furthermore, community-based programs, school-based interventions, and peer support networks offer valuable resources and desired support for youth navigating mental health challenges.

In essence, this comprehensive introduction aims to highlight a nuanced exploration of the complexities surrounding youth mental health. By shedding light on the factors contributing to its prevalence, the barriers impeding access to care, and the innovative strategies emerging to address these pressing issues, we hope to foster greater awareness, understanding, and action towards promoting the healthy mental state of youth in today's rapidly changing world.

Understanding the issues associated with the occurrence and prevalence of mental health (MH) in youth:

Disorders of mental health (MH) are alarmingly prevalent among youth, with a significant proportion of individuals experiencing challenges such as anxiety, depression, and stress. Studies indicate that up to one in four young individuals worldwide face mental health (MH) related issues every year, highlighting the scale of the problem. Moreover, the onset of mental health related disorders typically occurs

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during adolescence and early adulthood, making this demographic particularly vulnerable. Various factors and characteristics significantly contribute to the different issues which are significantly associated with the occurrence and prevalence of mental health (MH) among youth, including biological, psychological, and environmental factors.

Examination of the Challenges which are Faced by Youth:

Youth face a large number of different types of challenges that have an important impact on their mental well-being across various domains of life. These challenges include academic pressures, social expectations, financial stressors, and uncertainty about the future. Additionally, issues such as discrimination, trauma, and unexpected childhood experiences also have an impact on mental health issues among youth. Moreover, barriers to accessing mental health care, such as stigma, lack of awareness, and systemic obstacles, further compound the different types of challenges faced by young individuals. Understanding the diverse range of challenges which are faced by youth is crucial for developing holistic approaches to promoting mental well-being.

Impact of Social Media on Youth Mental Health:

Social media has become an integral and important part and issue of the life style of youth, offering both opportunities and challenges for mental health. In the present, modern, and knowledge-era, different social media-related platforms that are used by youth provide connectivity, support networks, and access to information; on the other hand, excessive use has negative effects on mental well-being. Issues such as cyberbullying, social comparison, and exposure to unrealistic standards can contribute to feelings of inadequacy, loneliness, and anxiety among youth. Moreover, the addictive nature of social media for youth can further exacerbate mental health issues. Understanding the significant impact of social media use on youth mental health is essential for developing strategies to promote healthy online behaviours and digital literacy.

Addressing Educational Pressures and Cognitive Challenges:

The academic environment can be a significant source of stress and anxiety for youth, particularly university students. Academic pressures, such as performance expectations, competition, and workload, can contribute to heightened distress and mental health

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issues. Moreover, learning difficulties and cognitive impairments can impact academic achievement and overall well-being. Addressing educational pressures and cognitive challenges requires comprehensive support systems within educational institutions, including access to the services of mental health, academic accommodations, and support networks.

Understanding Help-Seeking Behaviour Among Youth:

Help-seeking behaviour among youth is influenced by a complex interplay of individual, social, and structural factors. Gender differences further shape help-seeking patterns, with societal norms dictating different expectations for men and women regarding emotional expression and help-seeking behaviours. Understanding these factors is very essential for the development of interventions that effectively promote help-seeking behaviour among youth.

Exploring The Multifaceted Challenges Faced by Youth:

The challenges confronting youth mental health are multifaceted and intersect with various domains of life, including education, social relationships, and personal development. Academic pressures, social expectations, financial stressors, and uncertainty about the future are the hurdles young individuals encounter on youth's journey to future. Additionally, issues such as discrimination, trauma, and adverse childhood experiences can significantly impact mental well-being. Furthermore, barriers to accessing mental health care, such as stigma, lack of awareness, and systemic obstacles, exacerbate the challenges faced by young individuals, perpetuating a cycle of untreated mental health issues.

Innovations In Mental Health Care for Youth:

Amidst the challenges confronting youth mental health, different innovative approaches for the prevention, intervention, and support are emerging, offering hope for improved outcomes. Mobile health interventions (mHealth), for example, leverage technology to provide accessible tools for assessment, monitoring, and support, bridging gaps related to traditional mental health services. Community and clinical interventions, including school-based programs and integrated care pathways, play vital roles in prevention and early intervention, fostering resilience and promoting desired positive outcomes related to mental health among youth. Moreover, digital platforms and online resources

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offer opportunities for youths who may not seek traditional face-to-face services, empowering them to take charge of their mental well-being.

Conclusion:

The landscape of youth mental health is intricate, dynamic, and characterized by diverse challenges and opportunities. To address these complexities, a comprehensive and multifaceted approach is imperative. By prioritizing evidence-based interventions, expanding mental health support services, and promoting awareness and literacy, stakeholders can create environments conducive to outcomes related to positive mental health (PMH) for youth. Collaboration at all levels, coupled with ongoing research and evaluation, is crucial for refining interventions and ensuring equitable access to care. By embracing innovation and commitment, we can foster a future where all youth have the opportunity to thrive mentally, emotionally, and socially, contributing to overall well-being and societal progress.

Recommendations:

1. **Prioritize Evidence-Based Interventions:** Implement evidence-based strategies tailored to be beneficial to address and solve the multifaceted challenges related to mental health (MH). Focus on research-based identified interventions that have revealed demonstrated significant effectiveness to promote positive mental health (PMH) among young individuals.
2. **Expand Mental Health Support Services:** Increase access to mental health support services by enhancing resources and infrastructure. This includes investing in community-based mental health centres, school counselling programs, and teletherapy services to ensure easy access for youth.
3. **Promote Mental Health Literacy (MHL) and Awareness:** Launch targeted campaigns to raise awareness. Educate and provide resources to promote mental health literacy, empower young individuals to recognize signs of distress, and encourage help-seeking behaviour.
4. **Foster Collaboration at All Levels:** Facilitate collaboration among stakeholders across local, national, and global levels to address the mental health (MH) of youth comprehensively. Encourage partnerships among different government agencies,

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non-profit organizations, schools, healthcare providers, and community groups to create and provide supportive and expected environments.

5. Conduct Ongoing Research and Evaluation: Support research efforts to advance our understanding of youth mental health (MH) of youth trends and effective interventions. Continuously evaluate the influence of interventions to identify best practices, address existing gaps, and optimize outcomes for young individuals.

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journal homepage: www.elsevier.com/locate/msebStructural, photoluminescence, and thermoluminescence behaviors of Samarium doped CaWO₄ phosphorR. Paikaray^a, T. Badapanda^{a*}, H. Mohapatra^a, T. Richhariya^b, Nameeta Brahme^c, Satya N. Tripathy^d^a Department of Physics, C.V. Raman Global University, Bhubaneswar, Odisha 752054, India^b Department of Physics, Kalinga University, Raipur, Chhattisgarh 492101, India^c SoS in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur (C.G.) 492010, India^d Department of Physics, Government Autonomous College, Angul, Odisha 759143, India

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ABSTRACT

This manuscript reports the crystal structure, photoluminescence and thermoluminescence behavior of Samarium doped CaWO₄ i.e., Ca_{1-x}Sm_{2x/3}WO₄ (x: 0.01, 0.02, 0.03, 0.04, 0.05) synthesized by conventional solid state reaction method. The X-ray diffraction data are analyzed using Rietveld refinement method and showed that samples exhibit cento-symmetric tetragonal crystal structure with *I*4₁/*a* (No. 88) space group. The unit cell volumes are increased with rising Sm composition. The energy bandgaps of the phosphors are observed by the UV-Visible absorbance spectroscopy and found to be directly proportional to the cell volume. Photoluminescence properties are considered from the excitation as well as emission spectra. These spectra resulted that the critical quenching concentration occurred at *x* = 0.02 due to the dipole-dipole interactions with critical energy transfer distance of 20 Å. The color purity and correlated color temperature values of the sample can be measured from the CIE Chromaticity. It is also described the orange-red emission color of the phosphors. Lower UV dosimetry with second order kinetics is obtained from the thermoluminescence spectra of *x* = 0.02 with 30 min UV radiation.

1. Introduction

Now-a-days phosphors are used as luminescent materials in light emitting diodes due to their significant features like excellent luminescence behavior with various emission colors, less power consumption, good efficiency, extensive operation lifetimes, negligible pollution, and broad applicability in lighting as well as displays than the conventional lighting devices. Hence many researchers are paying attention to prepare these types of phosphors with great luminescence behaviors [1]. In last few years, several investigations are going on to find out the most appropriate phosphors with various emission colors. Among all the phosphors i.e., aluminates, silicates, molybdates, nitrates, tungstates and oxides; scheelite type tungstates are more efficient because of their self-activated nature, broad emission band and applications in LEDs, FEDs, display devices etc. [2–3]. Calcium tungstate as a host lattice attracts much more attention because of its good photoluminescence and thermoluminescence behaviors, low optical loss, broad emission seen in UV-Visible range, high color purity, suitable correlated color

temperature, naturally occurring phenomenon and can be appropriately used in the LEDs [4–5]. Also, the luminescence behaviors can be enhanced by incorporating rare earth elements in to the host material with the formation of various energy transfer paths and decreasing the critical quenching concentration. From the literature it has been observed that different rare earth ions are doped in Calcium Tungstate for the further analysis of the improved luminescence behaviors [6–7].

Europium and Terbium doped CaWO₄ phosphors have been prepared by Zhang et al. and red as well as green emission colors are shown by the material correspondingly [8]. A brief study on optical properties with yellow emission color of Dysprosium doped CaWO₄ is done by Du et al. [9]. Also Kaur et al. are analysed the photoluminescence properties of Samarium doped CaWO₄ [10]. But there is a lack of evidence on the energy transfer mechanism as well as the thermoluminescence behaviors of this material. However, thermoluminescence properties of CaWO₄ with different rare earth ions are also analyzed extensively [11–12]. Trap deepness and order of kinetics of Europium and Dysprosium doped CaWO₄ are discussed by Gayatri Sharma et al. [13] and

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Achieving structural, photoluminescence, temperature dependent photoluminescence and thermo-luminescence properties of $\text{SrAl}_2\text{O}_4:\text{Dy}^{3+}\text{Eu}^{3+}$ phosphor for WLED application

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Abstract

We present the $\text{SrAl}_2\text{O}_4:\text{Dy}$, $\text{SrAl}_2\text{O}_4:\text{Eu}$, & $\text{SrAl}_2\text{O}_4:\text{Dy}^{3+}\text{Eu}^{3+}$ phosphors and these samples were prepared by using the urea fuel combustion method at 550 °C. X-ray diffraction pattern indicates monoclinic structure and good crystallinity. Result of Scanning Electron Microscopy (SEM) and Energy Dispersive X-ray (EDX) spectra is exhibited synthesized compound were pure and overall good morphology. By the Brunauer–Emmett–Teller (BET) surface area analyzer, surface area was found 30.462 m²/g of $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_{0.04}$. Homogeneity, rotational, and vibrational properties were also investigated by FTIR and Raman spectroscopy. By the help of UV–visible spectroscopy band gap (~ 5 eV) was calculated. The photoluminescence properties were studied of $\text{SrAl}_2\text{O}_4:\text{Dy}_x$, $\text{SrAl}_2\text{O}_4:\text{Eu}_x$, & $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_x$ ($x = 0.01$ to 0.05) samples. In this order, we have found best $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_{0.04}$ photoluminescent sample rather than other samples. The CIE-1931 color coordinate (0.3103, 0.3035), CCT (6914 K), CRI (94), and color purity (89.1%) were calculated of the $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_{0.04}$ phosphor. Temperature-dependent photoluminescence spectra were measured of $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_{0.04}$ phosphor by 395 nm excitation wavelength. Thermoluminescence glow curve were measured of synthesized phosphors and it is exposed to UV radiation (254 nm). Thermo-luminescence trapping parameters, activation energy and average frequency factor were calculated by Chens peak shape method. The obtained $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_{0.04}$ is fine phosphor and it has good PL, TL properties due to perfect doping concentration of Dy and Eu, higher elemental purity and perfect crystalline morphology. Therefore, SrAl_2O_4 -based phosphor activated by Dy and Eu metals may be used for future prospective WLEDs applications.

Highlights

1. First time $\text{SrAl}_2\text{O}_4:\text{Dy}^{3+}\text{Eu}^{3+}$ nano phosphor synthesis by urea fuel combustion route.
2. Crystallinity, Particle Size, morphology, and Surface area estimated by XRD, SEM, and BET.
3. Band gap of the $\text{SrAl}_2\text{O}_4:\text{Dy}_{0.03}\text{Eu}_{0.04}$ phosphor was found ~ 5 eV electron volt.
4. PL, Temperature dependent PL spectra, and Long-lasting decay curve were also analysed.
5. Glow peak parameter, TL activation energy, and frequency factor were calculated by Chens-equation.

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Unveiling the Potential of Sm^{3+} Doped $\text{Li}_2\text{SrSiO}_4$ Phosphor for UVC Dosimetry: Comprehensive Analysis with Synthesis, Morphological, Elemental and Thermoluminescence Studies

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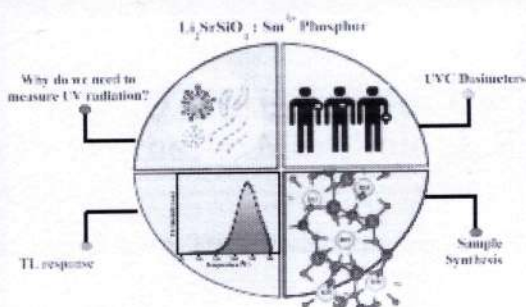
ABSTRACT: In the present study, the successful synthesis of a series of Sm^{3+} doped $\text{Li}_2\text{SrSiO}_4$ (LSS) phosphors using the solid-state reaction method was done. Phase identification, morphological and elemental analysis was investigated using X-ray diffraction, FESEM and EDX analyses, respectively. The experiments provided the proof of existence of constituent elements and surface morphology of phosphor under different magnification. Sm^{3+} doped $\text{Li}_2\text{SrSiO}_4$ phosphor's thermoluminescence properties are reported for the first time. Thermoluminescence experiments were conducted, and the highest intensity was observed at 1 mol % doping concentration of Sm^{3+} contained a single glow curve at $\sim 238^\circ\text{C}$. Furthermore, the study revealed that TL intensity exhibited a linear relationship with UV–C irradiation, and also, repeatability, fading, and filter analysis were probed. Fading tests, $T_{\text{in}} - T_{\text{stop}}$ method and $E_a - T_{\text{stop}}$ methods suggested the existence of a single trap. Various other methods were performed to evaluate the kinetic parameters and their reliability in estimating trapping parameters for a single glow curve. These findings collectively support the potential of LSS: Sm^{3+} phosphor for UVC dosimetry, marking a significant contribution to the understanding of its TL properties and defect states.

KEYWORDS: Thermoluminescence, UVC dosimetry, Kinetic Parameters, Activation Energy, Frequency Factor, Inorganic Phosphor, Glow Curve

1. INTRODUCTION

Thermoluminescence (TL) is an important kind of luminescence processes in which the sample absorbs energy from ionizing or nonionizing radiation and then releases that energy as visible light after thermal stimulation.¹ The emission is exhibited due to structural defects brought on by doping in the host lattice. Such defects get located in the band gap and can drastically change the luminescence characteristics of materials by trapping charge carriers in localized energy levels.² Hence, by evaluating the kinetic parameters of the lattice using TL, the formation of electronic trap levels caused by dopant ions can be studied. Applications of TL include radiation dosimetry in the environment, medical diagnostics, radiology, cosmic radiation detection, bone dosimetry, toxicity studies, aeroplane safety, accidental dosimetry and personal dosimetric monitoring.^{3,4}

To determine, anticipate or restrict the impact of radiation, a dosimeter is used to measure the energy deposited in a living or nonliving object from a radiation field.⁵ A commercial dosimeter needs to have a decent effective atomic number, a



low rate of fading, sensitivity, thermal and chemical stability, as well as a commercial shape and size according to uses. For dosimetric applications, a lot of commercial materials such as $\text{CaSO}_4:\text{Dy}$, $\text{LiF}:\text{Mg}:\text{Ti}$, $\text{LiF}:\text{Mg}:\text{Cu}:\text{P}$, CaF_2 , $\text{Li}_2\text{B}_4\text{O}_7:\text{Cu}$, $\text{Li}_2\text{B}_4\text{O}_7:\text{Mn}$, BeO and $\text{Al}_2\text{O}_3:\text{C}$, $\text{K}_2\text{Ca}_2(\text{SO}_4)_3:\text{Eu,Ce}$ are used.^{3–6} Commercial dosimeters made with $\text{LiF}:\text{Mg,Ti}$ and $\text{LiF}:\text{Mg,Cu,P}$ are known as TLD-100 and TLD-100H respectively.⁷ These materials are still being thoroughly studied today with various doped impurities since doping increases the defects levels and trapping centers, which helps to improve the luminescence characteristics and dosimetric behavior.⁶ As well, the scientific community is constantly investigating TL in novel materials in search of better and more effective

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Studies on structural, photo and thermoluminescence properties of Sm^{3+} activated $\text{Ca}_3\text{MgSi}_2\text{O}_8$ phosphors for solid-state lighting

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Abstract

The samarium activated orange–red–emitting calcium magnesium orthosilicates [$\text{Ca}_3\text{MgSi}_2\text{O}_8:\text{xSm}^{3+}$ (CMSOSM)] phosphors with different concentration were synthesized by solid–state reaction method. The monoclinic crystal structure with P21/c space group was confirmed by the PXRD technique. Under the excitation at 405 nm, characteristics emission spectra of Sm^{3+} ions in orange–red region were recorded at 565 nm, 570 nm, 602 nm, and 648 nm due to the transition of ${}^4\text{G}_{5/2} \rightarrow {}^6\text{H}_{5/2}$, ${}^6\text{H}_{7/2}$, ${}^6\text{H}_{9/2}$ respectively. The critical doping concentration of Sm^{3+} ion was 2.0 mol% and the critical distance was determined as 32 Å. The energy transfer among Sm^{3+} ions in $\text{Ca}_3\text{MgSi}_2\text{O}_8$ (CMSO) phosphors was found to be a dipole–quadrupole interaction. Furthermore, it's exciting to find that the red–emitting phosphors showed high thermal stability. $\text{Ca}_{2.98}\text{MgSi}_2\text{O}_8:\text{Sm}_{0.02}$ (CMSOSM2) exhibits a strong sharp peak at 104 °C was shoulder at 291 °C when heating rate (HTR) is constant 5 °Cs⁻¹. The shape of glow peak and intensity of isolated curve depend on dopant impurity rigorously, results in remarkable increasing in TL sensitivity. The photometric results indicate that the synthesized orange–red phosphor can be potentially applicable for solid–state lighting and display devices applications.

Spectroscopic investigation by incorporation of charge compensator ions in CaBaSiO₄: Dy³⁺ phosphors for solid-state lighting applications

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Abstract: In this research paper, we present a study on the preparation and spectroscopic properties of Dy³⁺-doped calcium barium ortho-silicate (CaBaSiO₄) phosphor. The phosphors were synthesized using the solid-state reaction route. The obtained powders underwent characterization through X-ray diffraction (XRD) and Fourier transform infrared (FTIR), confirming phase purity and the presence of functional groups, respectively. Energy-dispersive X-ray (EDX) reveals the elemental composition of the material under examination. The spectroscopic properties of Dy³⁺ in CaBaSiO₄ phosphor were investigated through emission and excitation spectra analysis. The emission spectra exhibit two peaks in the blue region at 482 nm and in the yellow region at 574 nm under UV excitation with a wavelength of 349 nm. Both emission peaks are attributed to the ⁴F_{9/2} → ⁶H_{15/2} and ⁴F_{9/2} → ⁶H_{13/2} characteristic transitions of the Dy³⁺ ion. The critical distance was calculated using the Blasse equation. Monovalent ions were added to the host as charge compensator ions to enhance the luminescence intensity. The CIE chromaticity coordinates were determined from the emission spectra, affirming that the CaBaSiO₄ phosphor is a suitable candidate for solid-state lighting applications, particularly in w-LEDs.

Keywords: Ortho-silicate; Phosphors; Photoluminescence; Charge compensator ion; w-LEDs

1. Introduction

In the current scenario, the development of highly efficient phosphors is a topic of research due to its widespread use in various areas such as optoelectronic devices, solid-state lasers, scintillation, etc. Researchers have focused on preparing such novel phosphor materials that exhibit excellent luminescent behavior. Nowadays, phosphors have been considered as one of the basic sources of solid-state lighting (SSL) technology. The white light-emitting diode (w-LED) is a new trend and the most usable device in SSL systems because it converts electrical energy into visible light [1]. Other advantages of w-LEDs include long life durability, environment-friendliness, high reliability, low power consumption, etc. [2]. Recently, phosphor materials have been used as the main source of intelligent LEDs. This intelligent LED technique has many advantages, such as they are energy saving, highly efficient, comfortable to use, and are safe in operation [3].

Nakamura et al. reported phosphor-based w-LEDs for the first time in 1997, opening a new window for research in this field [4]. Recently, two approaches for enhanced production of white light is trending among researchers: (i) the combination of blue light-emitting InGaN chip with yellow phosphor (YAG:Ce) and (ii) UV-LED with blue, green, and red phosphors. Yet, it is evident that high color tolerance and low color rendering index (CRI) are the drawbacks of these two approaches, which are responsible for the reduction in luminescence efficiency [5, 6]. Thus, the main aim of researchers is to develop white light-emitting novel phosphors that overcome the above-mentioned drawbacks. Therefore, phosphors with less complex compositions, high brightness, and good color purity are the fundamental components focused for white light emission [7].

To achieve these characteristics, alkaline earth silicate phosphors play a key role as a host on account of their stable crystal structure, and high thermal and chemical behavior [8]. Recently, alkaline earth silicates have been widely studied as light-emitting phosphor materials. Among the different alkaline earth silicates such as

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Investigation of photoluminescence and thermoluminescence properties of UV & γ irradiated $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:\text{Dy}^{3+}$ phosphor

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ABSTRACT

A series of Dy^{3+} -activated $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2$ phosphors were synthesized using a high-temperature solid-state reaction method. The crystal structure, surface morphology, elemental analysis and vibrational modes of synthesized phosphor were studied using X-ray Diffraction, Scanning electron microscope, Energy dispersive X-ray spectroscopy and Raman Spectroscopy technique, respectively. Luminescence properties of $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:\text{Dy}^{3+}$ phosphors were analyzed by photoluminescence (PL) and thermoluminescence (TL) techniques. Photoluminescence spectra of Dy^{3+} doped $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2$ phosphors were efficiently excited in the range of 300–400 nm and exhibited two emission peaks, positioned at 481 nm (blue) and 575 nm (yellow) due to ${}^4\text{F}_{9/2}-{}^6\text{H}_{15/2}$ and ${}^4\text{F}_{9/2}-{}^6\text{H}_{13/2}$ transitions, respectively, under excitation wavelength of 348 nm. CIE colour coordinate ($x = 0.2983$, $y = 0.3151$), Colour purity (13.3%), and CCT (7550 K) of the material were calculated which indicated that the prepared phosphor can be used as a white light-emitting phosphor. The TL glow curves of the synthesized phosphor were recorded using a Nucleonix 10091 TLD reader. All synthesized $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:4\text{mol}\%\text{Dy}^{3+}$ phosphors were exposed to UV rays (254 nm) and γ -rays (${}^{60}\text{Co}$ source). Maximum TL intensity was found for 40 min under UV irradiation (254 nm), and for γ irradiation (dose rate 8 kGy). Trapping parameters like activation energy, frequency factor and order of kinetics were calculated by Chen's peak shape method. The activation energy vs. T_{stop} method verifies the existence of overlapping peaks. In this work the long-lasting glow characteristics of prepared samples using fading measurements, and along with the TL emission spectrum were also investigated. Overall $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:\text{Dy}^{3+}$ phosphor revealed that the prepared phosphor can be used for excellent WLED phosphor and TLD material for both UV & γ based TL dosimetric applications.

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Study of morphological, elemental, optical and excitation wavelength dependent red photoluminescence in Eu^{3+} doped $\text{Li}_2\text{SrSiO}_4$ for solid state lighting

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ABSTRACT

A comprehensive investigation of Eu^{3+} doped $\text{Li}_2\text{SrSiO}_4$ phosphors synthesized via the solid-state reaction method was conducted. XRD confirmed the crystalline phase and SEM along with its 3D projection's observations confirmed that the phosphor particles were in the micro meter size range, indicating their suitability for applications in primary phosphor-converted LEDs. FTIR spectroscopy elucidated vibrational characteristics, while TGA, EDX and XPS analysed thermal stability, elemental composition and valence states respectively. Doping-induced band gap increase was attributed to the Moss-Burstein effect. Photoluminescence excitation studies revealed enhanced absorption at 394 nm compared to the charge transfer transition band (CTB) at 254 nm, aligning with industry-standard near-ultraviolet chips. XPS suggested two distinct Eu^{3+} sites in the LSS crystal, corroborated by excitation wavelength-dependent PL emission. As a result of excitation wavelengths, the magnetic-dipole transition (${}^3\text{D}_0 \rightarrow {}^7\text{F}_1$) at 592 nm, the electric-dipole transition (${}^5\text{D}_0 \rightarrow {}^7\text{F}_2$) at 615 nm and the induced electric-dipole transition (${}^5\text{D}_0 \rightarrow {}^7\text{F}_{3,4}$) at 650 and 700 nm arose. Additionally, the phosphor gave an improved conversion efficiency at 2% Eu doping. Low synthesis temperature, micro-sized particles, thermal stable, short lifetime, excitation bands at near UV to blue region, colour tunability, lower CCT, LER and similar CIE to available red phosphors are the key factors for the $\text{Li}_2\text{SrSiO}_4:\text{Eu}^{3+}$ proving reliable red phosphor for solid state lighting.

1. Introduction

Through the centuries, various lighting technologies have been used. Man has utilized natural sunlight to fire, then electricity-based lighting appliances for his needs. Since lighting is now a basic human need, there is always space for advancement, new technology and the adoption of better and less expensive options [1]. Nowadays, LEDs are extensively used in a variety of applications, including displays, fluorescence microscopy, plant development, automotive headlights, optical waveguides, flashlights, solid state lasers, sensors, general illumination in homes and more [2–4]. The development of solid state lighting technology, particularly phosphor-converted white light emitting diodes

(pc-WLED), has gained significant attention in recent years due to its advantages over conventional incandescent and fluorescent lamps, including low energy consumption, high energy efficiency, environmental friendliness due to mercury-free production, improved lifetime, compact design and high brightness [2,5,6].

In order to create pc-WLEDs, two primary techniques are used: first, a blue LED chip is combined with a yellow phosphor and second, a near ultraviolet (n-UV) LED chip is combined with tricolour (blue, green and red) phosphors [2,5]. The first technique uses a mixture of yellow-emitting $\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Ce}^{3+}$ (YAG: Ce^{3+}) phosphors and blue-emitting GaN chips, whose application is limited by their low colour rendering index (CRI) and high correlated colour temperature

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Investigation of Latent Fingerprint Detection and Cheiloscopy Development Using $\text{Li}_2\text{SrSiO}_4:\text{Tb}^{3+}$ Phosphor for Forensic-Based Applications

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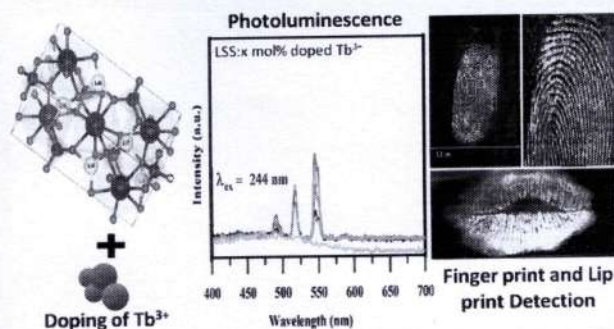
Supporting Information

ABSTRACT: Inorganic phosphors with rare-earth metal doping have recently been created and used in hot topics including phosphor-converted light-emitting diodes (pc-LEDs), counterfeit prevention, cheiloscopy (lip print detection), and fingerprint visualization. Using the Pechini sol–gel process, a silicate-based rare-earth metal-doped $\text{Li}_2\text{SrSiO}_4:\text{Tb}^{3+}$ (LSS:Tb) green-emitting phosphor was synthesized, and its characteristics were determined by X-ray diffraction, scanning electron microscopy, Fourier transform infrared spectroscopy, and photoluminescence studies. Through the JCPDS file, the prepared phosphor's structure was confirmed. Photoluminescence studies displayed the characteristic emission peaks of Tb^{3+} under an excitation wavelength of 254 nm. Implementation of the powder dusting method using LSS:3 mol % Tb phosphor on the latent fingerprint displayed good selectivity and contrast. Along with this, latent fingerprints were also detected on different surfaces to see the practicality of the prepared phosphor. Under UV irradiation, the level 1–3 structural properties of latent fingerprints and the level 1–6 detection of lip prints were distinguished and probed. The obtained results indicated that the synthesized phosphor could be used for fingerprint and lip print detection.

KEYWORDS: photoluminescence, latent fingerprint detection, lip print detection, cheiloscopy, Pechini sol–gel synthesis

1. INTRODUCTION

The long story of that inescapable mark of identity of fingerprints has been told and retold for many years and in many texts. These features are present on the palm side of each person's hands and on the soles of each person's feet in the friction ridge skin, which leaves behind impressions of its shapes when it comes into contact with an object. The impressions from the last finger joints are known as fingerprints. If you have fingers, you will definitely have a specific fingerprint.^{1–3} Not only humans but also animals have distinct fingerprints, which enables researchers to study and investigate their DNA, habitat, gripping techniques, evolution over different circumstances, hand proportion and body size, or/and their age.^{4–6} It is an interesting fact that no two people have the same fingerprints, which is supported by the fact that fingerprints are a unique identifier on their own and are made up of a set of haphazard ridges and furrows that appear between 6 and 25 weeks of human fetal (embryonic) development. Eccrine glands, which generate salt, a mixture of water, and sweat, are typically responsible for the natural secretion that occurs on the feet and hands. When a person contacts any surface with hands, this chemical phenomenon



creates a particular pattern on it.^{7,8} Today, the fingerprint identification technology is utilized in controlling gadgets, smart phones, mobile payment, access control, and time attachment.⁹ The most effective method and primary course in the forensic science department for identifying crime scenes as physical evidence of a person in the 19th century was latent fingerprint (LFP) examination.^{3,10,11} The LFPs that were observed at the crime scenes are exceptional but undetectable to the naked eye, making them difficult for investigators to see. Hence, there is a space for advanced technologies.^{12,13} These circumstances demonstrate the value of LFP detection as a forensic science tool for identifying an individual's information and catching criminals.^{3,14} Lip print detection is another fascinating and new area of forensic science for personal identification.¹⁵ In forensic investigations, the identification of

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CHAPTER 10

Other emerging applications of mechanoluminescence and outlook

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10.1 Introduction

The wonder of light discharge from a solid in response to a mechanical input is known as mechanoluminescence (ML). ML has proven to be a significant phenomenon for monitoring, not only from the perspective of comprehending the microscopic and microscopic characteristics of a crystal but also for other possible applications [1]. Writing these few sentences is equivalent to revealing only three cards from a deck of cards while neglecting the fact that there is a full deck available to be shuffled, played, explored, and combined to discover potential ideas and applications for mankind. Here, in this chapter, some of the potential applications of ML are discussed in upcoming sections.

10.2 History of ML applications

In 1605 Francis Bacon reported the first instance of sparking light while crushing sugar crystals, during the initial era of ML research. Later, studies investigated many salts, sugars, halides, and many more available natural stones. However, it was first thought that weak and unreproducible ML could constrain significant applications of ML but then to find and use powerful, dependable ML in applications, improving intensity was not a key section of focus [2]. Chandra et al. [3,4] have reported four generations of ML research:

- i. The pre-PMT (photomultiplier tube) generation (from the beginning to 1950);
- ii. The early post-PMT generation (from 1951 to 1990);
- iii. The late post-PMT generation (from 1990 to the present); and
- iv. The future generation of ML (yet to come).

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Photoluminescence studies of Eu^{3+} doped bismuth silicate based phosphor for plant grow LEDs

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Far red emission

ABSTRACT

Artificial red lights of good quality are essential for indoor plant growth as it has a wide spectrum effects on photosynthesis rate and photomorphogenic processes of organic plant growth cycle. In present work we report on Eu^{3+} doped $\text{Bi}_4\text{Si}_3\text{O}_{12}$ (BSO) phosphor for spectroscopic implication in smart plant grow LEDs. Eu^{3+} activated series of $\text{Bi}_4\text{Si}_3\text{O}_{12}$ phosphor have been prepared via traditional solid-state reaction method. Crystal structure and phase formation characterization is determined by using X-ray diffraction (XRD). Photoluminescence spectra of prepared phosphor shows broad excitation spectra ranging from 200 to 530 nm. The optimal Eu^{3+} doping concentration observed at 3 mol%. Emission spectra observed under the excitation of 270 nm shows broad emission band at 469 nm along with other characteristic peak at 500 nm–710 nm. Observed emission peaks at 622 nm, 656 nm and 702 nm were chosen opt for plant grow lights. The phytochrome PFR absorption spectra of plants matches well with the emission band of our Eu^{3+} doped BSO phosphor and can be considered as a viable choice for solid state lighting and plant grow light LEDs.

Introduction

Long-lasting phosphor is been researched and developed through many decades due to its various applications [1]. Many investigations on rare earth activated inorganic phosphors have been performed in recent years for their wide application in display devices, solar cell coating, solid state lasers, lightning gadgets, and so on [2]. Bismuth compound as a host material has gained very little attention despite of its promising features for optical application. Consequently, instead of optical devices, the majority of photoactive properties of bismuth materials have been used for catalytic or electrochemical applications [3]. A lot of effort has recently been done in the subject of smart agriculture. As plants use, different light spectrums for the growth of their different parts. Plants are less sensitive to light than humans. Blue and red light spectra are the most efficient for photosynthesis. Red light (629–662 nm) is required for stem development, leaf expansion, blooming, and seedling growth. Blue light (400–530 nm) impacts chlorophyll concentration and leaf thickness, while light of (430–470 nm) range is beneficial to vegetative development. Plant grows best under mix of red and blue light [4,5]. The ideal ratio is somewhere in between 5:1 red to blue. Present work is been carried out on Eu doped BSO as a suitable candidate for designing

suitable light emitting phosphor which can effectively used indoor LEDs for plant growth [6].

Experimental details

Materials were synthesized by solid-state reaction method. Initial raw materials Bi_2O_3 , SiO_2 , Eu_2O_3 (99.9%) were weighed according to stoichiometric ratio and mixed homogenously with the help of an agate mortar for 2 hrs. Each of the prepared materials was placed in an alumina crucible for heating at 750 °C for approximately 8 h before being grounded in an air environment. The obtained samples were again reheated for 5 h at a temperature 100 °C higher than the initial synthesized temperature and used for further analysis.

The phase formation of the prepared phosphor is confirmed using an Advance Bruker AXS-D8 diffractometer with Cu $K\alpha$ radiation. The XRD data were taken in the $10^\circ \leq 2\theta \leq 80^\circ$ range. The photoluminescence studies were monitored using a spectrofluorophotometer RF-5301PC (Shimadzu) equipped with a 150 W xenon lamp used as a source of excitation [7].

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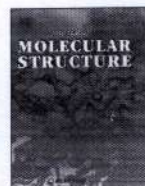
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Exploration of crystal structure, and luminescence behaviors of Terbium-activated CaWO_4 phosphor

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ABSTRACT

This manuscript includes structural, optical, photoluminescence, and thermoluminescence behaviors of Terbium incorporated CaWO_4 samples with nominal compositions of $\text{Ca}_{1-x}\text{Tb}_{2x/3}\text{WO}_4$ ($x = 0.01, 0.02, 0.03, 0.04, 0.05$) prepared by the traditional solid-state reaction route. Results found from the Rietveld refinements of X-ray diffraction patterns confirmed that all the samples have tetragonal crystal structures with $I4_1/a$ space group. The variation of unit cell volume with the compositions shows an anomaly at $x = 0.03$. Band gap energy values of these synthesized samples are found from the UV-Visible absorbance spectra with increasing order. Photoluminescence behaviors, as well as the FWHM values, are analyzed from the excitation along with the emission spectra. Critical quenching concentration at $x = 0.03$ with a critical energy transfer distance of $\sim 20 \text{ \AA}$ caused by the dipole-dipole interactions is found in these spectra. CIE Chromaticity coordinates are indicated the green emission color of all the prepared samples with high color purity, correlated color temperature, color rendering index, and luminous efficiency of radiation values. Quantum efficiency of the material with $x = 0.03$ Tb concentration is observed under 255 nm excitation wavelength. PL decay analyses of the phosphors are carried out and the average lifetime values are calculated. Thermoluminescence spectroscopy of $x = 0.03$ irradiating by 15 min of UV dose is described as the lower UV dosimetry and second-order kinetics of the material.

1. Introduction

Over the last few decades, phosphors having luminescent nature are used in the light emitting diodes rather than the conventional lighting devices [1]. They have good luminescence properties, different types of colors of emission, considerable efficiencies, excellent operating conditions, fewer pollutions, low power utilization, wide uses in lighting applications, and many more important features [2–3]. Therefore, several pieces of research are going on by scientists to synthesize phosphors with improved luminescence properties. Material scientists are involved to explore these types of phosphors like nitrates, molybdates, silicates, aluminates, oxides, and tungstates with enhanced photoluminescence behaviors [4]. It has been studied that metal tungstates with scheelite structures have wide emission ranges, good efficiencies, and self-activating behaviors and can be utilized in the lighting devices such as LEDs, FEDs, and display screens [5–6]. Among all the metal

tungstates, Calcium tungstates have prominent properties in photoluminescence and thermoluminescence spectroscopy, blue emission color with extensive emission range in UV-Visible region, a great value in color purity & quantum efficiency, less optical loss, appropriately correlated color temperature value [7]. Hence Calcium tungstate acts as a suitable host material for the light emitting diodes [8]. Moreover, past investigations are revealed that doping of different rare earth materials with CaWO_4 can be improved luminescence properties by producing various paths for energy transfer and reducing the critical quenching concentration of the material [9–10].

Photoluminescence behaviors with orange-red emission color of Sm-doped CaWO_4 are discussed extensively by Kaur et al. [11]. Du et al. explained the yellow emission color of Dy-doped CaWO_4 and also their optical behaviors [12]. Zhang et al. prepared Eu and Tb-doped CaWO_4 phosphors and investigated that they have red as well as green emission colors respectively [13]. However, the reason the behind energy transfer

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Luminescence Studies of $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{Eu}^{3+}$ Phosphor by Sol–Gel Method

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Abstract

A series of $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{xEu}^{3+}$ ($x = 0.01, 0.03, 0.05, 0.07$ and 0.09) phosphors were synthesized by the sol–gel method. X-ray diffraction (XRD), field-emission scanning electron microscopy (FESEM) and energy dispersive spectroscopy (EDS) techniques were used in the study of the crystal structure, surface morphology, and elemental composition of the prepared phosphors. Photoluminescence (PL) and thermoluminescence (TL) properties were also studied. When the $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{Eu}^{3+}$ phosphor was excited at 394 nm wavelength, the optimum emission peak centered at 592 nm was found. The calculated CIE coordinates from the PL emission spectra lie in the orange-red region of the visible spectrum. To determine the optimum doping concentration of Eu^{3+} , the variation in the luminescence intensity with different concentrations of Eu^{3+} in the $\text{CaY}_2\text{Al}_4\text{SiO}_{12}$ host lattice was also studied. To study the TL of the prepared samples, a ^{60}Co - γ (gamma) source was used for irradiation and to determine the trapping parameters such as activation energy (E), order of kinetics (b) and frequency factor (s) of the samples. Chen's peak shape method was used.

Keywords Sol–gel method · phosphor · photoluminescence · thermo-luminescence · FESEM · EDS

Introduction

Every phosphor material has its specific luminescence characteristics which depend on the activator ions and the crystallographic structures of the host lattice.¹ Various inorganic host materials, such as aluminates, silicates, phosphates, borates, sulfides, etc., have been used to prepare phosphors with the incorporation of appropriate doping elements. Recently, it has been observed that, among all the inorganic host materials, garnet is an interesting host matrix

for incorporation of activator ions due to its eminently good physical and chemical stability, high luminescent effectiveness, high thermal properties, and structural flexibility.²

Rare-earth ions have distinct color emissions and high color purity. Due to these properties, rare-earth ions are playing a pivotal role in scintillators, high-power optical amplifiers, solid-state lighting, display devices, and many other fields.³ Among the lanthanide ions, trivalent europium (Eu^{3+}) is well known for giving rise to intense orange-red emissions. The red emission from Eu^{3+} ion involves the transition from $^5\text{D}_0 \rightarrow ^7\text{F}_j$ ($j = 0, 1, 2, 3, 4$).^{3,4}

Several researchers have investigated the luminescence properties of different garnet phosphors. Singh et al.⁵ prepared YAG phosphors, i.e. $(\text{Y, Gd, Lu})_3(\text{Al, Ga})_5\text{O}_{12}:\text{Ce}^{3+}$, which are some of the most commercially used phosphors. Katelnikovas et al.⁶ modified $\text{Y}_{3-x}\text{Al}_5\text{O}_{12}:\text{Ce}^{3+}$ (YAG:Ce) as $\text{Y}_{3-x}\text{Mg}_2\text{AlSi}_2\text{O}_{12}:\text{Ce}^{3+}$ phosphors. Park et al.⁷ investigated the (LuAG:Ce) green phosphor, which possesses excellent luminescence and thermal properties correlated to the yellow $(\text{Y, Gd})_3(\text{Al, Ga})_5\text{O}_{12}:\text{Ce}^{3+}$ phosphor. The compositional modifications have also been achieved in several garnet hosts, like $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{xPb}^{2+}$, $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{xCe}^{3+}$ etc.^{2–9} Zhehan et al. studied the

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Thermoluminescence studies of Sm³⁺ doped ZnB₂O₄ phosphor

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Abstract: Solid-state reaction method was used to prepare the rare earth Sm³⁺ doped ZnB₂O₄ phosphors. The structural characterization of Sm³⁺ doped ZnB₂O₄ samples was recorded by X-ray diffraction (XRD) technique. A single phase structure similar to the standard JCPDS file-39-1126 was recorded using XRD. The graph plotted between TL intensity and temperature for different UV dose was recorded. The highest TL intensity was recorded for 20 minutes of UV dose. On further increase in the exposure dose, decrease in TL intensity was observed. The thermo-luminescence was recorded with varying percentage of Sm³⁺. The at most TL intensity was obtained with 3 mol% of Sm³⁺. The thermo-luminescence spectra of ZnB₂O₄ and Sm³⁺ doped ZnB₂O₄ phosphors were also studied.

Keywords: Zinc tetra borate, Thermo-luminescence, Phosphors, XRD.

1. Introduction

The phenomenon to produce light by thermal stimulation of radiation, from the previously irradiated material is called as thermo-luminescence (TL) [1, 2]. It is a comparatively simple technique to obtain information about point defects from a naturally occurring or artificially created material, when heated. By using this technique the changes in the defect concentration of insulators can be recorded. In diagnostic radiology and radiotherapy, TL dosimetry is very well defined techniques to detect the exposure doses to the patients. Hence it is a most widely used and very important part of the radiation dosimetry. TL technique could be an interesting area of research to calculate the doses variation during radiation processing applications: such as radiotherapy, food irradiation and medical product sterilization. The crystalline or polly-crystalline materials are commonly used for executing TL due to their opaqueness and high scattering of light. In the crystalline materials, the light emitted inside the layer has a grim chance to be gathered by the photon detector in compare to the light emitted near its surface. The ideal TL dosimeter material must be transparent to light and have ability to store the radiation. So, a material with good storage capacity, great sensitivity and good optical transparency may be required.

Since long, for luminescence applications, the researchers were using different rare earth ions doped zinc borates phosphors as host materials [3–7]. The rare earth activator ions, Sm³⁺, Eu³⁺, Tb³⁺, and Dy³⁺ can produce light in the visible range [8–15]. Incorporation of rare earth to zinc borate makes the material good for dosimetry application also. Zinc borate (boron-based inorganic material) showed excellent luminescence efficiency, wide band gap. It is also a low toxic, low cost and thermally stable material. Samarium (4f⁶) is the transition ion which has the specific advantage and has received much attention [16, 17]. The TL properties of a TL material are largely affected by the preparation method, and also the addition of impurities [18]. In this work undoped and different concentration of Sm³⁺ doped ZnB₂O₄ phosphors, their TL properties and the X-ray diffraction, EDS is also studied.



Long Lasting Persistent Photo-Luminescence Properties of $\text{Eu}_x\text{M}_{1-x}\text{MgAl}_{10}\text{O}_{17}$ (M = Ba, Ca, Sr, Zn) Phosphors

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Abstract. In this work, the $\text{Eu}_x\text{M}_{1-x}\text{MgAl}_{10}\text{O}_{17}$ [M = Ba, Ca, Sr, Zn, and x = 0.05] phosphors were prepared through a combustion route technique. The complexing reagents namely urea (fuels) were used to synthesis for $\text{Eu}_x\text{Ba}_{1-x}\text{MgAl}_{10}\text{O}_{17}$ (BAM: Eu), $\text{Eu}_x\text{Ca}_{1-x}\text{MgAl}_{10}\text{O}_{17}$ (CAM: Eu), $\text{Eu}_x\text{Sr}_{1-x}\text{MgAl}_{10}\text{O}_{17}$ (SAM:Eu), and $\text{Eu}_x\text{Zn}_{1-x}\text{MgAl}_{10}\text{O}_{17}$ (ZAM:Eu) phosphors. The crystallinity of the synthesized compound, elemental analysis and surface morphology were measured using the PXRD FE-SEM, and FTIR spectroscopy respectability. The average crystallite size ($\langle D_s \rangle$) of BAM: Eu, CAM:Eu, SAM: Eu, and ZAM: Eu were found 80, 30, 29, and 26 nm respectively. The photoluminescence emission spectra of phosphor were found broadband by the monitoring using common excitation (350 nm) and emission (450 nm). The CIE-1931 color- coordinates were calculated for each sample in the blue region. The overall PL emission was found near the blue [BAM: Eu, SAM: Eu, and ZAM: Eu] and blue-red [CAM:Eu] regions with high quantum efficiency and high color purity. Long-lasting PL decay was also recorded of samples with respect to all samples BAM:Eu was calculated from 0.46 to more than 40 min. Therefore, the BAM: Eu and other synthesized phosphors would be used as a blue-emitting phosphor in widely varying fields of lightings.

Keywords: Combustion route, Hexa-aluminate, Photo-luminescence, Long lasting PL Decay, Luminescence efficiency,

1. Introduction

The rare-earth ions and transition metals doped with aluminates, phosphate, silicates, borate, fluorides, sulphates, sulphites, perovskites, and metal oxides-based phosphors were synthesized by various synthesis method. Because the new generation of lighting technology is totally based on long-afterglow phosphors due to their potential application in emergency exit routes of traffic signs, textile printing, painting, decoration, lighting for household lamps, special lighting for synthetic crop production, and lighting for planting. Therefore, those excellent phosphors should have high quantum efficiency, maximum thermal stability, optimum brightness, eco-friendly, low energy consumption, long life span, and Corrosion-free emission. [1-5]. The hexa-aluminates ($\text{BaAl}_{12}\text{O}_{19}$, $\text{SrAl}_{12}\text{O}_{19}$, $\text{CaAl}_{12}\text{O}_{19}$, $\text{BaMgAl}_{10}\text{O}_{17}$, $\text{SrMgAl}_{10}\text{O}_{17}$, $\text{CaMgAl}_{10}\text{O}_{17}$, and $\text{ZnMgAl}_{10}\text{O}_{17}$ etc.) are long afterglow phosphors and they have high quantum efficiency. Interestingly, the aluminates are relatively easier were prepared by combustion route with lower cost than other materials (silicates, phosphate, borate, fluorides, sulphates, sulphites) and methods (solid state reaction, Sol-gel, Co-Precipitation, and Wet-chemical method etc.) [6-8]. Combustion synthesis is a novel technique that has been applied to the





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journal homepage: www.elsevier.com/locate/msspInvestigation of photoluminescence, thermoluminescence, and energy transfer mechanism in Ce/Dy co-doped Sr₂Al₂SiO₇Tripti Richhariya^{a,*}, Nameeta Brahm^b, D.P. Bisen^b, T. Badapanda^c, Kanchan Tiwari^d, Asmita Jain^e^a Department of Physics, Kalinga University, Raipur, C.G., 492101, India^b SoS in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur, C.G., 492010, India^c Department of Physics, C.V. Raman Global University, Bhubaneswar, Odisha, 752054, India^d Department of Physics, Govt. Nagarjuna P. G. College of Science, Raipur, C.G., 492010, India^e Center for Basic Science, Pt. Ravishankar Shukla University, Raipur, C.G., 492010, India

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ABSTRACT

In the present manuscript, we report the luminescence properties and energy transfer mechanism of Ce/Dy co-doped Sr₂Al₂SiO₇ (SASO) phosphors prepared through the solid-state reaction method. Phase identification was done through a powder X-Ray diffraction tool and the obtained diffractogram confirms the formation of the desired phase. The Photoluminescence excitation and emission spectra of the prepared samples were investigated. Photoluminescence studies revealed that the luminescence intensity rises with increasing Dy concentration and optimized intensity was observed at 1 mol%. The energy transfer in the host has been attained successfully to produce color tunability. The Commission International de l'Eclairage (CIE) chromaticity coordinates and correlated color temperature (CCT) has been calculated. The energy transfer mechanism is further investigated via Thermoluminescence (TL) spectra. Further, the TL properties of synthesized phosphors were analyzed via the glow curve method along with varying UV doses. As compared to the single-doped phosphors, the TL glow curve indicates that very high intensity is observed at very low UV doses and the major TL peak is located in a higher temperature region. The calculated kinetic parameter indicates that Ce/Dy co-doped SASO has both shallow and deeper traps. All these findings suggest the potential applicability of synthesized phosphors as a low UV dosimeter.

1. Introduction

White light-emitting diodes (WLEDs) are the most striking topic of research in the field of solid-state lighting and display technologies. Several attempts had already been made, and many others have been continued by many researchers, to develop an efficient, single-phase white light-emitting phosphor [1]. Until now, three well-known methods are considered the most convenient methods to achieve WLEDs. One of these methods is combining a blue-emitting LED chip with Ce³⁺-activated Y₃Al₅O₁₂. Nevertheless, this method is accompanied by several drawbacks, such as poor thermal stability and chemical durability, a low color rendering index (CRI), and a low correlated color temperature (CCT) [2]. To overcome these drawbacks, another method is employed in substitution of this method by integrating tri-color (Red, Green, and Blue) and UV LED chip. Still, the major issue with this

method is the reabsorption of blue light, which takes place through red and green light. This has a significant impact on luminous efficiency. Another approach is to use blue LED to stimulate single-phase yellow phosphor or mixed-phase red and green phosphor [3,4]. Thus, the task of achieving an efficient single-phase white light-emitting phosphor remains same. Nowadays, phosphor-converted (PC) LEDs get much attention in display technology due to their various advantages over traditional technology. For the development of a single-phase white light emitting diode, currently, the most widely used method is the introduction of a sensitizer and an activator into a single host. The phosphor prepared by this method may be efficiently able to generate white light via energy transfer between the sensitizer and activator [5].

For the choice of dopants, among the 14 rare earth ions, the trivalent cerium ion drew considerable attention. Trivalent cerium shows intense broadband spectra in the visible region due to its parity allowed 5d→4f

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Structural, Compositional and Photoluminescence Studies of $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:\text{Eu}^{3+}$ Red Phosphor Synthesized by Solid State Reaction Method

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Abstract

In this paper, Eu^{3+} doped phosphor $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2$ is successfully synthesized via a solid-state reaction method at high temperatures. Structure characterization is determined using X-ray diffraction (XRD). Surface morphology was analyzed using Field emission scanning electron microscopy (FESEM). The EDX spectra confirm the elements present in $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:\text{Eu}^{3+}$ phosphor. Photoluminescence (PL) spectra of $\text{Li}_4\text{SrCa}(\text{SiO}_4)_2:\text{Eu}^{3+}$ phosphor was efficiently excited by UV range 220-450nm and under the excitation 395nm phosphors shows good intensity with an orange-red intense peak at 591nm and 619 nm was due to ${}^4\text{D}_0-{}^7\text{F}_1$ and ${}^4\text{D}_0-{}^7\text{F}_2$ transition respectively. Commission International del' Eclairage (CIE) color coordinate was calculated, which confirms the Eu^{3+} doped phosphor with a CIE value of $(x=0.6259, y=0.3737)$. This phosphor is considered to be a new promising orange-red emitting phosphor for WLEDs application. This phosphor may be used for solid-state lighting.

Keywords: Solid state reaction, X-ray diffraction, FESEM, EDX, Photoluminescence.

Introduction

Luminescence is the most attractive phenomenon of light which is shown by the phosphor when the charge carriers are excited by some higher energy[1]. These phosphors can be named luminescent materials and rare-earth-doped luminescent materials are studied in many fields such as; display devices, LEDs, FEDs and fluorescence labels, solar cells etc[1-3]. In present days, increasing demand for developing white light emitting diodes (WLEDs) due to their long lifetime, high quantum yield, better optical properties, saving energy, reliability, safety and environmental friendly characteristics[3-5].

There are two different approaches that can be used for fabricated phosphor-converted white-light-emitting diodes (pc-WLEDs), which are fabricated by using blue LED chip and commercial yellow phosphor $\text{Y}_3\text{Al}_5\text{O}_{12}:\text{Ce}^{3+}$ (YAG: Ce^{3+}) phosphor. However, due to the deficiency of the red component, the phosphor emits cold white light with high correlated color temperature (CCT >4500 K) and poor color rendering index (CRI) which is generally unappealing for home use[6,7]. In this way, to overcome these problem pc-WLED devices can also be fabricated by another method where combines the tri-color RGB (red, green, and blue) phosphors with near-ultraviolet(350-410nm) LED chips[6-8]. Therefore, the supplement of the red component plays a very important role for generation of warm white light. According to the composition of phosphor



Luminescence studies of Sm³⁺ doped CdB₄O₇ phosphors

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ABSTRACT

Rare earth Sm³⁺-doped cadmium tetra borate (Cd B₄O₇) phosphors were synthesized by solid-state reaction method. X-ray diffraction (XRD) technique was used for the structural characterization of the prepared phosphors, whereas EDS was used for elemental composition confirmation. The diffraction pattern of the prepared samples is well matched with the standard XRD (JCPDS file no. 30-0204). Photoluminescence emission and excitation spectra for pure and rare earth (Sm³⁺)-doped Cd B₄O₇ phosphor were obtained. The emission spectra of Sm³⁺-doped Cd B₄O₇ showed a characteristic intense emission band at 608 nm along with less intense band at 561 nm and 644 nm under the excitation wavelength of 403 nm. The doping percentage was varied from 1 mol% to 4 mol% of Sm³⁺. The photoluminescence intensity of 2 mol% of Sm³⁺ was found to be highest. From the CIE diagram of the Sm³⁺ doped Cd B₄O₇ phosphor showed the calculated color coordinates in the orange region. The thermoluminescence studies of pure and Sm³⁺-doped samples were carried out. The results of both the samples showed good TL response. The highest TL intensity was observed for 2 mol% of Sm³⁺ concentration. The optimized UV exposure time was 25 min. Nearly 66% linear relation was recorded for total TL intensity and UV exposure time. The TL spectra fall in the orange region, similar to the recorded PL emission spectra.

1 Introduction

Many oxides, sulfides, selenides, tellurides, arsenides, phosphides borates, sulfates, fluorides, and silicates are the important luminescence

materials that have been developed and used over many decades [1]. The optical properties of CdS/ZnS were studied most in earlier times [2]. The borate-based phosphors were studied extensively due to their use in industries and mineralogy. Borate

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RESEARCH ARTICLE

Luminescence investigation of $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{Dy}^{3+}$ phosphor synthesized by sol-gel methodAnita Verma¹ | Ravi Sharma² | Durga Prasad Bisen¹ | Nameeta Brahme¹ | Kamlesh Thakkar¹ | Shalinta Tigga³ | Priya Chandrakar⁴¹SoS in Physics and Astrophysics, Pt. Ravishankar Shukla University, Raipur, (C.G.), India²Department of Physics, Govt. Arts and Commerce Girls College, Devendra Nagar, Raipur, C. G., India³Department of Pure and Applied, Physics, Guru Ghasidas Vishwavidyalaya, Bilaspur, (C.G.), India⁴Department of Physics, Smt. P.G. Daga Girls College, Raipur, (C.G.), India

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Abstract

Dy^{3+} -doped $\text{CaY}_2\text{Al}_4\text{SiO}_{12}$ phosphors were prepared using the sol-gel method. X-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), and energy dispersive spectroscopy analyses (EDS) were used to analyse the crystal structure, morphology, and elemental composition of the prepared samples. The luminescence behaviour of the sample was investigated using photoluminescence (PL) and thermoluminescence (TL) techniques. The prepared $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{x}\text{Dy}^{3+}$ phosphor showed a characteristic blue and yellow emission at ~ 480 and 583 nm, respectively, with an excitation wavelength of 350 nm. The most intense PL emission was found for a 4 mol% doping concentration of Dy^{3+} ions. The CIE diagram of the phosphor showed bluish-white colour emission. For TL studies, the prepared phosphors were irradiated with a ^{60}Co γ (gamma) source and the TL glow curve of the $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:0.04\text{Dy}^{3+}$ phosphor showed three overlapped peaks. For the Gaussian peaks, Chen's peak shape method was applied to determine the kinetic parameters of the samples.

KEYWORDS

phosphor, photoluminescence, sol-gel method, thermoluminescence, XRD

1 | INTRODUCTION

In recent decades a marked evolution has been noticed in the field of optical and luminescence applications using phosphor materials [1, 2]. Garnet-based phosphor materials show superb luminescence characteristics, high thermal stability, good chemical, and physical stability, and other energy-efficient properties. Garnet acquires a cubic crystal structure with complicated positioning of different cations in the unit cell. The affability of the garnet structure allows the substitution of ions at the dodecahedral, octahedral, and tetrahedral sites. Garnet phosphor material can be used in different fields such as laser and white light-emitting diodes (WLEDs). For example, the yttrium aluminium garnet (YAG) host with lanthanide ions is a broadly used phosphor material for solid-state lighting applications [1–3].


Garnet-based phosphors have been explored by many research groups. Singh *et al.* and Katelnikovas *et al.* investigated the

luminescence behaviour of the $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{Pb}^{2+}$ and yellow-emitting $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{Ce}^{3+}$ garnet phosphors respectively [4, 5]. Similarly YAG:Dy [6, 7], $\text{Lu}_1\text{Gd}_2\text{Ga}_2\text{Al}_3\text{O}_{12}:\text{Dy}$ [8], $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{Eu}_{0.03}$ (CYASG:Eu) [9], Nd-doped YAG nano-powders [10], and $\text{Pr}^{3+}-\text{Cr}^{3+}$ and $\text{Tb}^{3+}-\text{Cr}^{3+}$ co-doped $\text{Y}_3\text{Al}_2\text{Ga}_3\text{O}_{12}$ (YAGG) phosphors [11] have been studied by other research groups. Trivalent dysprosium is the most preferred rare earth ion for producing white light-emitting luminescence materials. To explore specific luminescence host materials with better enhancement in intensity, trivalent dysprosium ions play a vital role [12].

In the present study, we synthesized $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{x}\text{Dy}^{3+}$ phosphors using the sol-gel reaction method. The luminescence behaviour of the $\text{CaY}_2\text{Al}_4\text{SiO}_{12}:\text{x}\text{Dy}^{3+}$ phosphors was studied in detail via the combined techniques of XRD, FESEM, EDS, photoluminescence excitation/photoluminescence (PLE/PL) spectroscopy, and thermoluminescence (TL) spectroscopy.



Yttrium aluminum garnet based novel and advanced phosphor synthesized by combustion route activated by Dy, Eu, and Tb rare earth metals

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ABSTRACT

In the present studies, rare earth (Dy, Eu, and Tb) activated garnet-based ($Y_3Al_5O_{12}$) phosphors were prepared using the combustion method at 550 °C. The formation of the compounds has been checked by powder X-ray diffraction and structural parameters were calculated. The crystallite/particle size has been measured using Scherrer formula as well as by transmission electron microscopy which show that the size of the particles is in the nanorange. In the photoluminescence emission spectra, YAG:Dy_{0.05} emits two distinctive colors: blue and yellow, YAG:Eu_{0.05} emits red color, whereas YAG:Tb_{0.02} emits green phosphor. Thus, the combination of rare earth (Dy_{0.05}, Eu_{0.05}, Tb_{0.02}) with garnet gives BYRG (blue–yellow–red–green) emissions can produce white light. These discussed phosphors exhibit a strong absorption between 340 and 400 nm. The energy transfer mechanism was also discussed. The higher luminescence color purity (95.68%), Color Rendering Index (95), Correlated Color Temperature (5287 K), and Quantum efficiency (93.7%) are calculated, therefore, synthesized $Y_3Al_5O_{12}Dy_{0.05}Eu_{0.05}Tb_{0.02}$ phosphor material can be used as a WLED phosphor materials in solid-state lighting system.

1 Introduction

There are diverse field of Luminescence, luminescent materials and applications. Modern lighting system totally depends on advanced and novel materials for great efforts for enhancing display quality and

visibility [1–3]. In the present scenario, the need and requirement of novel phosphor is one of the most important and urgent challenges to synthesize luminescent material for white light emitting diodes (WLED) for solid lighting devices [4–6]. Other requirement should be fulfillment by modern technology like that maximum quantum efficiency, high

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Structural and luminescence studies of Eu^{3+} doped $\text{K}_2\text{BaSr}(\text{PO}_4)_2$ phosphor

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Abstract. Eu^{3+} doped $\text{K}_2\text{BaSr}(\text{PO}_4)_2$ phosphor which gave red emission, was successfully synthesized by using the solid-state reaction method. The X-ray powder diffraction technique determined the crystal structure and the photoluminescence (PL), and thermoluminescence (TL) were also measured. The XRD pattern of prepared $\text{K}_2\text{BaSr}(\text{PO}_4)_2$ is good matched with the COD CIF File number 00-100-7161. The structure of the phosphor is orthorhombic. The crystallite sizes are evaluated from diffraction peaks using the Scherrer formula. In PL emission, two peaks are found at 592 nm and 614 nm at 395 nm excitation wavelength. The as-developed phosphor can be used in the development of WLEDs.

Keywords. Photoluminescence; Thermoluminescence; $\text{K}_2\text{BaSr}(\text{PO}_4)_2$; Eu^{3+} ; WLED

1. Introduction

In recent years, most researchers concentrated on the luminescence properties of inorganic phosphors. Because these phosphors are a variety of applications such as illumination, near-infrared detection, display, plant growth, etc, which require different luminescent properties [1-4]. Phosphates are widely used as ideal hosts for luminescent samples because of their merits like various structures, mild synthesis conditions, high emission efficiency, and excellent thermal/chemical stabilities [5, 6]. Rare earth-doped phosphates are extensively used in white light-emitting diodes (WLED) because by changing of doping concentration emission colours can be tuned [7,8].

Trivalent rare earth ions (Ln^{3+}) have high atomic number and unique electronic configurations $[\text{Xe}]4f^n$ ($n = 0-14$). From ultraviolet (UV) to near-infrared (NIR), rare earth luminescent materials have a wide range of fascinating optical properties. In rare-earth doped phosphor, excitation, and emission can be tuned through the change of doping concentration which impacts the long luminescent lifetimes, and excellent photostability. In every area of photonics and optoelectronics, including lighting, sensing, displays, energy saving, optical information storage, and healthcare, rare earth luminous materials are used [8, 9].

The activator Eu^{3+} is widely used for the preparation of fluorescent and phosphorescent materials because it has high atomic number and their transition reveals both orange and red emissions, may be due to f-f transitions which is also used in WLEDs [8, 10]. Thus, the PL intensity is based on Eu^{3+} local site symmetry, and their electronic energy level structure. The transitions in Eu^{3+} are hypersensitive and they depend on the chemical environments. Doping of Eu^{3+} in phosphate host gives red-orange emitting luminescent materials. These red-light emitting materials mixed with green phosphor and placed on the blue LED make the WLEDs. WLEDs with good CRI are a challenging task for researchers. Past several years, many scientists were focused to synthesized silicate phosphors for the development of WLEDs but their efficiencies are not good [11 - 13]. Nowadays researchers are focused on rare earth-doped phosphates which are simply synthesized and their developed WLEDs have high CRI [14-16].



Weak secondary cyclotron line in eclipsing High Mass X-ray Binary Cen X-3

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ABSTRACT

We report the time resolved spectroscopy result from two observations of Cen X-3, over one binary orbit with ASTROSAT and two binary orbit with NuSTAR. NuSTAR covered two intensity states where the light curve showed transition in count rate from first to second binary orbit by a factor of ~ 3 . A phenomenological model comprising of partially absorbed powerlaw with smoothed high energy cutoff, cyclotron absorption ~ 24 keV and 6.4 keV iron emission gave good fit for ASTROSAT observation. NuSTAR spectra required two additional emission components, a broad one ~ 5.7 keV and a narrow one ~ 6.9 keV. A weak secondary absorption feature at ~ 11.6 keV and ~ 14.5 keV was seen in the residuals of the spectral fit for ASTROSAT and NuSTAR data respectively. The secondary absorption energy showed no correlation with the cutoff energy. Its strength varied within 0.1 to 0.6 keV with its width ~ 1.6 keV. Its energy and optical depth showed linear positive correlation with the fundamental cyclotron line energy and depth respectively. The cyclotron line energy showed anti-correlation to flux described by a powerlaw with negative index and the secondary absorption also showed similar trend to flux. Depth of secondary absorption was $\sim 45\%$ and centroid energy was $\sim 54\%$ of fundamental. Depth and energy ratio of secondary to fundamental lied within 2σ deviation from 0.5. We suggest this secondary absorption to be a redshifted dipolar cyclotron resonance feature exhibiting sub-harmonic behaviour.

Key words: X-rays : binaries – pulsars: individual: Cen X-3 – accretion, accretion discs – stars: neutron – methods: data analysis – techniques: spectroscopic

1 Introduction

Among the most luminous objects in the X-ray regime are the accretion-powered X-ray binaries (XRBs), which came to discovery in the 1970s (Giacconi et al. 1971; Tananbaum et al. 1972), Centaurus X-3 (Cen X-3 hereafter) being first of its kind, by UHURU. The host star accretes matter from the companion star in two basic modes: disk accretion via Roche Lobe overflow and wind accretion. In accretion-powered Pulsars, the matter falls onto the neutron star's surface, forming an accretion column (Becker & Wolff 2005). High-Mass X-ray Binaries (HMXBs) have young optical companion stars of spectral type B or O, typically with mass $M \geq 10 M_{\odot}$ and high magnetic fields $B \sim 10^{12}$ G. Low-Mass X-ray Binaries (LMXBs) have older optical companions with mass $M \leq 1 M_{\odot}$ and lower magnetic fields $B \sim 10^9$ to 10^{10} G.

Cen X-3 is a widely studied HMXB, which hosts a neutron star and a young and massive O6-8 type supergiant star (V779 Cen or Krzeminski's star) as the optical component (Krzeminski 1974). The mass of the optical star is estimated to be $M_c \sim 20.5 M_{\odot}$ and radius to be $R_c \sim 12 R_{\odot}$ (Hutchings et al. 1979). Distance to the binary system was estimated earlier to be ~ 8 kpc (Krzeminski 1974) and

later to be 5.7 ± 1.5 kpc (Thompson & Rothschild 2009) and recent to be 7.2 kpc (Gaia Collaboration et al. 2023). This eclipsing HMXB is known to pulsate at ~ 4.8 s, and has an orbital period ~ 2.1 days (Schreier et al. 1972). Cen X-3 is one of the brightest sources in X-rays with a luminosity of $\sim 5 \times 10^{37}$ erg s⁻¹ (Suchy et al. 2008). It is a disk-fed system by Roche Lobe overflow. A QPO of 35 ± 2 mHz was measured by Takeshima et al. (1991), ~ 40 mHz by Raichur & Paul (2008) and recently ~ 26 mHz in the low state by Bachhar et al. (2022), thereby supporting the evidence of accretion disk. The compact neutron star mass M_n is estimated to be $1.2 \pm 0.21 M_{\odot}$ and has an inclination of 70° with the plane of the binary orbit (Ash et al. 1999).

Initial estimation of neutron star magnetic field $\sim 2.6 \times 10^{12}$ G using quasi-periodic oscillation analysis at frequency ~ 40 mHz was reported with Broad Band X-Ray Telescope (BBXRT) observation of 1990, December 9 (Audley 1998). The same work showed evidence of cyclotron resonance scattering feature (CRSF hereafter) in Cen X-3 with energy (E_{cyc} hereafter) at 25.1 ± 0.3 keV with RXTE observation of 1996, March 1. Using 45.36 ks BeppoSAX observation of 1997, February 27 and 28, Santangelo et al. (1998) reported the X-ray spectrum to be described by an absorbed power law model with a high energy cutoff ~ 14 keV folded around 8 keV along with a soft excess ~ 0.1 keV, one iron emission line ~ 6.7 keV and a

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Search for merger ejecta emission from late-time radio observations of short GRBs using GMRT

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ABSTRACT

In some cases, the merger of two neutron stars can produce a rapidly rotating and highly magnetized millisecond magnetar. A significant proportion of the rotational energy deposited to the emerging ejecta can produce a late-time radio brightening from interacting with the ambient medium. Detection of this late-time radio emission from short GRBs can have profound implications for understanding the physics of the progenitor. We report the radio observations of five short GRBs – 050709, 061210, 100625A, 140903A, and 160821B using the legacy Giant Metrewave Radio Telescope (GMRT) at 1250, 610, and 325 MHz frequencies and the upgraded-GMRT (uGMRT) at band 5 (1050–1450 MHz) and band 4 (550–900 MHz) after ~ 2 –11 yr from the time of the burst. The GMRT observations at low frequencies are particularly important to detect the signature of merger ejecta emission at the peak. These observations are the most delayed searches associated with some GRBs for any late-time low-frequency emission. We find no evidence for such an emission. We find that none of these GRBs is consistent with maximally rotating magnetar with a rotational energy of $\sim 10^{53}$ erg. However, magnetars with lower rotational energies cannot be completely ruled out. Despite the non-detection, our study underscores the power of radio observations in the search for magnetar signatures associated with short GRBs. However, only future radio observatories may be able to detect these signatures or put more stringent constraints on the model.

Key words: gravitational waves – surveys – stars: magnetars – stars: neutron – gamma-ray bursts – neutron star mergers.

1 INTRODUCTION

Double neutron star (DNS) or neutron star–black hole mergers have been argued to be the most promising progenitors for short-duration gamma-ray bursts (short GRBs; Paczynski 1986; Narayan, Paczynski & Piran 1992; Ruffert & Janka 1999). The gravitational waves (GWs) discovery from the DNS merger GW 170817 and simultaneous observation of a short GRB 170817A, along with the discovery of its electromagnetic counterparts in various bands, have revolutionized the era of multimessenger astronomy (Abbott et al. 2017; Goldstein et al. 2017; Savchenko et al. 2017) and has strengthened the hypothesis that short GRBs result from the merger of compact objects.

However, there are uncertainties about the final phase of the merger as GW observations are not sensitive to the post-merger dynamics of neutron star mergers (see e.g. fig. 1 of Bartos, Brady & Márka 2013) given the current sensitivities of the detectors. Numerical simulations have shown that the merger remnant may form a rapidly spinning supra-massive, highly magnetized neutron star (magnetar) before

collapsing to a black hole (Ozel 2011; Giacomazzo & Perna 2013). Whether the situation occurs or not depends crucially on the resultant mass of the remnant and the highly uncertain equation of states (EoS) of dense neutron stars (Ozel 2011; Lasky & Glampedakis 2016; Ozel et al. 2016; Lan et al. 2020). With the recent discovery of millisecond pulsar MSP J0740+6620 having the mass of $2.14^{+0.10}_{-0.09} M_{\odot}$ (Cromartie et al. 2020), this mass is often used as the lower limit of maximum neutron star mass. For a binary mass $< 3 M_{\odot}$, a long-lived supra-massive neutron star remnant could be formed (Dai et al. 2006; Giacomazzo & Perna 2013) before collapsing to a black hole.

In the case of a DNS merger, the resultant product will be rapidly rotating with a spin period close to the centrifugal breakup value ($P \sim 1$ ms). The remnant could also acquire a strong magnetic field $\geq 10^{14}$ – 10^{15} G, which may be enhanced by the Kelvin–Helmholtz instabilities and the dynamo activity (Duncan & Thompson 1992; Usov 1992; Price & Rosswog 2006; Kiuchi et al. 2015; Guilet et al. 2017). During the merger, when the neutron stars are tidally disrupted, mass is thrown out with sub-relativistic velocities, which is expected to undergo r -process nucleosynthesis and produce UV/opt/IR emission resulting in a ‘kilonova’ (Li & Paczyński 1998; Tanvir et al. 2017;

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Effect of TiO_2 on ion transport properties and dielectric relaxation of sodium ion-conducting novel PEO/PAN-blended solid polymer electrolyte

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In the present manuscript, a comprehensive study of temperature-dependent ionic conductivity, dielectric behaviour, and thermal, structural, and morphological characteristics of nano-composite polymer electrolyte (NCPE) films has been performed. NCPE films were prepared by hot-press method from a blend of two polymers, Poly (ethylene oxide) (PEO) and Poly (acrylonitrile) (PAN), complexed with sodium perchlorate (NaClO_4) complexing salt and titanium dioxide (TiO_2) nanofiller. Electrochemical Impedance Spectroscopy (EIS) has been used to investigate electrical and dielectric properties and their correlations. The effect of TiO_2 concentration on ionic conductivity and dielectric relaxation has been investigated at different temperature ranges. Both the smoother surface and the presence of all essential components were verified by scanning electron microscopy (SEM) and energy-dispersive spectroscopy (EDAX), respectively. Thermogravimetric Analysis (TGA) revealed high thermal stability, and Differential Scanning Calorimetry (DSC) and X-ray Diffraction (XRD) confirmed enhanced amorphous phase. The cyclic voltammetry (CV) curve exhibits excellent reversibility and cyclability.

Introduction

In materials, there are two types of conduction: due to electronic and ionic. Solid-State Ionics is a branch of Material Science, in which materials with high ionic transport characteristics are studied, these materials have a wide range of applications, one of them being for energy storage devices. The demand for safe, dependable, and effective energy storage devices to store electrical energy has increased [1]. In the modern era, portable electronic devices viz. mobile phones, fitness trackers, tablet computers, etc. become more widespread in our culture and many areas of our lives are now dependent on the functioning of electronic equipment directly or indirectly [2]. Furthermore, recent improvements in processing power, long durability, screen size, and the desire for ultra-thin and lighter gadgets have raised the demand for lighter batteries with improved energy density [3–6].

In the development of advanced energy storage systems and conversion devices, polymer electrolytes are more prominent materials due to their flexibility, desired shapes/sizes,

mechanical/chemical/thermal stability over a wide temperature range, and light-weight, non-volatility, and corrosion-free properties [7, 8]. Polymer electrolytes are chosen for energy storage applications such as high energy density solid polymer batteries because they allow for easy formation of close electrode/electrolyte contact [9, 10]. The primary function of polymer electrolytes in the battery is to serve as a separator between the anode and cathode materials [11, 12]. It also acts as an ion transport medium for the conduction of ions during electrochemical processes, like charging/discharging. The ions in the electrolyte are adsorbed/desorbed on the porous electrode, due to which fast charging/discharging of the solid polymer battery system has occurred and that provides a high energy density [13–15]. Polymer Electrolyte materials have mainly been classified into Gel Polymer Electrolyte (GPE) and solvent-free/dry Solid Polymer Electrolyte (SPE). The GPE has higher ionic conductivity but exhibits poor mechanical stability, whereas the SPE is mechanically stronger and may be made into free-standing electrolyte membranes [16, 17]. In SPE, instead of using an additional



Physical and electrical property studies on sodium (Na⁺) – Ion conducting Nano-Composite Polymer Electrolyte membranes

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ABSTRACT

Present work reports that Polymer Electrolyte Membranes: [97PEO: 3NaCOOCH₃] dispersed with ceramic filler SiO₂ have been synthesized using the hot-press casting technique. Ion transport properties have been evaluated in terms of the essential ionic conductivity (σ) and total ionic (t_{ion}) / cationic (t_+) transference numbers using different ac/dc techniques to evaluate its usefulness in all-solid-state battery applications.

Structural/thermal properties have been characterized using X-ray Diffraction (XRD), Differential Scanning Calorimetry (DSC) and Thermal Gravimetric Analysis (TGA) techniques. The thermal laminated pouch cell has been fabricated and tested by sandwiching the best optimized NCPE film between MnO₂ cathode and Graphite anode. Cyclic Voltammetry study of NCPE film exhibits good electrochemical behaviour and is more suitable for battery fabrication.

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1. Introduction

Modern electrochemical power sources, viz. batteries, fuel cells, super-capacitors etc., developed by Polymer electrolyte membranes have great technological attention. Solid Polymer Electrolytes have several advantages over conventional solid/liquid/aqueous electrolyte systems [1–4]. These include size/shape flexibility, intimate electrode/ electrolyte contact/ compatibility, more comprehensive temperature range of operation, larger recharge cyclability, longer shelf life etc. In 1973, the first Solid Polymer Electrolytes (SPEs) film, that is, Poly (ethylene oxide) PEO complexed with alkali metal salt, was reported by Fenton et al. [5]. The first solid polymer electrolyte SPE film: PEO: Li⁺-ionic salt-based battery, was practically demonstrated by Armand et al. in 1979 [6]. Polymer electrolyte materials with different mobile ion species viz. H⁺, Ag⁺, Cu⁺, Li⁺, Na⁺, K⁺, Mg²⁺, Zn²⁺ etc., have been investigated and tested for their applications in electrochemical power sources [7–14]. However, most modern portable batteries are primarily based on Li⁺-ion conducting polymer electrolytes and Lithium metal electrodes. Lithium chemicals are known for

their several limitations. They are more reactive, difficult to handle in open ambience, toxic, expensive, low natural abundance etc.; hence, the batteries based on these chemicals involve several safety and environmental issues [15–16]. Thus, most of the researchers mainly focus their work on non-lithium-based battery technology [17–20], such as Na-ion batteries (NIBs), as compared to Li-ion batteries due to the materials advantages and low-cost resources [21–24].

The present paper reports the synthesis of Na⁺-ion conducting Nano-Composite Polymer Electrolyte (NCPE) films: [97PEO: 3NaCOOCH₃] + xSiO₂ in varying filler concentrations. These films were prepared by a completely dry/solution-free hot-press casting technique. The hot-press technique has advantages over traditional film casting procedures such as sol-gel and solution cast. Hot-press film casting technique is solvent-free, more rapid and cost-effective. Optimum Conducting Composition (OCC) NCPE film has been identified. NCPE OCC film was subjected to materials characterization and ion transport properties studies to evaluate its usefulness in all-solid-state battery applications. Materials and thermal property studies have been characterized by X-ray Diffraction (XRD), Differential Scanning Calorimetry (DSC), Thermal Gravimetric Analysis (TGA) and ion transport mechanism have been measured by AC Impedance Spectroscopy (IS). Finally, an

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Electrical and thermal analysis on Na⁺ - ion conducting novel blended solid polymer electrolyte membranes

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ABSTRACT

In this study, the hot press method has been used to synthesize a blended solid polymer electrolyte (BSPE), containing poly (ethylene oxide) and polyacrylonitrile (PEO/PAN) matrix complexed with sodium perchlorate (NaClO₄) salt. The film with varying salt concentration has been prepared, in which the BSPE OCC (optimum conducting composition) film exhibits the highest ionic conductivity is (σ_{IT}) $\sim 2.10 \times 10^{-6} \text{ Scm}^{-1}$ at room temperature. X-ray diffraction (XRD), Impedance Spectroscopy (IS), Differential Scanning Calorimetry (DSC) and Thermal Gravimetric Analysis (TGA) techniques have been adopted for the characterization. These investigations are demonstrated their utility and potential for all-solid-state device applications.

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1. Introduction

In the last few decades, polymer-based electrolytes have received a lot of interest for electrochemical applications such as batteries, supercapacitors and sensors [1–3]. The dissociated form of salt provides mobile ions, while the polymer facilitates ion transport and which gives the electrolyte a free-standing and flexible consistency. Due to their characteristics such as light weight, flexibility, geometric stability, increased safety, and no leakage, these systems are unquestionably superior to liquid electrolytes and brittle ceramic matrix electrolytes. Polymer electrolytes (PEs) have excited the interest of the scientific community as a feasible alternative to traditional liquid-based electrolytes as a result of this research and development [4,5]. Initially, gel polymer electrolytes (GPEs) were made by adding an organic solvent (such as EC, PC, DEC / DMC) to a polymer salt matrix as a plasticizer, and they exhibited superior properties over liquid electrolytes. However, due to weak mechanical properties and interfacial difficulties prohibited them from being used in a safe battery system. Solid polymer electrolyte (SPE) films appear the best alternative, with the ability to solve the problems associated with all traditional and GPE systems. The SPE has several advantages, including a simple

and low-cost design method, flexibility, and device scale-down, which reduces both cost and weight. Because no liquid is used, the all-solid-state battery provides more safety than the existing one. The high ionic conductivity, a wide range of voltage, good mechanical stability with a wide temperature range, and interfacial qualities are desirable properties for SPE film membranes. Another significant advantage of SPE is that it may act as both an electrolyte and a separator in energy storage and conversion devices [6–8]. Since the beginning of polymer electrolytes, polyethylene oxide (PEO) is one of the most common polymers for the synthesis of electrolyte membranes. It's a semi-crystalline polymer that interacts with the cation of the salt and operates as a solid solvent due to the presence of ether oxygen in its main chain. Ion transport in PEO-based electrolytes is aided by the segmental motion of the polymer chains, which is highly dependent on the amorphosity of the system [9,10]. However, the semi-crystalline nature of PEO, reduces the ionic conductivity of these electrolytes, limiting their practical applicability. Various strategies such as polymer blending, crosslinking, and so on, have been adopted to improve the electrochemical characteristics of such systems, including reducing the crystallinity of PEO-based electrolytes and increasing ionic conductivity at ambient temperature. Polymer blending looks to be more convincing and effective in recognized ways, as it blends and enhances the properties of the particular host polymer. According to some recently published research SPEs have been used in a variety of formulations, i.e., poly (vinyl

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आदिवासी जीवन शैली में पेसा अधिनियम 1996 का महत्व और उपयोगिता

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शोध सार

स्वशासन की अवधारणा विश्वभर में लोकतंत्र की सफलता की कुंजी मानी जाती है। राजनीतिक प्रणाली और संस्थाओं में जनता की सहभागिता, जो उनके जीवन को नियंत्रित करती है, मानवाधिकार की मूल आवश्यकता है और उनके सामाजिक और आर्थिक विकास के लिए भी आवश्यक है। पंचायती राज व्यवस्था विकास की प्रक्रिया में सभी हितधारकों को शामिल करती हुई एक विकेंद्रीकृत शासन संरचना के रूप में कार्य करती है। अनुसूचित क्षेत्रों में पंचायती विस्तार अधिनियम, 1996 ने देश की पंचायती प्रणाली में बहुत समय से बंद रहे सुधारों को लागू किया है। पेसा एक साहसिक कानून है जो आदिवासी अधिकारों, सांस्कृतिक अधिकारों, भाषा और पहचान जैसे कई मुद्दों से जुड़ा हुआ है, इसके अलावा उनके क्षेत्र में स्थित सभी संसाधनों जैसे भूमि, जल, जंगल और खनिजों के अधिकारों और आदिवासी समुदायों के अधिकारों पर बल देता है। इसके माध्यम से लोग अपने स्वयं के संस्थानों, संस्कृतियों और परंपराओं को स्थायी रूप से संरक्षित रखने और मजबूत करने के साथ-साथ अपनी आकांक्षाओं और जरूरतों के अनुसार अपने विकास को आगे बढ़ाने के लिए सक्षम होते हैं।

मुख्य शब्द

स्वशासन, पेसा अधिनियम, विकास, आदिवासी.

प्रस्तावना

लोकतांत्रिक विकेंद्रीकरण निर्णय लेने की प्रक्रियाओं में लोगों की भागीदारी पर जोर देने के साथ शासन का एक प्रमुख साधन है जिससे विकास कार्यक्रमों के कार्यान्वयन में जवाबदेही और पारदर्शिता सुनिश्चित होती है। यह माना जाता है कि विकेंद्रीकरण एक वैध संस्थागत ढांचे के माध्यम से स्थानीय शासी संस्थाओं को राजनीतिक, प्रशासनिक और वित्तीय शक्तियों को निहित करके जमीनी

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स्तर पर शासन प्रणाली को मजबूत करने की एक प्रक्रिया है जैसा कि शासन निर्णय लेने की एक प्रक्रिया है, राष्ट्रीय से स्थानीय स्तर पर शासन का विकेंद्रीकरण विकास और विकास के लिए अच्छा माहौल बनाने के साथ लोगों को निर्णय लेने की प्रक्रिया में अधिक प्रत्यक्ष रूप से भाग लेने में सक्षम बनाता है। विकेंद्रीकृत शासन लोगों को प्रशासनिक मामलों में अधिक चौकस बनाता है और लोगों और प्रशासन के बीच की खाई को कम करता है।

भारत में, ग्रामीण क्षेत्रों में विकास कार्यक्रमों को बढ़ावा देने के लिए विकेंद्रीकृत शासन की कल्पना स्थानीय सरकार के एक साधन के रूप में की गई है। ग्रामीण स्थानीय स्वशासी संस्थाओं को सुदृढ़ करने के लिए दो महत्वपूर्ण विधानों जैसे, 1992 का 73वां संविधान संशोधन अधिनियम और पंचायतों के प्रावधान (अनुसूचित क्षेत्रों तक विस्तार) अधिनियम, 1996 के लागू होने के बाद लोकतांत्रिक विकेंद्रीकरण ने एक नया आकार लिया है। संविधान का 46 अनुच्छेद प्रावधान करता है कि राज्य समाज के कमजोर वर्गों और विशेष रूप से अनुसूचित जातियों और अनुसूचित जनजातियों के शैक्षिक और आर्थिक हितों को विशेष ध्यान से बढ़ावा देगा और सामाजिक अन्याय और सभी प्रकार के शोषण से उनकी रक्षा करेगा। भारत के संविधान ने पाँचवीं और छठी अनुसूची क्षेत्र प्रावधानों को लागू करने के साथ आदिवासी विकास के लिए विशेष प्रशासनिक संरचना को चित्रित करके विशेष प्रावधान भी प्रदान किए हैं। हालाँकि, इन प्रावधानों के बावजूद, भारत में आदिवासी विकास कार्यक्रमों की विफलता के कारण अनुसूचित जनजातियों को अभी भी सामाजिक और आर्थिक रूप से पिछड़ा माना जाता है। जनजातीय विकास प्रशासन की प्रकृति लोकतांत्रिक के बजाय अधिक आधिकारिक है, जो भारत में जनजातीय विकास कार्यक्रमों की विफलता का एक प्रमुख कारण है। तो इस संदर्भ में, पंचायत (अनुसूचित क्षेत्र तक विस्तार) अधिनियम – पेसा ने शासन का एक लोकतांत्रिक मॉडल प्रदान किया है जो अधिक सहभागी, अधिक जवाबदेह है और आदिवासी क्षेत्रों में बेहतर प्रशासन प्रदान करता है।

पंचायतों का अनुसूचित क्षेत्रों तक विस्तार अधिनियम, 1996 24 दिसंबर, 1996 को लागू हुआ। इस अधिनियम का उद्देश्य जनजातीय समाजों के नियति पर नियंत्रण और प्राकृतिक संसाधनों पर उनके पारंपरिक अधिकारों की संरक्षा और सुरक्षा करने का है। इस अधिनियम के तहत आंध्र प्रदेश, बिहार, झारखंड, गुजरात, हिमाचल प्रदेश, महाराष्ट्र, मध्य प्रदेश, छत्तीसगढ़, उड़ीसा और राजस्थान जैसे राज्यों के आदिवासी क्षेत्रों में पंचायतें स्थापित की गईं।

अधिनियम के प्रावधानों के अनुसार, राज्य सरकारों को एक वर्ष के भीतर यानि 23 दिसंबर, 1997 तक अपने कानून बनाने की आवश्यकता थी। अधिकांश राज्यों ने अधिनियम को प्रभावी करने के लिए आवश्यक राज्य कानून बनाए हैं जो 1996 के अंत में लागू हो गए।

इस अधिनियम की मुख्य विशेषताएं हैं:

1. प्रत्येक गांव में एक निर्वाचित ग्राम सभा होगी और यह लोगों की परंपराओं और रीति-रिवाजों की रक्षा और संरक्षण के लिए सक्षम होगी।
2. ग्राम सभा सामाजिक और आर्थिक विकास के लिए योजनाओं, कार्यक्रमों और परियोजनाओं को उनके कार्यान्वयन से पहले अनुमोदित करेगी।
3. यह गरीबी उन्मूलन और अन्य कार्यक्रमों के तहत लाभार्थियों के रूप में व्यक्तियों की पहचान या चयन के लिए जिम्मेदार होगा।
4. प्रत्येक ग्राम पंचायत संबंधित ग्राम सभा से योजनाओं, कार्यक्रमों और परियोजनाओं के लिए धन के उपयोग का प्रमाण पत्र प्राप्त करेगी।
5. प्रत्येक पंचायत में अनुसूचित क्षेत्रों में सीटों का आरक्षण पंचायत में समुदायों की आबादी के अनुपात में होगा।
6. अनुसूचित क्षेत्रों में लघु जल निकायों की योजना और प्रबंधन पंचायतों को उपयुक्त स्तर पर सौंपा जाएगा।
7. ग्राम सभा या पंचायतों की सिफारिशें:
 - i. खनन खनिजों के लिए लाइसेंस

- ii. अनुसूचित क्षेत्रों में नीलामी द्वारा गौण खनिजों के दोहन के लिए रियायतें देने के लिए अनिवार्य होंगी।
8. राज्य विधानमंडल पंचायतों और ग्राम सभा को विशेष रूप से अधिकार संपन्न करेगा:
 - i. किसी भी नशीले पदार्थ की बिक्री और खपत पर प्रतिबंध लगाने या विनियमित या प्रतिबंधित करने की शक्ति।
 - ii. लघु वन उपज का स्वामित्व।
 - iii. अनुसूचित क्षेत्रों में भूमि हस्तांतरण को रोकने की शक्ति।
 - iv. ग्रामीण बाजारों के प्रबंधन की शक्ति।
 - v. अनुसूचित जनजातियों और सामाजिक क्षेत्रों को धन उधार देने को नियंत्रित करने की शक्ति।
 - vi. आदिवासी उप-योजनाओं सहित ऐसी योजनाओं के लिए स्थानीय योजनाओं और संसाधनों को नियंत्रित करने की शक्ति।
 - vii. राज्य विधान पंचायतों को शक्तियां और अधिकार प्रदान कर सकते हैं, जो उन्हें स्व-शासन की संस्थाओं के रूप में कार्य करने में सक्षम बनाने के लिए आवश्यक हो सकते हैं।

अधिनियम के उद्देश्य

1. पंचायतों से संबंधित संविधान के भाग IX के प्रावधानों को कुछ संशोधनों के साथ अनुसूचित क्षेत्रों तक विस्तारित करना।
 2. जनजातीय जनसंख्या के बड़े हिस्से को स्वशासन प्रदान करना।
 3. सहभागी लोकतंत्र के साथ ग्राम शासन करना और ग्राम सभा को सभी गतिविधियों का केंद्र बनाना।
 4. पारंपरिक प्रथाओं के अनुरूप एक उपयुक्त प्रशासनिक ढांचा तैयार करना।
 5. जनजातीय समुदायों की परंपराओं और रीति-रिवाजों की रक्षा और संरक्षण करना।
- पेसा अधिनियम के तहत ग्राम सभाओं को व्यापक शक्तियां सौंपी गई थीं:
1. किसी भी नशीले पदार्थ की बिक्री और खपत पर प्रतिबंध लगाना या उसे विनियमित या प्रतिबंधित करना।
 2. लघु वनोपज का स्वामित्व।
 3. अनुसूचित क्षेत्रों में भूमि के हस्तांतरण को रोकना और किसी अनुसूचित जनजाति की अवैध रूप से हस्तांतरित भूमि को बहाल करने के लिए उचित कार्रवाई करना।
 4. गाँव के बाजारों को किसी भी नाम से जाना जाता है।
 5. अनुसूचित जनजातियों को धन उधार देने पर नियंत्रण का प्रयोग करें।
 6. सभी सामाजिक क्षेत्रों में संस्थाओं और कार्यकर्ताओं पर नियंत्रण रखें।
 7. आदिवासी उप-योजनाओं सहित ऐसी योजनाओं के लिए स्थानीय योजनाओं और संसाधनों पर नियंत्रण।

महत्व

1. इसका उद्देश्य सत्ता का विकेंद्रीकरण करना और स्वदेशी समुदायों को सशक्त बनाना, सहभागी लोकतंत्र का मार्ग प्रशस्त करना और परिकल्पना की गई कि स्थानीय शासन का प्रत्येक स्तर स्वतंत्र है।
2. यह शासन के मूलभूत सिद्धांत पर आधारित है कि मानव समुदाय अपने अस्तित्व की अधिकांश चुनौतियों को संभालने के लिए सबसे अच्छी एजेंसी हैं, अपने मामलों का प्रबंधन करते हैं और सहभागी विचार-विमर्श लोकतंत्र के साधन के माध्यम से बढ़ती मुक्ति की दिशा में प्रगति करते हैं।
3. यह 6वीं अनुसूची क्षेत्र के समान पंचायतों के उपयुक्त स्तर बनाने का भी आह्वान करता है, जहां प्रशासनिक सीमाएं स्व-शासन के लिए पर्याप्त स्वायत्त हों।

4. अधिनियम का निर्माण ग्राम स्वराज की गांधीवादी अवधारणा के आसपास किया गया है जिसे संविधान में अनुच्छेद 40 (ग्राम पंचायतों का संगठन) के रूप में शामिल किया गया था और पेसा को अपना देने के बाद ही जीवित हुआ था।
5. 73वें संशोधन के द्वारा सम्मिलित किये गए अनुच्छेद 243 ने ग्राम और ग्राम सभा को पहली बार संविधान का एक हिस्सा बनाया और पेसा ने सत्ता हस्तांतरण और स्वशासन की अवधारणा को आकार दिया।
6. इसलिए पेसा का पहला मूल खंड कानूनी धारणा के साथ शुरू होता है कि "ग्राम सभा" "सक्षम" है और राज्य सरकारों से कानूनी, प्रक्रियात्मक और प्रशासनिक सशक्तिकरण सुनिश्चित करने का आह्वान करती है।

अध्ययन के उद्देश्य

अधिनियम के संदर्भ में विकेंद्रीकृत स्वशासी संस्थाओं और अनुसूचित जनजातियों के सामाजिक-आर्थिक विकास की प्रक्रिया में उनके योगदान के बीच की कड़ी को समझने के लिए पेसा का कार्यवाही करना। अध्ययन को पेसा अधिनियम के कार्यान्वयन की प्रकृति और सीमा को समझने के लिए भी डिज़ाइन किया गया है और किस प्रकार इस अधिनियम के कार्यान्वयन की प्रक्रिया ने जनजातीय क्षेत्रों में शासन प्रणाली (संरचना और कार्य) के परिवर्तन की दिशा में नेतृत्व किया है। आँकड़ों के स्रोत आँकड़ों के संग्रह की प्रक्रिया द्वितीयक आँकड़ों के आधार पर निर्भर होगी जैसे पुस्तकें, पत्रिकाएँ, सरकारी प्रकाशन, जनगणना रिपोर्ट, आर्थिक सर्वेक्षण रिपोर्ट, जिला और राज्य गजेटियर, राज्य और जिला योजना दस्तावेज, जिला और राज्य मानव विकास रिपोर्ट, वार्षिक रिपोर्ट विभिन्न विभागों, जिला प्रशासन, ब्लॉक प्रशासन और पंचायती राज संस्थाओं की रिपोर्ट और रिकॉर्ड आदि।

राज्य सरकारों को पंचायत (अनुसूचित क्षेत्रों तक विस्तार) अधिनियम (PESA), 1996 के प्रावधानों के अनुरूप लाने के लिए निम्नलिखित विषयों से संबंधित अपने विषय कानूनों/अधिनियमों में संशोधन करने की आवश्यकता है:

- i. अधिग्रहण भूमि;
- ii. गौण खनिजों के लिए पूर्वक्षण लाइसेंस या खनन पट्टा प्रदान करना;
- iii. नीलामी द्वारा गौण खनिजों के दोहन के लिए रियायत प्रदान करना।
- iv. लघु जल निकायों की योजना और प्रबंधन।
- v. किसी भी नशीले पदार्थ की बिक्री और खपत पर प्रतिबंध लगाने या उसे विनियमित या प्रतिबंधित करने की शक्ति।
- vi. लघु वनोपज का स्वामित्व;
- vii. अनुसूचित क्षेत्रों में भूमि के अन्य संक्रामण को रोकने की शक्ति;
- viii. ग्राम बाजारों का प्रबंधन करने की शक्ति;
- ix. अनुसूचित क्षेत्रों में धन उधार पर नियंत्रण करने की शक्ति।

यह न केवल "प्रथागत कानून, सामाजिक और धार्मिक प्रथाओं, और सामुदायिक संसाधनों के पारंपरिक प्रबंधन प्रथाओं" की वैधता को स्वीकार करता है, बल्कि राज्य सरकारों को निर्देश देता है कि वे कोई भी कानून न बनाएं जो इनके विपरीत हो। समुदाय के लिए एक स्पष्ट भूमिका को स्वीकार करते हुए, यह ग्राम सभा को व्यापक अधिकार देता है।

पेसा: परिचालन मुद्दे और चुनौतियां

हालांकि पेसा अधिनियम, 1996 ने प्राकृतिक संसाधनों, बड़ी परियोजनाओं के विस्थापन और स्वशासन के मुद्दों पर जनजातीय लोगों के संघर्ष को मजबूत किया, व्यवहार में स्थिति पूरी तरह से अलग है। पाँचवीं और छठी अनुसूचियों में कई निषेधों के बावजूद, आदिवासी क्षेत्रों को बिना किसी संशोधन के यंत्रवत् और कभी-कभी कानून द्वारा निर्ममता से शासित किया जा रहा है। ओडिशा में, यह देखा गया है कि खानों, खनिजों आदि के लिए लाइसेंस

देने जैसे गंभीर मुद्दों को ग्राम सभा के बजाय जिला परिषद को दिया गया है और निर्णय स्थानीय लोगों के ज्ञान और परामर्श के बिना किया जाता है। देखने में आया है कि अनुसूचित क्षेत्रों में निचली ग्राम सभा/ग्राम पंचायत को बहुत कम शक्ति दी गई है। वास्तव में पेसा को उसकी सही भावना से लागू नहीं किया जा रहा है। अधिकांश योजनाओं का पालन सामान्य पंचायतों द्वारा किया जाता है और आदिवासियों में इस अधिनियम के प्रति जागरूकता और जानकारी का अभाव है। जमीनी स्तर पर लोगों को सशक्त बनाने के प्रयास किए गए हैं, लेकिन बड़े पैमाने पर लोगों को इस अधिनियम की खूबियों और इससे होने वाले बदलावों के बारे में जानकारी नहीं है। पेसा की वास्तविक भावना तब आएगी जब निर्णय लेने की प्रक्रिया में आदिवासियों की सीधी भागीदारी होगी। ग्राम सभा की शक्ति को और मजबूत किया जाना चाहिए।

निष्कर्ष

1996 का पेसा अधिनियम भारत में जनजातीय क्षेत्रों और आदिवासियों के उत्थान के लिए उन्हें मुख्यधारा में लाने के लिए कानून का सबसे महत्वपूर्ण हिस्सा है। 73वें संविधान संशोधन के बाद से, पंचायतों ने खुद को भारत में लोकतांत्रिक व्यवस्था के एक महत्वपूर्ण घटक के रूप में स्थापित किया है। इस कानून से आदिवासियों को जमीन-जंगल-जल पर अपना दावा कायम करने में मदद मिलेगी, लेकिन जल्द ही इच्छाएं गायब हो गईं, क्योंकि पेसा अधिनियम-1996 और वन अधिकार अधिनियम-2006 के प्रावधानों को लागू करने के लिए राजनीतिक इच्छाशक्ति बहुत कमजोर है। इसके अलावा, धनी गैर-आदिवासी निहित स्वार्थों के साथ कानूनों में खामियों का फायदा उठाने के लिए हमेशा तैयार रहते हैं और संबंधित अधिकारियों के साथ मिलकर गरीब आदिवासियों को उनके मूल अधिकारों से वंचित करते हैं। अपनी संस्कृति की विरासत की रक्षा और सरकार की समग्र नीतियों के साथ सामंजस्य स्थापित करना समाज की आवश्यकता है। जब तक सरकार पर्याप्त बुनियादी ढांचे की स्थापना करके और आदिवासियों को इसके लाभों के बारे में जागरूक करके पूर्वोक्त अधिनियमों के प्रावधानों के प्रभावी कार्यान्वयन को सुनिश्चित नहीं करती है, तब तक पेसा के अधिनियम का उद्देश्य और इरादा विफल हो जाएगा और इसके तहत लाभ आदिवासियों के लिए मृगतृष्णा बने रहेंगे।

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महिलाओं के सामाजिक, आर्थिक एवं राजनैतिक विकास में शिक्षा की भूमिका

शोध सार

ORIGINAL ARTICLE



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भारत में महिला शिक्षा का इतिहास प्राचीन वैदिक काल से जुड़ा हुआ है। उल्लेखनीय है कि लगभग 3000 से अधिक वर्ष पूर्व वैदिक काल के दौरान महिलाओं को समाज में एक प्रतिष्ठित स्थान प्राप्त था और उन्हें पुरुषों के समान समाज का एक महत्वपूर्ण अंग समझा जाता था। ब्रिटिश इंडिया काल में पहला ऑल-गर्ल्स बोर्डिंग स्कूल वर्ष 1821 में दक्षिण भारत के तिरुनेलवेली में स्थापित किया गया था। वर्ष 1840 तक स्कॉटिश चर्च सोसाइटी द्वारा दक्षिण भारत में निर्मित 06 स्कूल मौजूद थे जिनमें कुल 200 लड़कियों का नामांकन कराया गया था। वर्ष 1848 में पुणे में ज्योतिबा फूले एवं सावित्रीबाई फूले ने पुणे में प्रथम गर्ल्स स्कूल की स्थापना की। मद्रास मिशनरियों ने 1850 में स्कूल में लगभग 8000 से अधिक लड़कियों का नामांकन कार्य किया था। वर्ष 1848 में पुणे में ज्योतिबा फूले एवं सावित्रीबाई फूले ने पुणे में प्रथम गर्ल्स स्कूल की स्थापना की। मद्रास मिशनरियों ने 1850

में स्कूल में लगभग 8000 से अधिक लड़कियों का नामांकन कार्य था। ईस्ट इंडिया कंपनी के कार्यक्रम बुड्स डिस्पैच ने वर्ष 1854 में महिलाओं की शिक्षा और उनके लिए रोजगार की आवश्यकता को स्वीकार किया। वर्ष 1879 में स्थापित बेथून कॉलेज वर्तमान में एशिया का सबसे पुराना महिला कॉलेज है। स्वतंत्रता प्राप्ति के पश्चात् प्रथम पंचवर्षीय योजना से महिला शिक्षा पर ध्यान केंद्रित किया गया। जनगणना 1951 के अनुसार भारत में महिला साक्षरता दर 9 प्रतिशत था जिसे उन्नत करने का लक्ष्य रखा गया। यही कारण है की 2011 की जनगणना अनुसार भारत में महिला शिक्षा का प्रतिशत बढ़कर 65 प्रतिशत हुआ है। आज महिलाएं शिक्षित होकर सामाजिक, आर्थिक एवं राजनैतिक विकास में अपना योगदान दे रहीं हैं। इस शोध आलेख में महिलाओं के सामाजिक, आर्थिक एवं राजनैतिक विकास में शिक्षा की भूमिका को ज्ञात करने का प्रयास किया गया है। प्रस्तुत शोध आलेख द्वितीयक डाटा पर आधारित है। द्वितीयक डाटा का सारणीयन, विश्लेषण एवं प्रस्तुतीकरण कर तथ्यों को समझने का प्रयास किया गया है। द्वितीयक डाटा से प्राप्त आंकड़ों से स्पष्ट होता है कि महिलाएं आज सामाजिक संस्थाओं के अध्यक्ष, सदस्य एवं सचिव के साथ अपने बच्चों के समाजीकरण के माध्यम से समाज का विकास कर रही हैं। ये अब परिवार के सभी प्रकार के कार्यों में अपनी सहभागिता सुनिश्चित कर रहीं हैं। पुरुष वर्ग द्वारा प्रत्येक कार्यों में महिलाओं से सहमति ली जा रही है। महिलाओं को अब प्रत्येक प्रकार के सरकारी एवं निजी क्षेत्रों में कार्य करते हुए देखा जा सकता है। महिलाएं अब पुरुषों के साथ कंधे से कंधा मिलाकर कार्य कर रही हैं। भारत सरकार के त्रिस्तरीय पंचायती राज व्यवस्था एवं संवैधानिक प्रावधानों के जरिये महिलाएं अब सरपंच, पंच, सचिव, पार्षद, महापौर और यहाँ तक की संसद एवं विधानसभाओं के सदस्य के रूप में सामने आ रही हैं। इस प्रकार शिक्षा ने महिलाओं का सर्वांगीण विकास किया है।

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महिला, शिक्षा, विकास, सामाजिक, आर्थिक, राजनैतिक.

प्रस्तावना

स्त्री शक्ति राष्ट्र शक्ति का अभिन्न अंग होती है जिसे सशक्त और शामिल किये बिना कोई भी राष्ट्र शक्तिशाली नहीं हो सकता। शिक्षित महिला न केवल स्वयं लाभान्वित होती है, वरन उससे भावी पीढ़ी भी लाभान्वित होती है। शिक्षा किसी भी प्रकार के कौशल की प्राप्ति एवं विवेकपूर्ण दृष्टिकोण के विकास के लिए पूर्णतया आवश्यक है। "किसी भी समाज या राष्ट्र की प्रगति के लिए महिला शिक्षा का विशेष महत्व है। किसी भी शिक्षित समाज की वास्तविक स्थिति जानने का तरीका है कि हम यह जानने का प्रयास करें कि समाज में महिलाओं की शैक्षिक स्थिति कैसी है, उनको क्या-क्या अधिकार प्राप्त हुए हैं और उनकी मूलभूत संसाधनों तक कितनी पहुँच है तथा राजनीतिक व सामाजिक निर्णय निर्माण की प्रक्रिया में उनकी कितनी सहभागिता है? देखा जाय तो महिलाओं की शिक्षा विकास का एक महत्वपूर्ण कारक है जिसने महिलाओं का स्तर और उनकी समाज में भूमिका को उठाने में सहायता की है।" सामान्य तौर पर शिक्षा आर्थिक आत्मनिर्भरता में सहायक होती है। इससे महिलाओं का सामाजिक स्तर ऊपर उठता है।

शिक्षा चाहे पुस्तकीय ज्ञान से संबंधित हो, चाहे लोक ज्ञान, कृतियों और प्रथाओं के रूप में दी जाती हो अथवा यह परिवार के दैनिक कार्य के विषय में हो, हम उस संपूर्ण ज्ञान को शिक्षा के अंतर्गत सम्मिलित करते हैं। वैदिक काल में महिलाओं की स्थिति बहुत अच्छी थी। डॉक्टर राधाकुमुद लिखते हैं कि ऋग्वेद ने उस समय की योग्य स्त्रियों के लिए उच्चतम सामाजिक स्थिति प्रदान की थी।

शिक्षा के द्वारा ही महिलाएँ प्राचीन समय की अच्छाइयों बुराइयों से लेकर नये समाज से संबंधित कुरीतियों, अंधविश्वास से हट कर नये समाज के निर्माण में सहयोग दे रही है, यही कारण है कि आज की नारी पुरानी परंपराओं से दूर होती जा रही है। आज गांवों में भी आधुनिकता दिखाई पड़ रही है जिसके प्रभाव के कारण आज महिलाएँ स्कूल, कॉलेज, बैंक, अस्पताल, आफिस में स्वयं जाकर अपना कार्य कर रही है और आत्मनिर्भर होती जा रही है।

किसी भी देश के विकास संबंधी सूचकांक को निर्धारित करने हेतु उद्योग, व्यापार, खाद्यान्न उपलब्धता, शिक्षा इत्यादि के स्तर के साथ ही इस देश की महिलाओं की स्थिति का भी अध्ययन किया जाता है। नारी की सुदृढ़ एवं सम्मानजनक स्थिति एक उन्नत, समृद्ध तथा मजबूत समाज की द्योतक है। शिक्षा एवं आर्थिक स्वतंत्रता ने महिलाओं में नवीन चेतना भर दी है। जीवन के प्रत्येक क्षेत्र में महिलाओं की भूमिका में वृद्धि हो रही है। आज महिलाएँ राजनीति, बिजनेस, कला तथा खेल सहित रक्षा क्षेत्र में भी नए आयाम गढ़ रही हैं। सेना जैसे संवेदनशील क्षेत्र में भी महिलाएँ अपनी भूमिका का पुरुषों के साथ कदम मिलाकर निर्वहन कर रही हैं। हाल ही में अवनी चतुर्वेदी सहित तीन लड़कियों को वायुसेना में फाइटर प्लेन उड़ाने की अनुमति प्रदान की गई है।

महिलाओं की शिक्षा पर ध्यान देते हुए विश्वविद्यालय शिक्षा आयोग (1948) के ऐतिहासिक शब्द भी ध्यान देने योग्य हैं—“शिक्षित स्त्री के बिना शिक्षित पुरुष ही नहीं सकता।” यदि पुरुषों और स्त्रियों में से केवल एक के लिए सामान्य शिक्षा का प्रावधान करना हो तो यह अवसर स्त्रियों को दिया जाना चाहिए क्योंकि यह शिक्षा स्वमेव अगली पीढ़ी को प्राप्त हो जाएगी।” सन् 1963 के वनस्थली विद्यापीठ में भाषण देते हुए पं. जवाहर लाल नेहरू ने भी इसी तथ्य को दोहराया था कि “लड़के की शिक्षा केवल एक व्यक्ति की शिक्षा है, परन्तु एक लड़की की शिक्षा पूरे परिवार की शिक्षा है।” उपरोक्त विवेचन से महिलाओं की शिक्षा की आवश्यकता स्पष्ट होती है, लेकिन स्त्री शिक्षा इतनी आवश्यक होते हुए भी उपेक्षित है। कानूनी एवं संवैधानिक अधिकार प्राप्त होने के बाजवूद महिलाओं की स्थिति सोचनीय है। शैक्षिक, आर्थिक, सामाजिक, राजनैतिक आदि दृष्टियों से महिलाएँ अभी भी पिछड़ी हुई हैं। स्वामी विवेकानन्द के कथनानुसार “कोई राष्ट्र तब तक अपना पूर्ण विकास नहीं कर सकता जब तक उसका प्रत्येक नागरिक राष्ट्र के विकास में भागीदार नहीं बनता।”

महिला उत्थान में शिक्षा ने अहम् भूमिका अदा की। शिक्षा में महिलाओं के स्वतंत्र व्यक्तित्व तथा राष्ट्रीय चेतना का विकास हुआ। आज महिला हर क्षेत्र में पुरुष के साथ कंधे से कंधा मिलाकर चल रही है। शिक्षा के विकास से महिलाओं में जो जागृति आई है, उसी के परिणामस्वरूप उन्होंने आर्थिक क्षेत्र में पदार्पण किया है।

उद्देश्य

महिला शिक्षा देश के विकास के लिए सबसे महत्वपूर्ण है क्योंकि वे रचनाकार होती है। यदि उन्हें शिक्षित करें शक्तिशाली बनाएँ, प्रोत्साहित करें तो यह देश के लिए अच्छा है। राष्ट्रीय नीति का लक्ष्य महिलाओं की उन्नति, विकास और सशक्तिकरण सुनिश्चित करना है। उसके उद्देश्य में महिलाओं के विकास के लिए साकारात्मक आर्थिक एवं सामाजिक नीतियों के माध्यम से ऐसा अनुकूल माहौल तैयार करना है जिससे महिलाएँ अपनी क्षमता को साकार कर सकें तथा स्वास्थ्य देखभाल, गुणवत्तापूर्ण शिक्षा, रोजगार, समान पारिश्रमिक एवं सामाजिक सुरक्षा का लाभ उठा सकें तथा सामाजिक, आर्थिक, राजनैतिक क्षेत्र में महत्वपूर्ण योगदान दे सकें।

भारतीय नारी के परिप्रेक्ष्य में बीसवीं सदी के आखिरी पाँच दशक खास महत्त्व रखता है। शिक्षा के प्रसार के साथ ही व्यापक साक्षरता आन्दोलन, सूचना प्राद्यौगिकी और संचार माध्यमों में आयी क्रान्ति के तहत भारतीय नारी समाज में भी सजगता आयी। इस माहौल में पहले की अपेक्षा भारत की महिलाएँ मतदान का अधिकार जिम्मेदारी के साथ सार्थक रूप में निभाती हैं। महिला प्रतिनिधि पंचायत स्तर से लेकर संसद तक महिलावर्ग के अधिकार के लिए आवाज उठाने में सक्षम हैं। कोई भी ऐसा क्षेत्र नहीं है जहाँ नारी न पहुँची हो। भारतीय नारियों ने विमान चलाने से लेकर शून्याधरा की यात्रा तक में सफलता हासिल की है। सक्रिय राजनीति, कुशल प्रशासन, वाणिज्य प्रबंधन, सूचना प्रद्यौगिकी और शेयर बाजार जैसी उद्यमिता की दिशा में भी उन्होंने अपनी विशिष्ट क्षमताओं का परिचय पूरे विश्व को दिया है।

यह महिलाओं की कार्यक्षमता का द्योतक है, क्योंकि प्रायः कमजोर समझी जाने वाली महिलाएँ आज कठिन माने जाने वाले क्षेत्रों में भी अपनी क्षमता का प्रदर्शन कर रही हैं। गांधी जी ने कहा था कि "महिलाएँ पुरुषों से बेहतर सैनिक साबित हो सकती हैं। बस उनको मौका देने की जरूरत है।" कल्पना चावला, सुनीता विलियम्स, टेंसी थॉमस, अवनी चतुर्वेदी जैसी अनेक नारियाँ आज समाज में महिलाओं की मजबूत छवि प्रस्तुत कर रही हैं। अग्नि-पांच मिसाइल के विकास में प्रमुख भूमिका निभाने वाली टेंसी थॉमस को 'मिसाइल वुमेन' के नाम से जाना जाता है।

महिलाएँ न केवल सामान्य शिक्षा, विश्वविद्यालय तथा कालेजों में ही जा रही हैं बल्कि मुख्यमंत्री, राज्यपाल, प्रधानमंत्री, राष्ट्रपति बन रही हैं, एवरेस्ट पर विजय प्राप्त कर रही हैं, वायु सेना और नौ सेना में अपनी सेवा प्रदान कर रही हैं।

सामाजिक विकास के क्षेत्र में महिलाओं के व्यक्तिगत योगदान को पहचान देने के लिए केंद्र सरकार ने स्त्री शक्ति के नाम से पांच राष्ट्रीय पुरस्कारों की स्थापना की है। यह पुरस्कार भारतीय इतिहास को सम्मानित महिलाओं के नाम पर रखे गए हैं, जो अपने साहस और एकता के लिए विख्यात हैं, जैसे- देवी अहिल्याबाई होल्कर, कन्नगी, माता जीजाबाई, रानी गिडेनेलु जेलियांग, रानी लक्ष्मीबाई आदि।

देश के कई आर्थिक संस्थानों के शीर्ष पदों पर महिलाएँ कार्यभार संभाल रही हैं तथा देश के विकास में अपना योगदान दे रही हैं। अरुंधति महाचार्य, शिखा शर्मा, नैनालाल किदवई, सावित्री जिंदल आदि आर्थिक क्षेत्र में शीर्ष पदों पर काबिज हैं। भारत के संबंध में कई बार विश्व बैंक ग्रुप आदि ने कहा है कि अगर यहाँ पर महिलाओं की आर्थिक भागीदारी में वृद्धि की जाए तो भारत की विकास दर में तीव्र वृद्धि हो सकती है। गौरतलब है कि 1994 से 2012 के मध्य कई लाख भारतीय गरीबी रेखा से बाहर निकल चुके हैं। इन आँकड़ों में और बढ़ोतरी होती अगर कार्यबल में महिलाओं की भागीदारी में और इजाफा होता। 2012 में सिर्फ 27 प्रतिशत वयस्क भारतीय महिला विभिन्न क्षेत्रों में कार्यरत थीं। एक ओर जहाँ केन्द्र व राज्यों की सरकारें महिला उत्थान की नई-नई योजनायें बना लगीं हैं। वहीं कई गैर सरकारी संगठन भी उनके अधिकारों के लिये उनकी आवाज बुलन्द करने लगे हैं। महिलाओं में ऐसी प्रबल भावना को उजागर करने का प्रयास भी किया जा रहा है कि वह अपने अन्दर छिपी ताकत को सा

लाकर बिना किसी सहारे के आने वाली हर चुनौती का सामना कर सकें।

महिलाओं की भूमिका राजनीति में मजबूत होती जा रही है। शिक्षा, स्वास्थ्य, खेलकूद, कानून, अभियांत्रिकी, प्रबंधन के साथ-साथ राजनीति के क्षेत्र में भी महिलाएं आगे आ रही हैं और अपनी स्थिति को सुधारने के प्रयास में लगी हुई हैं। महिलाओं की राजनीतिक स्थिति को आज समाज की स्थिति के विकास के एक निर्धारक के रूप में स्वीकार किया जाता है क्योंकि महिलाएं प्रत्यक्षतः तथा अप्रत्यक्षतः राजनीतिक क्रियाओं में योगदान देती हैं। वह समस्त पारिवारिक दायित्वों को बोझ उठाकर पुरुषों को केवल राजनीतिक क्रियाएं सम्पादित करने का पूरा समय व अवसर प्रदान करती हैं अथवा स्वयं भी पारिवारिक उत्तरदायित्वों का निर्वाह करने के साथ-साथ पुरुषों के साथ कंधे से कंधा मिलाकर राजनीतिक क्रियाओं में संलग्न होती हैं। आज भागीदारी की दृष्टि से कृषि, पशु व्यवसाय, हैण्डलूम आदि में महिलाओं के अनुपात में काफी सीमा तक वृद्धि हुई है। पिछले दशक में महिलाओं की क्रियाओं से सम्बन्धित नये आयाम उभरकर सामने आये हैं।

भारत में लगभग 15 वर्षों के लिए देश की प्रधानमंत्री श्रीमती इंदिरा गांधी थी। भारत की पहली महिला राष्ट्रपति श्रीमती प्रतिभा पाटिल और विदेशमंत्री श्रीमती सुषमा स्वराज, लोकसभा अध्यक्ष सुमित्रा महाजन, रक्षामंत्री निर्मला सीतारमण जी, सूचना और प्रसारण मंत्री स्मृति ईरानी, कांग्रेस अध्यक्ष सोनिया गांधी, राजस्थान की मुख्यमंत्री सुश्री वसुंधरा राजे सिंधिया, पश्चिम बंगाल की वर्तमान मुख्यमंत्री ममता बनर्जी को किसी भी परिचय की आवश्यकता नहीं है। उन्होंने आधुनिक भारत की राजनीति में प्रमुख और निर्णायक भूमिका निभायी हैं।

निष्कर्ष

जैसे-जैसे महिलाओं का शिक्षा की ओर रुझान बढ़ा है अर्थात् वे शिक्षित हुई हैं, वैसे-वैसे वे सभी सामाजिक, आर्थिक व राजनीतिक क्षेत्र में भी सुदृढ़ हुई हैं तथा आत्मनिर्भर बनी हैं। आज ऐसा कोई क्षेत्र नहीं जहां महिलाओं ने अपनी उपस्थिति दर्ज न कराई हो। राष्ट्र के विकास की अग्रदूत बनी महिलाओं द्वारा देश ही नहीं वरन् विदेशों में भी अपने राष्ट्र का परचम लहराया है, यह सब अथक प्रयासों के द्वारा धीरे-धीरे संभव हो पाया है। महिलाएं समाज का अनिवार्य अंग हैं। सामाजिक, आर्थिक क्षेत्र के साथ-साथ राजनीति के क्षेत्र में उनकी अहम भूमिका है। जैसे-जैसे शहरों के साथ ग्रामीण क्षेत्र की महिलाओं में राजनीति जागरूकता आ रही है। शिक्षा के प्रचार-प्रसार और बदलते सामाजिक परिवेश में राजनीति में महिलाएं आगे आ रही हैं और केन्द्रीय, प्रान्तीय, स्थानीय शासन में अपनी भागीदारी निभा रही हैं इसलिये महिलाओं को सशक्त और सुदृढ़ बनाने पर ही समाज सुदृढ़ होगा। महिलाओं को सुदृढ़ करने के लिये उनका शिक्षित होना आवश्यक है ताकि अपने अधिकारों को समझ कर समाज एवं राष्ट्र का विकास कर सकें।

भारत की आर्थिक-सामाजिक प्रगति उसके महिलाओं के सामाजिक-आर्थिक प्रगति पर निर्भर करती है। इक्कीसवीं सदी की शुरुआत में देर सवेर सभी राज्य सरकारों में महिला प्रतिनिधित्व को स्थानीय स्वशासन में स्वीकारा है तथा "यत्र नार्यस्तु पूज्यन्ते रमन्ते तत्र देवता" की देववाणी को अंगीकार करते हुए त्रिस्तरीय पंचायती राज व्यवस्था में महिलाओं की भागीदारी को सुनिश्चित किया है।

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वैश्वीकरण का भारतीय महिलाओं पर प्रभाव

ORIGINAL ARTICLE



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शोध सार

वैश्वीकरण एक जटिल घटना है जिसने मानव जीवन के हर पहलू को प्रभावित किया है, जिसमें लैंगिक भूमिकाएं और संबंध शामिल हैं। महिलाएं कई तरह से प्रभावित हुई हैं और भारत इसका अपवाद नहीं है। प्रस्तुत शोधपत्र भारत में महिलाओं पर वैश्वीकरण के प्रभाव की जांच करता है, तीन प्रमुख क्षेत्रों पर ध्यान केंद्रित करता है: आर्थिक, सामाजिक और सांस्कृतिक। अध्ययन से पता चलता है कि जहां वैश्वीकरण ने भारत में महिलाओं के लिए नए अवसर पैदा किए हैं, वहीं इसने लैंगिक असमानताओं और भेदभाव को भी कायम रखा है। लैंगिक समानता को बढ़ावा देने और महिलाओं को सशक्त बनाने के उद्देश्य से नीतियों को स्थानीय संदर्भ को ध्यान में रखना चाहिए और भारत में महिलाओं की जरूरतों और आकांक्षाओं के प्रति उत्तरदायी होना चाहिए। वैश्वीकरण ने लाम और चुनौतियां दोनों लाते हुए

दुनिया को बदल दिया है। इसने आर्थिक विकास और गरीबी में कमी लाने में योगदान दिया है, इसने आय असमानता, पर्यावरणीय गिरावट और कुछ क्षेत्रों में नौकरियों के नुकसान में भी योगदान दिया है। वैश्वीकरण ने आर्थिक असमानता, पर्यावरणीय गिरावट और सांस्कृतिक समरूपता सहित महत्वपूर्ण चुनौतियां भी पेश की हैं। व्यापार और निवेश नीतियों के उदारीकरण ने प्रतिस्पर्धा में वृद्धि की है और नौकरी के नुकसान और कुछ क्षेत्रों में मजदूरी में गिरावट आई है।

मुख्य शब्द

मीडिया, महिला शिक्षा, महिला एवं समाज, वैश्वीकरण, महिला।

30.12.2021
Head
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प्रस्तावना

वैश्वीकरण एक बहुआयामी प्रक्रिया है जिसने दुनिया भर के समाजों को प्रभावित किया है। यह अंतरराष्ट्रीय व्यापार, निवेश और संचार के तेजी से विस्तार के कारण अर्थव्यवस्थाओं, समाजों और संस्कृतियों के बढ़ते अंतर्संबंध को संदर्भित करता है। वैश्वीकरण ने आर्थिक वृद्धि और विकास के लिए नए अवसर पैदा किए हैं। यह विशेष रूप से लैंगिक समानता और महिलाओं के अधिकारों के संबंध में महत्वपूर्ण चुनौतियां भी लेकर आया है।

भारत में, महिलाओं पर वैश्वीकरण का प्रभाव विशेष रूप से महत्वपूर्ण रहा है। भारत में महिलाओं को ऐतिहासिक रूप से शिक्षा, रोजगार और राजनीतिक प्रतिनिधित्व तक पहुँचने में महत्वपूर्ण चुनौतियों का सामना करना

पड़ा है। भारतीय समाज की पितृसत्तात्मक प्रकृति ने लैंगिक असमानताओं और भेदभाव को कायम रखा है, खासकर महिलाओं के आर्थिक और सामाजिक अवसरों के संबंध में।

वैश्वीकरण ने महिलाओं के लिए वैश्विक अर्थव्यवस्था में भाग लेने के नए अवसर पैदा किए हैं, विशेषकर सूचना प्रौद्योगिकी, व्यवसाय प्रक्रिया, आउटसोर्सिंग और वस्त्र जैसे उद्योगों में। हालांकि, वैश्विक बाजार के विस्तार से अनौपचारिक क्षेत्र का भी विकास हुआ है, जो कम-कुशल और कम वेतन वाली नौकरियों में बड़ी संख्या में महिलाओं को रोजगार देता है। अनौपचारिक क्षेत्र में घरेलू काम, छोटे पैमाने पर निर्माण और स्ट्रीट वेंडिंग जैसी गतिविधियां शामिल हैं। अनौपचारिक क्षेत्र में महिलाओं को काम करने की खराब स्थिति, कम वेतन और सामाजिक सुरक्षा तक सीमित पहुंच सहित महत्वपूर्ण चुनौतियों का सामना करना पड़ता है।

इसके अलावा, वैश्वीकरण का भारत में सामाजिक मानदंडों और लिंग संबंधों पर महत्वपूर्ण प्रभाव पड़ा है। उपभोक्ता संस्कृति के विकास और महिलाओं के शरीर के वस्तुकरण के कारण कॉस्मेटिक सर्जरी, बॉडी शैमिंग और यौन उत्पीड़न में वृद्धि हुई है। पश्चिमी सांस्कृतिक मूल्य और मानदंड भारतीय समाज में तेजी से प्रचलित हो गए हैं, जिससे पारंपरिक लिंग भूमिकाओं और मूल्यों से दूर हो गए हैं।

इस शोधपत्र का उद्देश्य भारत में महिलाओं पर वैश्वीकरण के प्रभाव की जांच करना है, जिसमें तीन प्रमुख क्षेत्रों: आर्थिक, सामाजिक और सांस्कृतिक पर ध्यान केंद्रित किया गया है। यह औपचारिक और अनौपचारिक क्षेत्रों में आर्थिक अवसरों तक पहुंचने में महिलाओं के सामने आने वाली चुनौतियों के साथ-साथ सामाजिक मानदंडों और लैंगिक संबंधों पर वैश्वीकरण के प्रभाव का पता लगाएगा। यह शोधपत्र भारत में लैंगिक समानता को बढ़ावा देने और महिलाओं को सशक्त बनाने के उद्देश्य से नीतियों और हस्तक्षेपों की भी जांच करेगा और वैश्वीकरण के संदर्भ में महिलाओं के सामने आने वाली चुनौतियों का समाधान करने में उनकी प्रभावशीलता का आकलन करेगा।

आर्थिक प्रभाव

वैश्वीकरण का भारत में महिलाओं के लिए उपलब्ध आर्थिक अवसरों पर मिश्रित प्रभाव पड़ा है। एक ओर, वैश्विक बाजार में भारतीय अर्थव्यवस्था के एकीकरण ने महिलाओं के लिए कार्यबल में, विशेष रूप से सेवा क्षेत्र में भाग लेने के नए अवसर पैदा किए हैं। वैश्विक उत्पादन श्रृंखला में महिलाएं श्रम का एक महत्वपूर्ण स्रोत बन गई हैं, कई कंपनियां अपने काम को भारत में आउटसोर्स कर रही हैं।

हालांकि, कार्यबल में महिलाओं की भागीदारी सामाजिक मानदंडों और पितृसत्तात्मक रवैये के कारण सीमित रहती है जो उनकी गतिशीलता और शिक्षा और प्रशिक्षण तक पहुंच को प्रतिबंधित करती है। भारत में कई महिलाओं से अभी भी पारंपरिक लिंग भूमिकाओं को पूरा करने की उम्मीद की जाती है, जैसे कि उनके परिवारों की देखभाल करना, जो घर के बाहर भुगतान वाले काम में संलग्न होने की उनकी क्षमता को सीमित कर सकता है। वंचित पृष्ठभूमि की महिलाओं, जैसे कि निचली जातियों, जनजातियों और अल्पसंख्यक समुदायों की महिलाओं को भेदभाव और बहिष्कार के कारण आर्थिक अवसरों तक पहुंचने में अतिरिक्त बाधाओं का सामना करना पड़ता है।

इसके अलावा, वैश्विक उत्पादन श्रृंखला में महिलाओं का काम अक्सर कम भुगतान वाला और अनिश्चित होता है, जिसमें सीमित नौकरी की सुरक्षा और करियर में उन्नति के कुछ अवसर होते हैं। विशेष रूप से अनौपचारिक क्षेत्र में कम-कुशल और कम-वेतन वाली नौकरियों में महिलाओं का असमान रूप से प्रतिनिधित्व किया जाता है। अनौपचारिक क्षेत्र का विकास महिलाओं के लिए एक महत्वपूर्ण चुनौती है, क्योंकि यह बहुत कम नौकरी की सुरक्षा, काम करने की खराब स्थिति और सामाजिक सुरक्षा तक सीमित पहुंच प्रदान करता है।

इन चुनौतियों के बावजूद वैश्वीकरण ने महिला उद्यमियों और छोटे व्यवसाय के मालिकों के लिए भी अवसर पैदा किए हैं। भारत में महिलाओं के स्वामित्व वाले व्यवसाय बढ़ रहे हैं, खासकर सूचना प्रौद्योगिकी, शिक्षा और स्वास्थ्य सेवा जैसे क्षेत्रों में। हालांकि, महिला उद्यमियों को महत्वपूर्ण चुनौतियों का सामना करना पड़ता है, जिसमें वित्त, बाजार और नेटवर्क तक सीमित पहुंच शामिल है।

वैश्वीकरण ने भारत में महिलाओं के लिए नए आर्थिक अवसरों का नेतृत्व किया है, इसने लैंगिक असमानताओं और भेदभाव को भी कायम रखा है। वैश्विक अर्थव्यवस्था में महिलाओं की भागीदारी सामाजिक मानदंडों और पितृसत्तात्मक रवैये के कारण सीमित है और अनौपचारिक क्षेत्र के विकास ने महिलाओं के लिए नई चुनौतियां पैदा की हैं। नीति निर्माताओं को इन चुनौतियों का समाधान करना चाहिए और वैश्वीकरण के संदर्भ में लैंगिक समानता और महिला सशक्तिकरण को बढ़ावा देना चाहिए। यह नीतियों और हस्तक्षेपों के माध्यम से प्राप्त किया जा सकता है जो शिक्षा और प्रशिक्षण तक पहुंच में सुधार करते हैं, महिलाओं की उद्यमिता को बढ़ावा देते हैं, और उन संरचनात्मक बाधाओं को दूर करते हैं जो औपचारिक अर्थव्यवस्था में महिलाओं की भागीदारी को सीमित करती हैं।

सामाजिक प्रभाव

वैश्वीकरण का भारत में महिलाओं पर रखी गई सामाजिक भूमिकाओं और अपेक्षाओं पर महत्वपूर्ण प्रभाव पड़ा है। वैश्वीकरण के सबसे महत्वपूर्ण सामाजिक प्रभावों में से एक उपभोक्ता संस्कृति का विकास और महिलाओं के निकायों का वस्तुकरण रहा है। महिलाओं के शरीर इच्छा और उपभोग की वस्तु बन गए हैं, जिससे महिलाओं के वस्तुकरण और यौनकरण में वृद्धि हुई है। महिलाओं को अक्सर विज्ञापन और मीडिया में यौन वस्तुओं के रूप में चित्रित किया जाता है, जो हानिकारक लैंगिक रूढ़िवादिता को कायम रखता है और महिलाओं के खिलाफ हिंसा की संस्कृति में योगदान देता है।

मीडिया के वैश्वीकरण का भारत में लैंगिक भूमिकाओं और संबंधों पर भी गहरा प्रभाव पड़ा है। पश्चिमी सांस्कृतिक मूल्य और मानदंड भारतीय समाज में तेजी से प्रचलित हो गए हैं, जिससे कॉस्मेटिक सर्जरी, बॉडी शेमिंग और यौन उत्पीड़न में वृद्धि हुई है। सुंदरता, स्त्रीत्व और कामुकता के पश्चिमी आदर्शों को कई भारतीय महिलाओं ने आत्मसात कर लिया है, जिससे संकीर्ण सौंदर्य मानकों और लिंग भूमिकाओं के अनुरूप दबाव पैदा हो गया है।

इसके अलावा, सेवा क्षेत्र और अनौपचारिक अर्थव्यवस्था के विकास ने महिलाओं के लिए नए अवसर पैदा किए हैं, लेकिन इसने शोषण और दुर्व्यवहार के नए रूपों को भी जन्म दिया है। कई महिलाएं कम वेतन वाली, अनौपचारिक नौकरियों में काम करती हैं जो बहुत कम नौकरी सुरक्षा या सामाजिक सुरक्षा प्रदान करती हैं, जिससे उन्हें शोषण और दुर्व्यवहार का शिकार होना पड़ता है। सेवा क्षेत्र में काम करने वाली महिलाएं, जैसे कि घरेलू काम, अक्सर अपने नियोक्ताओं से यौन उत्पीड़न और हिंसा का शिकार होती हैं।

भारत में महिलाओं पर वैश्वीकरण के सामाजिक प्रभाव जटिल और विविध रहे हैं, जबकि वैश्वीकरण ने महिलाओं के लिए नए आर्थिक अवसर पैदा किए हैं, इसने हानिकारक लैंगिक रूढ़िवादिता को भी कायम रखा है। महिलाओं के शरीर को वस्तुकृत किया है, और महिलाओं के खिलाफ हिंसा की संस्कृति में योगदान दिया है। नीति निर्माताओं को वैश्वीकरण के संदर्भ में इन चुनौतियों का समाधान करने और लैंगिक समानता और महिला सशक्तिकरण को बढ़ावा देने के लिए काम करना चाहिए। यह नीतियों और हस्तक्षेपों के माध्यम से प्राप्त किया जा सकता है जो लिंग-संवेदनशील मीडिया को बढ़ावा देते हैं, महिलाओं के खिलाफ हिंसा के मूल कारणों को संबोधित करते हैं, और शिक्षा और प्रशिक्षण तक महिलाओं की पहुंच को बढ़ावा देते हैं।

सांस्कृतिक प्रभाव

भारत में महिलाओं पर वैश्वीकरण का सांस्कृतिक प्रभाव महत्वपूर्ण रहा है। भारतीय अर्थव्यवस्था के वैश्वीकरण और मध्यम वर्ग के विकास के कारण पारंपरिक लिंग भूमिकाओं और संबंधों में बदलाव आया है। महिलाओं को तेजी से परिवार और समाज में समान भागीदार के रूप में देखा जाता है, और कार्यबल में उनकी भागीदारी को एक सकारात्मक विकास के रूप में देखा जाता है। शिक्षा और रोजगार के अवसरों के विस्तार ने महिलाओं को सशक्त बनाया है, और वे अब पहले की तुलना में अधिक स्वतंत्र और मुखर हैं। महिलाएं जीवन में बाद में शादी करने, कम बच्चे पैदा करने और करियर बनाने, पारंपरिक लिंग मानदंडों और अपेक्षाओं को चुनौती देने का विकल्प चुन रही हैं।

हालाँकि, पारंपरिक लिंग भूमिकाएँ और पितृसत्तात्मक दृष्टिकोण भारतीय समाज में गहराई से व्याप्त हैं, और

महिलाओं को अर्थव्यवस्था, समाज और राजनीति में उनकी पूर्ण भागीदारी के लिए महत्वपूर्ण बाधाओं का सामना करना पड़ता है। सामाजिक मानदंडों और पितृसत्तात्मक रवैये के कारण महिलाओं की गतिशीलता अक्सर प्रतिबंधित होती है, जो शिक्षा, स्वास्थ्य देखभाल और अन्य संसाधनों तक उनकी पहुंच को सीमित करती है। घरेलू हिंसा, यौन उत्पीड़न और हमले सहित महिलाओं के खिलाफ हिंसा कानूनी सुधारों और सामाजिक सक्रियता के बावजूद भारतीय समाज में एक व्यापक समस्या बनी हुई है।

भारतीय संस्कृति के वैश्वीकरण से पारंपरिक सांस्कृतिक प्रथाओं और मूल्यों का भी क्षरण हुआ है, जिससे व्यक्तिवाद में वृद्धि हुई है और समुदाय आधारित मूल्यों में गिरावट आई है। इसका महिलाओं पर सकारात्मक और नकारात्मक दोनों तरह का प्रभाव पड़ा है। एक ओर, इसने नए सांस्कृतिक रूपों का उदय किया है जो व्यक्तिवाद, विविधता और रचनात्मकता का जश्न मनाते हैं, जिससे महिलाओं को खुद को अभिव्यक्त करने और अपनी पहचान पर जोर देने के लिए नई जगह मिलती है। दूसरी ओर, इसने सांस्कृतिक प्रथाओं के समरूपीकरण और स्थानीय और स्वदेशी संस्कृतियों के हाशिए पर जाने का भी नेतृत्व किया है, जो महिलाओं की पहचान और पहचान की भावना को कमजोर कर सकता है।

कुल मिलाकर, भारत में महिलाओं पर वैश्वीकरण का सांस्कृतिक प्रभाव जटिल और बहुआयामी है, जबकि इसने महिलाओं के लिए नए अवसर पैदा किए हैं और पारंपरिक लैंगिक मानदंडों और भूमिकाओं को चुनौती दी है, इसने पितृसत्तात्मक दृष्टिकोण और लैंगिक असमानताओं को भी कायम रखा है। महिला सशक्तिकरण के लिए वैश्वीकरण की क्षमता को पूरी तरह से महसूस करने के लिए, उन अंतर्निहित सामाजिक और सांस्कृतिक बाधाओं को दूर करना आवश्यक है जो उनकी भागीदारी और एजेंसी को सीमित करती हैं। इसके लिए एक व्यापक दृष्टिकोण की आवश्यकता है जो असमानता और भेदभाव के अन्य रूपों के साथ लिंग के प्रतिच्छेदन को पहचानता है, और लिंग-संवेदनशील नीतियों और कार्यक्रमों को बढ़ावा देता है जो महिलाओं को सशक्त बनाता है व लैंगिक समानता को बढ़ावा देता है।

निष्कर्ष

वैश्वीकरण ने भारत में महिलाओं के लिए नए अवसर पैदा किए हैं, लेकिन इसने लैंगिक असमानताओं और भेदभाव को भी कायम रखा है। वैश्विक अर्थव्यवस्था में महिलाओं की भागीदारी सामाजिक मानदंडों और पितृसत्तात्मक व्यवहारों के कारण सीमित है जो उनकी गतिशीलता और शिक्षा और प्रशिक्षण तक पहुंच को प्रतिबंधित करते हैं। भारतीय अर्थव्यवस्था के वैश्वीकरण ने अनौपचारिक क्षेत्र के विकास को भी प्रेरित किया है, जो कम-कुशल और कम वेतन वाली नौकरियों में बड़ी संख्या में महिलाओं को रोजगार देता है। वैश्विक बाजार के विस्तार से उपभोक्ता संस्कृति का विकास हुआ है और महिलाओं के शरीर का वस्तुकरण हुआ है। पश्चिमी सांस्कृतिक मूल्य और मानदंड भारतीय समाज में तेजी से प्रचलित हो गए हैं, जिससे कॉस्मेटिक सर्जरी, बॉडी शेमिंग और यौन उत्पीड़न में वृद्धि हुई है।

लैंगिक समानता को बढ़ावा देने और महिलाओं को सशक्त बनाने के उद्देश्य से नीतियों को स्थानीय संदर्भ में ध्यान में रखना चाहिए और भारत में महिलाओं की जरूरतों और आकांक्षाओं के प्रति उत्तरदायी होना चाहिए। इसमें लैंगिक असमानताओं और भेदभाव को बनाए रखने वाले सामाजिक मानदंडों और पितृसत्तात्मक व्यवहारों को संबोधित करना, शिक्षा और प्रशिक्षण तक महिलाओं की पहुंच को बढ़ावा देना और यह सुनिश्चित करना शामिल है कि आर्थिक अवसरों तक महिलाओं की समान पहुंच है।

इसके अलावा, महिलाओं के निकायों के वस्तुकरण और वस्तुकरण को संबोधित करने के लिए प्रयास किए जाने चाहिए और मीडिया में महिलाओं के अधिक सकारात्मक और सशक्त प्रतिनिधित्व को बढ़ावा देना चाहिए। इसमें मीडिया में महिलाओं की आवाज़ और दृष्टिकोण का समर्थन करना और विज्ञापन और मनोरंजन में महिलाओं के अधिक विविध और समावेशी चित्रण को बढ़ावा देना शामिल है।

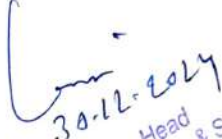
अंत में, वैश्वीकरण का भारत में महिलाओं पर सकारात्मक और नकारात्मक दोनों प्रभाव पड़ा है। जबकि इसने

महिलाओं के लिए वैश्विक अर्थव्यवस्था में भाग लेने के नए अवसर पैदा किए हैं, इसने लैंगिक असमानताओं और भेदभाव को भी कायम रखा है। लैंगिक समानता को बढ़ावा देने और महिलाओं को सशक्त बनाने के उद्देश्य से नीतियों और हस्तक्षेपों को स्थानीय संदर्भ को ध्यान में रखना चाहिए और भारत में महिलाओं की जरूरतों और आकांक्षाओं के प्रति उत्तरदायी होना चाहिए। केवल तभी हम लैंगिक समानता और महिला सशक्तिकरण को बढ़ावा देने के लिए वैश्वीकरण की क्षमता को सही मायने में महसूस कर सकते हैं।

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मानव तस्करी से पीड़ित जनजातीय परिवारों की सामाजिक पृष्ठभूमि का समाजशास्त्रीय अध्ययन

□ सुश्री ज्योति ठाकुर
✦ डॉ. निस्तर कुजुर

सूचक शब्द : मानव तस्करी, आजीविका, बेरोजगारी, टिकाऊ साधनों तक पहुँच का अभाव, चुनौतियाँ।

छत्तीसगढ़ राज्य भी मानव तस्करी की समस्या से अछूता

नहीं है, यहां का जशपुर जिला राज्य में मानव तस्करी समस्या से सबसे अधिक पीड़ित जिलों में से एक है। यूनिसेफ के सर्वेक्षण रिपोर्ट (2012-14) में बच्चों के 1500 मामले केवल छत्तीसगढ़ राज्य के जशपुर जिला के 05 विकासखण्डों में मानव तस्करी मामले दर्ज किये गये थे। छत्तीसगढ़ राज्य के जनजातीय बाहुल्य अन्य जिले भी मानव तस्करी की समस्या से जूझ रहे हैं। मानव तस्करी प्रत्येक समाज के लिये एक मुख्य चुनौती है, वहीं वर्तमान समय में छत्तीसगढ़ राज्य का आदिवासी बहुल जिला जशपुर मानव तस्करी का गढ़ बना हुआ है, जहाँ पर जनजाति समुदाय भी तस्करी जैसी समस्या की चुनौतियों का सामना कर रहा है। इस जिले में उरांव, गोंड, पहाड़ी कोरवा, बिरहोर जनजातियाँ निवासरत हैं, विकास के अभाव

में जनजातीय परिवार भी रोजगार की कमी, गरीबी व अशिक्षा जैसे दंश झेल रहे हैं, परिणामस्वरूप यह समाज जीवनयापन हेतु रोजगार की तलाश में सदैव रहा है।

भूमि कि कमी, मौसमी खेती, सयुक्त परिवार होने से भोज्य समाग्री कि कमी मुख्य कारण हैं।

विदुसी विमल¹ के अनुसार बड़े शहरों में आकर्षक

मानव तस्करी एक वैश्विक समस्या है। मानव तस्करी IPC की धारा 1860 के अंतर्गत एक अपराध है, अनु.23(1) के अंतर्गत भारत में मानव तस्करी निषिद्ध है, बच्चों व महिलाओं को बहला फुसलाकर बेचा व खरीदा जाता है। उन्हें अन्य राज्यों या देशों में भेज दिया जाता है, देह व्यापार की मांग महिलाओं के शोषण को बढ़ा देती है, पुरुषों, बच्चों में मजदूरी व भीख मंगवाई जाती है, हर साल हजारों लोग मानव तस्करी के दुष्क्र में फँस कर शिकार हो जाते हैं। जनजातीय समुदाय भी इस अपराध के दुष्क्र से दूर नहीं हैं। जनजातीय समुदाय सदियों से विभिन्न समस्याओं का शिकार होता रहा है, इन समस्याओं में मानव तस्करी की समस्या एक प्रमुख समस्या है। यह समस्या संविधान की 5वीं अनुसूचित क्षेत्र संपूर्ण छोटानागपुर क्षेत्र (वर्तमान झारखण्ड, ओड़ीसा एवं छत्तीसगढ़) में देखने को मिलती है। पूर्वोत्तर छत्तीसगढ़ के जिला इस समस्या से जूझ रहे हैं, प्रस्तुत अध्ययन जशपुर जिला पर केंद्रित है। यहां, लोगों में उन्नत आजीविका के साधनों का अभाव है, परिणामस्वरूप जनजातीय परिवारों में बेरोजगारी, गरीबी प्रमुख समस्या है। बेहतर जीवन की खोज में इन परिवारों के युवा, युवती एवं महिलाएँ बड़ी संख्या में महानगरों में रोजगार के लिए पलायन करते हैं और ज्ञान व शिक्षा की कमी से आसानी से मानव तस्करो के चंगुल में फँस जाते हैं, तस्कर इन युवतियों का कई रूपों में शोषण करते हैं। समस्या इस स्तर तक पहुँच गयी है, कि प्रभावित क्षेत्रों में घरों के दीवारों पर “मानव तस्करो से सावधान” “मानव तस्करो का पता चलने पर इस नंबर पर डायल करे।” लिखा देखा जा सकता है।

रोजगार प्रस्ताव अवैध व्यापार दलालों और एजेंटों द्वारा बेहतर तथा आरामदायक जीवन देने का वादा, विवाह के लिए युवा लड़कियों की माँग की जाती है। अत्यन्त गरीबी व वंचित होने, जागरूकता का अभाव, घरेलू हिंसा से पीड़ित लोग तस्करो के चंगुलों में फँस जाते हैं। जीवनयापन के लिए उन्हें अपनी दैनिक आवश्यकताओं की पूर्ति के लिए प्रतिदिन संघर्ष करना पड़ता है। यहाँ तस्कर कॉफी संगठित हैं, जो बाहर से आकर प्रत्येक वर्ष शहरों एवं महानगरों में इन आदिवासी बहुल जिलों की लड़कियों को प्लेसमेंट, एजेन्सियों के द्वारा नौकरी दिलाने के नाम पर ले जाते हैं, और घरेलू काम एवं देह व्यापार में धकेल दिया जाता है। कुजुर निस्तर² के अनुसार आदिवासी क्षेत्रों में रोजगार का आभाव होना जिसके परिणाम स्वरूप जनजाति

महिलाएँ बड़े रूपों में महानगरों की ओर पलायन करती हैं, रोजगार की तालाश में, अच्छे परिवार में कार्य मिलने की स्थिति में इनकी स्थिति ठीक होती है, वहीं परिवार

□ शोध अध्येत्री समाजशास्त्र एवं समाजकार्य अध्ययनशाला, पंडित रविशंकर शुक्ल विश्वविद्यालय, रायपुर (छ.ग.)

✦ प्रोफेसर एवं अध्यक्ष समाजशास्त्र एवं समाजकार्य अध्ययनशाला, पंडित रविशंकर शुक्ल विश्वविद्यालय, रायपुर (छ.ग.)

धीरे-धीरे देह व्यापार में फंसती जाती हैं, वहीं कुछ दलालों के हाथों बेची भी जाती हैं। इन्हें भी दैनिक शोषण का सामना करना पड़ता है। जनजातियों में बेरोजगारी, अशिक्षा व जागरूकता की कमी शासन का अनदेखा करना भी इन्हें मानव तस्करी का शिकार बनाती है। मुख्यतः जनजाति क्षेत्र में तस्करी के लिए दलालों का एक गिरोह कार्यरत होता है, जो गरीब, अशिक्षित, व बेरोजगार युवाओं को अपना शिकार बनाते हैं।

प्रकाश, सी.एम.³ के अनुसार महिलाओं की तस्करी में फंसने का मुख्य कारण गरीबी, अशिक्षा, घरेलू हिंसा, भेदभाव आदि हैं। महिलाओं की तस्करी मुख्यतः वैश्यावृत्ति, बार डांसर, घरेलू कार्य, सरोगेसी के लिये की जाती है। बच्चों की तस्करी भीख मंगवाने, होटलों में कार्य, कपड़ा कारखानों, मछली फार्म, निःसंतान दम्पतियों, नशीली दवाइयों कि तस्करी, अंग निकालने, सर्कस के लिए, दाख भट्टी, मनोरंज के लिए किया जाता है। यह तथ्य इस बात को स्पष्ट करता है, कि तस्कर प्रभावित गांवों और क्षेत्रों में रोजगार के उन्नत साधनों का अभाव है, और आर्थिक चुनौतियां इन्हें नगरों की ओर बढ़ने में सहायक होती हैं। यह घटना जनजातियों में असुरक्षा और भय को पैदा करता है तथा प्रश्न उत्पन्न करता है, कि संवैधानिक प्रावधान इन्हे सुरक्षा और रोजगार प्रदान करने दिशा में विफल सिद्ध हो रहे हैं। समय समय पर शासन द्वारा मानव तस्करी नियंत्रण हेतु विभिन्न प्रयास किये जा रहे हैं, परन्तु जनजातीय क्षेत्र में ये सारी गतिविधियां विफल होती जा रही हैं, इन्हीं का लाभ उठाकर दलालों के द्वारा आदिवासी किशोर एवं किशोरियों को बहलाया व फुसलाया जाता है, दलालों, एजेंसियों के लुभावने विज्ञापनों के झूठे झाँसों में आकर तस्करी जैसी घटनाओं में फंस जाती हैं, रायगढ़ एवं जशपुर जिला के तस्कर प्रभावित परिवारों की आर्थिक स्थिति और मानव तस्करी की चुनौतियों को स्पष्ट करने का प्रयास किया गया है।

अध्ययन क्षेत्र का परिचय - जनगणना 2011 छत्तीसगढ़ राज्य के उत्तर-पूर्वी भाग में स्थित जिला जशपुर जिसका दक्षिण पूर्वी भाग उड़ीसा की सीमा से लगा हुआ है, जिसकी समुद्र तल से ऊंचाई 753 मीटर है, इस जिले का कुल क्षेत्रफल 5838वर्ग किलोमीटर है। 2011की जनगणना के अनुसार कुल जनसंख्या 8,51, 669 व जनसंख्या घनत्व 150 किलोमीटर प्रति व्यक्ति है, इस

जिले में महिला पुरुष अनुपात 1004 महिलाएं प्रति 1000 पुरुषों पर है, जिले की साक्षरता दर 68.7 प्रतिशत है, व जनजातीय जनसंख्या 5,30,378 कुल जनसंख्या का 62.27 प्रतिशत, जशपुर जिले में 8 ब्लॉक, बगीचा, दुलदुला, फरसाबहार जशपुर, कांसावेल, कुनकुरी, मनोरा हैं।¹

साहित्य समीक्षा

नायर पी.एम.⁵ की पुस्तक "राष्ट्रीय मानव अधिकार" संबंधी अध्ययन कमीशन अनुसंधान परियोजना (NHRC&UNIFEM) 2016 के आधार पर सामाजिक विज्ञान संस्था द्वारा संचालित किया गया। इनका अध्ययन कानून की कमियाँ कानून प्रवर्तन नीतियों की असफलता तथा प्रवासन की मजबूत कड़ी को चित्रित करता है। मानव तस्करी को रोकने के लिए प्रवर्तन निर्देशालय के अधिकारियों की भूमिका महत्वपूर्ण होती है, लेकिन भारत में इनकी स्थिति अच्छी नहीं है।

वर्मा दिनेश नारायण⁶ भारत जैसे देश से मानव तस्करी समाप्त करना है, तो सबसे आवश्यक यह है, कि विभिन्न संस्थाओं में समन्वय स्थापित किया जाए जैसे पुलिस व प्रशासन के मध्य। इनके साथ साथ गरीबी एवं अशिक्षा ऐसे अपराधों को आश्रय देते हैं, अतः अपराधों के कारणों को उत्पन्न करने वाली सामाजिक समस्याओं को भी समाप्त करना अति आवश्यक होगा।

मोहंती के.आर.⁷ ने अनुसूचित जनजाति की महिलाओं एवं बच्चियों की तस्करी के कारणों का विश्लेषण किया है। ज्ञात हुआ कि कमजोर वर्ग की महिलाएं तथा लड़कियाँ इस जटिल मानवीय पीड़ा से गुजरती हैं, क्योंकि लड़कियों के साथ निम्न स्थिति जताकर भेदभाव किया जाता है। महिलाओं व लड़कियों के पास सम्मानपूर्वक जीवन जीने का कोई विकल्प नहीं होता तब ये मानव तस्करी के शिकार होती हैं, उसके बाद सामाजिक तिरस्कार, बंधुवा मजदूर व एड्स जैसी बीमारियों के साथ जीवन जीने को मजबूर किया जाता है।

मिश्रा वीरेन्द्र⁸ के अध्ययन 'मानव तस्करी से संपर्क और नीति व कानून' से ज्ञात हुआ कि कानूनी प्रक्रिया वह सुरक्षा प्रदान नहीं कर पाते हैं, जैसी सुरक्षा की उम्मीद पीड़ित करता है। शासन से अपराधियों के विरुद्ध जाने पर जान का खतरा बना रहता है, जिसके परिणामस्वरूप तस्करी से पीड़ित व्यक्ति कानून की सहायता लेने के लिये नहीं सोच पाता है। शासन के द्वारा तस्करी रोकथाम हेतु

जो कानून बनाए गए हैं, उनका समय पर क्रियान्वयन न हो पाना तस्करी जैसे अपराध को बढ़ावा देता है। पीड़ितों के हौसलों को कम करती हैं, अपराध पंजीबद्ध करवाने पर आगे नुकसान के डर से पीड़ित दबाव का अनुभव करते हैं। मानव तस्करी से संघर्ष नीति व कानून का सही संचालन आवश्यक है, पीड़ितों को पूर्ण सुरक्षा प्रदान हेतु कार्यवाही किया जाना तथा समय पर नीति व कानूनों का क्रियान्वयन अति आवश्यक है।

देव हिमिका⁹ के अध्ययन का उद्देश्य मानव तस्करी जैसे अपराधों के घटित होने के कारणों को ज्ञात करना है, भारत व पश्चिम बंगाल में तस्करी की वर्तमान स्थितियों को ज्ञात करना तथा तस्करी की घटनाओं को रोकने के लिए शासन की भूमिका का अध्ययन करना है। अध्ययन से ज्ञात हुआ कि, मानव तस्करी की भारत व प. बंगाल में तस्करी का मुख्य कारण, गरीबी, अशिक्षा, बेरोजगारी, लिंग आधारित भेद-भाव, कानून की शिथिलता, घरेलू हिंसा आदि हैं। प्रतिवर्ष सीमावर्ती देशों नेपाल, भूटान आदि में महिलाओं की तस्करी बड़ी संख्या में होती है। शासन द्वारा तस्करी जैसे अपराधों की रोकथाम हेतु विशेष कानून आवश्यक हैं तथा एन.जी.ओ. के माध्यम से निगरानी की विशेष आवश्यकता है, वहीं तस्करी से प्रभावित पीड़ितों के पुर्नवास हेतु उचित कदम उठाने की आवश्यकता है। रोजगारमुखी योजनाओं का क्रियान्वयन अति आवश्यक हैं, ताकि लोगों को स्थानीय स्तर पर रोजगार प्राप्त हो सकें, व सीमावर्ती क्षेत्रों में उचित निगरानी प्रबन्ध की आवश्यकता हैं।

जनजातीय समुदाय में तस्करी की समस्या बेहद आम समस्या बन चुकी है, कहीं न कहीं शासन का अनदेखापन, कानून व्यवस्था में कमी व अपराध को रोकने हेतु विभिन्न संस्थाओं में ताल मेल की कमी होना है। ऐसे अपराधों के बढ़ने का कारण अशिक्षा, गरीबी, बेरोजगारी है। शिक्षा ही ऐसा माध्यम है जिससे ऐसे अपराधों को रोका जा सकता है।

अध्ययन पद्धति :- प्रस्तुत अध्ययन छत्तीसगढ़ राज्य के जशपुर जिला के मानव तस्करी से पीड़ित जनजाति परिवारों पर आधारित है। जनजाति परिवारों का चयन उद्देश्यपूर्ण निर्दर्शन द्वारा 60 तस्करी पीड़ितों का चयन

किया गया है। तथ्यों का संकलन प्राथमिक व द्वितीय स्रोतों के द्वारा किया गया है, तथ्यों के संकलन हेतु अवलोकन, साक्षात्कार अनुसूची का प्रयोग किया गया है। प्रस्तुत शोध पत्र में जनजातियों के मानव तस्करी से पीड़ित होने की सामाजिक व आर्थिक स्थिति का अध्ययन किया गया है।

प्रस्तुत अध्ययन के उद्देश्य:- प्रस्तुत अध्ययन के प्रमुख उद्देश्य निम्नलिखित रहे हैं

1. तस्करी प्रभावित जनजातीय परिवारों की सामाजिक स्थिति ज्ञात करना ।
2. जनजातियों कि आर्थिक स्थिति को ज्ञात करना ।
3. पीड़ितों में शिक्षा के स्तर को ज्ञात करना ।

कुपुस्वामी सामाजिक आर्थिक स्केल¹⁰ : इस पैमाने का अविष्कार 1979 मे कुपुस्वामी द्वारा किया गया था, इस पैमाने के माध्यम से परिवार की मासिक आय का स्तर, शिक्षा का स्तर, व्यवसाय के स्तर को ज्ञात किया जाता है। इस पैमाने के माध्यम से शिक्षा, व्यवसाय, मासिक आय के स्तर को स्कोर द्वारा प्रदर्शित किया जाता है, जहाँ पर शिक्षा का स्कोर 7-1 व व्यवसाय का स्कोर 7-1 वहीं मासिक आय का स्कोर 10-2 व सामाजिक आर्थिक स्थिति का वर्ग को उच्च, मध्य, निम्न द्वारा प्रदर्शित किया गया है, इस पैमाने के माध्यम से किसी भी परिवार की सामाजिक आर्थिक स्थिति का आकलन सरलता से किया जा सकता है।

शिक्षा का स्तर

शिक्षा प्रत्येक समाज की प्रगति के लिए महत्वपूर्ण सीढ़ी है। जनजातीय समाज में शिक्षा का उद्देश्य केवल किताबी ज्ञान समझा जाता है। आदिवासी समाज की शिक्षा का स्तर अन्य समाज की अपेक्षा बहुत ही पिछड़ा है। इन समाजों में कुछ वर्षों से शिक्षा का प्रसार हुआ है, परन्तु आंतरिक क्षेत्रों में, जहाँ पर मुख्य रूप से जनजातीय निवासरत गाँव हैं वहाँ पर, बुनियादी शिक्षा की स्थिति बेहाल है। वर्तमान समय मे शाला त्यागी जनजातीय बच्चों का अनुपात अन्य समाज की अपेक्षा बेहद चिन्ताजनक है। उत्तरदाताओं की शिक्षा की स्थिति को जानने का प्रयास किया है जो सारणी क्रमांक 01 में प्रदर्शित है।

कुप्पुस्वामी का सामाजिक आर्थिक स्केल

उत्तरदाताओं में शिक्षा का स्तर	स्कोर	उत्तरदाताओं के व्यवसाय का स्तर	स्कोर
स्नातकोत्तर या पेशेवर उपाधि	7	व्यवसाय	7
स्नातक उपाधि	6	छोटे व्यवसायी	6
हायर सेकेण्डरी	5	प्रबंधकीय कार्य	5
हाईस्कूल	4	कुशल कामगार	4
पूर्व माध्यमिक स्कूल	3	अर्ध कुशल कामगार	3
साक्षर, माध्यमिक स्कूल से कम	2	अकुशल कामगार	2
निरक्षक	1	बेरोजगार	1
उत्तरदाताओं के पारिवारिक मासिक आय का स्तर	स्कोर	सामाजिक-आर्थिक स्थिति का वर्ग	स्कोर
>78603	10	Upper (I)	26-29
39,033-78,062	6	Upper middle (II)	16-25
29,200-39,032	5	Lower middle(III)	11-15
19,516-29,199	4	Upper lower (IV)	5-10
11,708-19,515	3	Lower (V)	<5
3908-11707	2		

**सारणी क्रमांक-01
शिक्षा का स्तर**

(क)उत्तरदाताओं में शिक्षा का स्तर	अंक	उत्तरदाता (N=60)		
		आवृत्ति	प्रतिशत	कुप्पुस्वामी पैमाने के अनुसार अंक
स्नातकोत्तर या पेशेवर उपाधि	7	-	-	-
स्नातक उपाधि	6	-	-	-
हायर सेकेण्डरी	5	3	5	15
हाईस्कूल	4	6	10	24
पूर्वमाध्यमिक स्कूल	3	23	38.3	69
साक्षर, माध्यमिक स्कूल से कम	2	28	46.7	56
निरक्षर	1	3	5	3
कुल (क)		60	100	167
शिक्षा का अंक				2.78
शिक्षा का वर्ग				Lower (V)


सारणी संख्या 01 के विश्लेषण से स्पष्ट होता है, कि मानव तस्करी से पीड़ितों में सर्वाधिक 46.7 प्रतिशत उत्तरदाता केवल साक्षर, माध्यमिक से कम स्कूल तक ही शिक्षा प्राप्त किये हुए हैं, 38.3 प्रतिशत पूर्व माध्यमिक शिक्षा व 10 प्रतिशत हाईस्कूल व 5 प्रतिशत हायर सेकेण्डरी की ही शिक्षा प्राप्त किये हुए हैं, अर्थात् इस पैमाने के आधार पर परिवार की शिक्षा का स्तर निम्न Lower (V) होना पाया गया।

व्यवसाय का स्तर

व्यवसाय व्यक्ति के विचार, रहन-सहन, खान-पान, पहनावे आदि को प्रभावित करता है। विशेषकर व्यवसाय का स्तर व्यक्ति की आर्थिक स्थिति को वगीकृत करता है, कि वह उच्च है, अथवा निम्न है। उत्तरदाताओं के परिवार के सदस्यों के व्यवसाय को ज्ञात करने का प्रयास किया गया है। जनजातीय वर्ग भी अपनी जीवनयापन हेतु किसी न किसी प्रकार के व्यवसाय में संलग्न होते हैं,

(148)

राधा कमल मुर्जी : चिन्तन परम्परा ✨ जुलाई-दिसम्बर, 2023


 30/12/2024
 Head of Social Work,
 (C.G.)
 S.O.S. in Soc
 Pt. F

परन्तु इनका एक स्थिर व्यवसाय नहीं है। इनका जीवन मौसम आधारित व्यवसाय पर निर्भर होता है, मानसून आने पर कृषि व कृषि मजदूरी का कार्य किया जाता है ग्रीष्म काल में वन उपज संग्रहण कर व पशुपालन, आदि

कर अपना जीवन चलाते हैं। उत्तरदाताओं के व्यवसाय से संबंध में जानने का प्रयास किया है जो सारणी क्रमांक 02 में प्रदत्त है।

सारणी क्रमांक-02
व्यवसाय का स्तर

(ख) उत्तरदाताओं के व्यवसाय का स्तर	अंक	उत्तरदाता (N=60)		
		आवृत्ति	प्रतिशत	कुप्युस्वामी पैमाने के अनुसार अंक
व्यवसाय	7	-	-	-
छोटे व्यवसायी	6	09	15	54
प्रबंधकीय कार्य	5	-	-	-
कुशल कामगार	4	5	8.3	20
अर्ध कुशल कामगार	3	8	13	24
अकुशल कामगार	2	38	63.7	76
बेरोजगार	1	-	-	-
कुल (ख)		60	100	174
व्यवसाय का अंक				2.90
व्यवसाय का वर्ग				Lower (V)

सारणी संख्या 02 के विश्लेषण से स्पष्ट होता है, कि सर्वाधिक 63.7 प्रतिशत उत्तरदाता अकुशल कामगार व 15 प्रतिशत छोटे व्यवसायी 13 प्रतिशत अर्ध कुशल कामगार एवं 8.3 कुशल कामगार व्यवसाय पर निर्भर हैं। कुप्युस्वामी पैमाने पर आकलन करने पर जो अंक प्राप्त हुए उसमें अकुशल कामगार 76 अंक, छोटे व्यवसायी 54 अंक, अर्ध कुशल कामगार 24 अंक, 20 अंक कुशल कामगार को। इससे पैमाने के द्वारा आकलन करने पर स्पष्ट हुआ कि उत्तरदाताओं की व्यवसायिक स्थिति निम्न Lower (V) है।

मासिक आय का स्तर

जनजाति परिवार का व्यवसाय स्थिर नहीं होता है, सदैव मौसम आधारित व्यवसाय पर निर्भरता व योजना

आधारित कार्य से धन की प्राप्ति की जाती है, जिससे आय गणना भी भिन्न-भिन्न होती है। इस समुदाय में कृषि मजदूरी, वन उपज आदि का कार्य करके आय प्राप्त की जाती है। अध्ययनरत जनजाति वर्तमान समय में भी आर्थिक रूप से पिछड़ी है। जनजातीय क्षेत्र में पर्याप्त रोजगार के अवसरों की कमी है, जिसके परिणाम स्वरूप परिवार के पालन पोषण हेतु गाँव व शहरों की ओर जाना पड़ता है, समय के साथ परम्परागत सम्पत्तियों का विभाजन होना भी आय के साधनों में कमी लाता है। आय का साधन स्थान क्षेत्र व आयु के आधार पर भिन्न हो सकती है। सूचनादाताओं की आय की स्थिति को सारणी क्रमांक 3 में प्रदर्शित किया गया है।

[Handwritten Signature]
30.12.2024
Head
S.O.S. (1749)
Pt. R. U. R.

सारणी क्रमांक -03
पारिवार की मासिक आय का स्तर

(ग) उत्तरदाताओं के पारिवार की मासिक आय का स्तर	अंक	उत्तरदाता (N=60)		
		आवृत्ति	प्रतिशत	कुपुस्वामी पैमाने के अनुसार अंक
>78603	10	-	-	-
39,033-78,062	6	-	-	-
29,200-39,032	5	-	-	-
19,516-29,199	4	-	-	-
11,708-19,515	3	-	-	-
3908-11707	2	13	21.6	26
3,907	1	47	78.4	47
कुल (x)		60	100	73
पारिवार की मासिक आय अंक				1.21
पारिवार की मासिक आय वर्ग				Lower (V)

सारणी संख्या 03 के विश्लेषण से स्पष्ट होता है, 78.4 प्रतिशत परिवारों की मासिक आय 3,907 से कम है, व 21.6 प्रतिशत परिवारों की मासिक आय 3908-11707 तक है। कुपुस्वामी पैमाने पर प्राप्त अंक क्रमशः 47 व 26 हैं, अर्थात् इस पैमाने के आधार पर परिवार की मासिक आय का स्तर निम्न Lower (V) होना पाया गया।

सामाजिक - आर्थिक स्थिति का वर्ग
किसी भी परिवार की शिक्षा व व्यवसाय, अर्जित की जाने वाली मासिक आय का स्तर परिवार की स्थिति को सामाजिक-आर्थिक रूप से प्रदर्शित करती है, जिसके आधार पर परिवारिक स्थिति का उच्च होना या निम्न होना ज्ञात होता है। परिवार की सामाजिक-आर्थिक स्थिति का आकलन सारणी क्रमांक 4 में किया गया है।

सारणी क्रमांक -04
सामाजिक - आर्थिक स्थिति का वर्ग

सामाजिक - आर्थिक स्थिति	कुपुस्वामी पैमाने के अनुसार अंक	प्रतिशत
(क) शिक्षा का अंक	167	2.78
(ख) व्यवसाय का अंक	174	2.90
(ग) पारिवार की मासिक आय अंक	73	1.21
कुल योग (क+ख+ग)	414	
सामाजिक-आर्थिक स्थिति का अंक		6.89
सामाजिक-आर्थिक स्थिति का वर्ग		Upper lower (IV)

उपर्युक्त पैमाने के अनुसार तस्करी से प्रभावित परिवारों का सामाजिक -आर्थिक वर्ग का विश्लेषण करने पर शिक्षा का स्तर, व्यवसाय व परिवारिक मासिक आय की गणना करने पर प्राप्त अंक क्रमश 167,174,73 प्राप्त हुआ, जिसका कुपुस्वामी सामाजिक आर्थिक पैमाने पर Upper

lower (IV) वर्ग होना ज्ञात हुआ।

मूलभूत आवश्यक सुविधाएँ

अध्ययन में मानव तस्करी से प्रभावित परिवार में दैनिक जीवन की मूलभूत आवश्यक सुविधाओं की उपलब्धता को ज्ञात करने का प्रयास किया गया जो निम्नानुसार

पाई गई -

मूलभूत सुविधाएँ

आवासीय मूलभूत सुविधाओं में सोने के लिए खाट व चटाई, बैठने के लिए पीढ़ा कहीं-कहीं पालस्टीक की कुर्सी देखने को मिली, दैनिक उपयोग के बर्तन में स्टील

एल्युमीनियम, कांसे की उपलब्धता देखने को मिली। विद्युत व्यवस्था, शासन से प्राप्त शौचालयों की उपलब्धता देखी गयी परन्तु पानी के अभाव में इसका उपयोग घरेलू, अतिरिक्त सामानों को रखने में किया जाता है, जिसमें जलाऊ लकड़ी, छेना देखने को मिला।

सारणी क्रमांक -05

मूलभूत सुविधाएँ

परिवार में भौतिक सुविधाएँ	हाँ आवृत्ति/प्रतिशत	नहीं आवृत्ति/प्रतिशत	योग आवृत्ति/प्रतिशत
कुर्सी	22/36.6	38/63.4	60/100
गैस सिलेन्डर	20/33.4	40/66.6	60/100
पलंग	07/11.6	53/88.4	60/100
मोटर साइकिल	11/18.3	49/81.7	60/100
आलमारी	06/10	54/90	60/100
टेलीविजन	03/5	57/95	60/100
कुकर	05/8.4	55/91.6	60/100
पंखा	06/10	54/90	60/100
फ्रिज	03/5	57/95	60/100
मोबाइल	47/78.3	13/21.7	60/100
मिक्सी	02/3.4	58/96.6	60/100

सारणी संख्या 05 के विश्लेषण से स्पष्ट होता है कि सर्वाधिक 88.4 प्रतिशत उतरदाताओं के पास पलंग उपलब्ध हैं, व 5 प्रतिशत उतरदाताओं के पास सोने हेतु किसी भी प्रकार की व्यवस्था नहीं है, एवं घरेलू संचार सुविधा के रूप में 78.3 प्रतिशत उतरदाताओं के पास मोबाइल की सुविधा उपलब्ध है, 13 प्रतिशत के पास किसी भी प्रकार की संचार सुविधा नहीं है, बैठक व्यवस्था के रूप में 36.6 प्रतिशत के घरों में कुर्सी पायी गयी व 63.4 प्रतिशत के पास किसी भी प्रकार की बैठक हेतु कुर्सी न होना ज्ञात हुआ, 33.4 प्रतिशत के पास घरेलू उपयोग हेतु गैस सिलेन्डर उपलब्ध होना ज्ञात हुआ व शेष 66.6 प्रतिशत परिवारों के पास गैस सिलेन्डर न होना ज्ञात हुआ, आवागमन सुविधा के रूप में 30 प्रतिशत के पास साइकिल पायी गयी व 18.31 प्रतिशत के घरों में मोटरसाइकिल होना ज्ञात हुआ, शेष 81.7 प्रतिशत के पास किसी भी प्रकार की आवागमन सुविधा न होना ज्ञात हुआ, 5 प्रतिशत उतरदाताओं के पास फ्रिज, 5.0 पलंग,

अलमारी जैसी वस्तु उपलब्ध न होना पाया गया, अन्य भौतिक वस्तुएँ कम ही तस्कारी प्रभावित परिवारों के पास होना पाया गया।

आवास का प्रकार :

समान्यतः मैदानी क्षेत्र के गाँव कस्बों में आवास के स्वरूपों में तेजी से परिवर्तन हो रहा है, कच्चे, अर्द्ध-पक्के मकान बहुलतः दिखाई देते हैं। अध्यनगत उतरदाताओं के आवास की प्रकृति जिसमें प्रमुखतः तीन प्रकार के आवास देखने को मिलते हैं, प्रथम प्रकार का आवास छोटे आकार का जिसमें दो कमरे व बाजू में एक झोपड़ी नुमा आवास, दूसरे प्रकार के आवास में बीच में आँगन के चारों ओर निर्मित आवास में चार से सात कमरे तक तथा तीसरे प्रकार का आवास अर्द्ध पक्का जिसमें कुछ कमरे पक्के, कुछ अर्द्ध पक्के और कच्चे कमरे आवास देखने में पाये गये। आवासीय व्यवस्था इनकी सामाजिक आर्थिक पृष्ठभूमि को प्रदर्शित करती है। यह तथ्य उनकी आर्थिक पृष्ठभूमि को निर्धारित करता है। इन आवासों में विद्युत की उपलब्धता के नाम पर एकल

शोध आलेख : आधुनिक टेक्नोलॉजी और किसान : संभावनाएं और चुनौतियाँ (छत्तीसगढ़ राज्य के विशेष संदर्भ में) / फलेन्द्र कुमार एवं प्रो. एल. एस. गजपाल

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सम्पादक, अपनी माटी ७ रविवार, जून 30, 2024

आधुनिक टेक्नोलॉजी और किसान : संभावनाएं और चुनौतियाँ
(छत्तीसगढ़ राज्य के विशेष संदर्भ में)
- फलेन्द्र कुमार एवं प्रो. एल. एस. गजपाल



Mural work on wall
size 5x10 ft

शोध सार : कृषि क्षेत्र के सुधार में प्रौद्योगिकी ने महत्वपूर्ण भूमिका निभाई है, डिजिटल प्रौद्योगिकी के आगमन के साथ, दायरा व्यापक हो गया है। कृषि में नए कृषि पद्धतियों में विकास हो रहा है, जिससे नुकसान कम हो रहा है और दक्षता बढ़ रही है। वर्तमान युग में कृषि में नई-नई प्रणालियों एवं मशीनरी का प्रयोग हो रहा है। इससे पहले जब कोई तकनीक नहीं थी, किसानों को कृषि के सभी पहलुओं को मैन्युअल रूप से करना पड़ता था। लेकिन अब तकनीक ने बहुत आर दिया है। प्रस्तुत अध्ययन छ.ग. राज्य के चार जिलों के 8 गांव पर आधारित है। अध्ययन का उद्देश्य किसानों में आधुनिक टेक्नोलॉजी के संभावनाओं एवं चुनौतियों का अध्ययन करना है। चयनित उत्तरदाताओं से प्राथमिक आंकड़ों को एकल विषय अध्ययन एवं साक्षात्कार के माध्यम से एकत्र किया गया है। इस अध्ययन से, यह है कि खेती में तकनीकों के प्रयोग से किसानों की उत्पादकता और आय में वृद्धि हो रही है। हालांकि, इस प्रक्रिया में कई चुनौतियाँ भी हैं। कृषकों के पास त ज्ञान की कमी और वित्तीय संसाधनों की अभाव भी उन्हें आधुनिक तकनीकों का उपयोग करने में रोकता रहा है। कृषि निकायों, सरकारी अधिकारियों, और संघठनों को आधुनिक तकनीक के उपयोग के लिए किसानों को प्रेरित करने, तकनीकी ज्ञान को बढ़ावा देने, और संभावित समस्याओं का समाधान करने सक्रिय भूमिका निभानी चाहिए।

बीज शब्द : कृषि विकास, खेती, आधुनिक, टेक्नोलॉजी, किसान, कृषक, तकनीकी, कृषि, डिजिटल, ग्रामीण।

मूल आलेख :

शोध आलेख : आधुनिक टेक्नोलॉजी और किसान : संभावनाएं और चुनौतियाँ (छत्तीसगढ़ राज्य के विशेष संदर्भ में) / फलेन्द्र कुमार एवं प्रो. एल. एस. गजपाल

भारतीय सभ्यता का विकास मुख्य रूप से कृषि विकास पर निर्भर रहा है। भारत देश की आधी से अधिक आबादी गाँव में निवास करती है व अधिक आबादी प्रत्यक्ष या अप्रत्यक्ष तौर पर अपना जीवन यापन कृषि या कृषि कार्यों से जुड़ी गतिविधियों के माध्यम से करते हैं। (सुरेन्द्र आहूजा एवं तिरु 2022)। कृषि भारतीय अर्थव्यवस्था व ग्रामीण जन जीवन का आधार है। हालाँकि धीरे धीरे भारतीय अर्थव्यवस्था में कृषि क्षेत्र का योगदान घट कर केवल 18% हो गया है लेकिन देश की 56 प्रतिशत से अधिक जनसंख्या प्रत्यक्ष रूप से कृषि क्षेत्र पर ही निर्भर है। भारत में कृषि काफी हद तक प्रकृति पर निर्भर है और ग्लोबल वार्मिंग के मुद्दे खेती को अप्रत्याशित बनाते हैं। समय की मांग है कि उत्पादकता बढ़ाने और लाभप्रदता बढ़ाने के लिए किसानों को तकनीक और नवीन दृष्टिकोण के उपयोग के बारे में शिक्षित किया जाए। कृषि क्षेत्र के सुधार में प्रौद्योगिकी ने महत्वपूर्ण भूमिका निभाई है। आधुनिक मशीन उपयोग, खाद, बीज, सिंचाई व्यवस्था, कटाई, फसल काटना तकनीक के कारण और अधिक उन्नत हो गया है। किसानों के पास आधुनिक कृषि उपकरण; वर्तमान युग में कृषि में नई-नई प्रणालियों एवं मशीनरी का प्रयोग किया जा रहा है। इससे पहले जब कोई तकनीक नहीं थी, किसानों को कृषि के सभी पहलू में न्यूनतम रूप से करना पड़ता था। लेकिन अब तकनीक ने किसानों के लिए फसल काटना और काटना बहुत आसान बना दिया है।

कुल कार्यबल के लगभग 65 प्रतिशत को रोजगार देने के बावजूद कृषि क्षेत्र भारत के सकल घरेलू उत्पाद का केवल 18 प्रतिशत हिस्सा है। खाद्यान्न उत्पत्ति सुधार के बावजूद, निपटने के लिए कई चुनौतियाँ हैं क्योंकि सरकार का लक्ष्य सकल घरेलू उत्पाद के हिस्से के रूप में कृषि उत्पादन को बढ़ाना है (फाउंडेशन : 2023)। पिछले कुछ समय से ऐसा माना जा रहा है कि कृषि विकास पद्धतियाँ प्राकृतिक संसाधनों का नवीकरण की तुलना में अधिक तेजी करती हैं। मानव आबादी में तेजी से वृद्धि के परिणामस्वरूप भोजन और आश्रय की मांग बढ़ गई है, जिसे प्रदान करने के लिए भूमि की "प्राकृतिक" वहन क्षमता बढ़ाव है। प्राकृतिक असंतुलन प्रदूषण, मिट्टी के क्षरण, वन्यजीवों की आबादी में गिरावट और वनस्पतियों और जीवों में मानव-निर्मित परिवर्तनों में दिखाई देता है।

कृषि में नवाचार से कृषि पद्धतियों में विकास हो रहा है, जिससे नुकसान कम हो रहा है और दक्षता बढ़ रही है। किसानों की आय दोगुनी करने संबंध में डिजिटल प्रौद्योगिकी की भूमिका की सराहना की है, जो ग्रामीण भारत की कृषि गतिविधियों को आधुनिक बनाने और व्यवस्थित करने में परिवर्तनकारी निभा सकती है। जियो-एग्री (जियो-कृषि)प्लेटफॉर्म को फरवरी 2020 में प्रारंभ किया गया था, और इसने किसानों को सशक्त बनाने के लिए संपूर्ण मूल्य श्रृंखला कृषि पारिस्थितिकी तंत्र को डिजिटल बना दिया। भारत में डिजिटल कृषि पहल डिजिटल कृषि मिशन 2021-2025 की शुरुआत सितंबर 2021 (ए.ए.ए. खान : 2021)।

डिजिटल कृषि मिशन 2021-2025 का उद्देश्य एआई, ब्लॉकचेन, रिमोट सेंसिंग, रोबोट और ड्रोन सहित अत्याधुनिक तकनीकों पर आधारित परिणामों को प्रोत्साहित करना और गति देना है। जून 2021 में, कृषि और किसान कल्याण मंत्रालय ने 6 राज्यों के 100 गांवों के लिए एक पायलट कार्यक्रम चलाने में मदद के लिए भारत सरकार ने 'यूनिफाइड फार्मर सर्विसेज इंटरफेस' नामक पायलट कार्यक्रम शुरू किया गया जो भारत के छोटे-जोते वाले किसानों के लिए एक लाभ प्रदान करने के लिए हाथ में लिया गया। इस गठबंधन का उद्देश्य एआई सेंसर का उपयोग करके बेहतर मूल्य प्रबंधन और कृषि उपज में माध्यम से किसानों की आय को बढ़ावा देना है।

हाल ही में सरकार ने इंडिया डिजिटल इकोसिस्टम ऑफ एग्रीकल्चर (आईडीईए) ढांचे की मूल अवधारणा को अंतिम रूप दे दिया है, जो संघबद्ध किंगडोम के लिए संरचना निर्धारित करेगा। इसके अलावा, विभाग द्वारा संचालित योजनाओं से संबंधित डेटाबेस को एकीकृत किया जाएगा। आईडिया भारत में लिए एक बेहतर पारिस्थितिकी तंत्र बनाने में प्रभावी ढंग से योगदान करने के लिए उभरती प्रौद्योगिकियों का लाभ उठाने के लिए अभिनव कृषि-केंद्रित समाधानों के लिए एक नींव के रूप में काम करेगा। यह पारिस्थितिकी तंत्र विशेष रूप से किसानों की आय बढ़ाने और समग्र रूप से कृषि क्षेत्र की दक्षता में सुधार लाने में प्रभावी योजना बनाने में सरकार की मदद करेगा।

भारतीय संघ के 26वें राज्य के रूप में दिनांक 01 नवंबर, 2000 को छत्तीसगढ़ का गठन हुआ। छ.ग. राज्य की भौगोलिक स्थिति 17°46' से 24° अक्षांश तथा 80°15' से 84°20' पूर्व देशांश है। राज्य की औसत वार्षिक वर्षा 1207 मि.मी. है। राज्य का कुल भौगोलिक क्षेत्रफल लगभग 138 लाख हे. है। फसल उत्पादन का निरा क्षेत्र 46.51 लाख हे. है, जो कि कुल भौगोलिक क्षेत्रफल का 34 प्रतिशत है। राज्य के लगभग 57 प्रतिशत क्षेत्र में मध्यम से हल्की छ.ग. देश के सबसे सम्यक् जैव विविध क्षेत्रों में से एक है, जिसका लगभग 63.40 लाख हे. क्षेत्र वनाच्छादित है, जो कि राज्य के कुल भौगोलिक क्षेत्र का 46% है। (संचालनालय कृषि छत्तीसगढ़ रायपुर : 2024)।

छत्तीसगढ़ राज्य की कुल जनसंख्या लगभग 2.55 करोड़ है, जिसमें से लगभग 70 प्रतिशत जनसंख्या कृषि कार्य में संलग्न है। राज्य में लगभग 37.4 लाख कृषक परिवार हैं, जिसमें से लगभग 80 प्रतिशत लघु एवं सीमांत श्रेणी के हैं। धान, सोयाबीन, उड़द एवं अरहर खरीफ मौसम की मुख्य फसलें हैं तथा रबी मुख्य रूप से चना एवं तिवड़ा का उत्पादन लिया जाता है। राज्य के कुछ जिले गन्ना उत्पादन हेतु उपयुक्त हैं तथा वर्तमान में राज्य में 04 सहकारी शक्कर संस्थान सफलतापूर्वक संचालित किए जा रहे हैं। राज्य की अन्य फसलों में मक्का, लघु-धान्य, मूंग, गेहूँ, मूंगफली इत्यादि सम्मिलित हैं। (वही : 2024)।

फसल क्षेत्र का राज्य के सकल राज्य घरेलू उत्पाद (स्थिर भाव) में भागीदारी वर्ष 2023-24 (अग्रिम) 26,12,897 लाख रूपये अनुमानित है। फसल योजनांतर्गत 2022-23 खरीफ में 14,13,225 कृषकों का बीमा कराया गया, राज्य में अब तक 3,473 कृषि यंत्र सेवा केन्द्रों की स्थापना की जा चुकी है। वर्तमान में 69 कृषि उपज मंडियाँ एवं 121 उप-मंडियाँ कार्यरत हैं। छत्तीसगढ़ राज्य की लगभग 80 प्रतिशत जनसंख्या का जीवन यापन कृषि पर निर्भर है। 40.10 लाख कृषक परिवारों में से 82 प्रतिशत लघु एवं सीमांत श्रेणी में आते हैं। (छ.ग.आर्थिक सर्वेक्षण, 2023-24)। वर्तमान में छत्तीसगढ़ प्रदेश के सभी सिंचाई से लगभग 36 प्रतिशत क्षेत्र में सिंचाई सुविधा उपलब्ध है जिसमें से सर्वाधिक 52 प्रतिशत क्षेत्र जलाशयों / नहरों के माध्यम से सिंचित हैं एवं 29 प्रतिशत क्षेत्र न सुनिश्चित सिंचाई के अंतर्गत आते हैं। (अधिकारिता: वर्षा पर निर्भर है (छ.ग.आर्थिक सर्वेक्षण : 2022-23)। छत्तीसगढ़ राज्य में बढ़ती जनसंख्या में प्रवास के कारण केवल उनकी सामाजिक आर्थिक स्थिति ही ठीक नहीं रहती है, बल्कि प्रवास का प्रभाव बच्चों की शिक्षा और स्वास्थ्य पर भी नकारात्मक प्रभाव डाल रहा है।

Head of Social Work
S.A.S. & Social Work
P.R.S.U., Raipur (C.G.)
30.11.2024

शोध आलेख : आधुनिक टेक्नोलॉजी और किसान : संभावनाएं और चुनौतियाँ (छत्तीसगढ़ राज्य के विशेष संदर्भ में) / फलेन्द्र कुमार एवं प्रो. एल. एस. गजपाल
राज्य में प्रवास को रोकने के लिए कृषकों को सामाजिक आर्थिक रूप से समर्थवान बनाने की आवश्यकता है, यह कार्य कृषि में उन्नत प्रौद्योगिकी से ही संभव है (गजपाल : 2009)।

भारत में कृषि में आधुनिक प्रौद्योगिकी का महत्व

विश्व की छोटी बड़ी अर्थव्यवस्था भारत की आबादी का ज्यादातर हिस्सा आज भी कृषि और इससे क्षेत्रों में कार्यरत है। (बनवारी लाल यादव : 2022)
प्रौद्योगिकी कृषि के कई क्षेत्रों को प्रभावित करती है, जैसे कि उर्वरक, कीटनाशक, बीज प्रौद्योगिकी, आदि। जैव प्रौद्योगिकी और अनुवंशिक इंजीनियरिंग प्रणामस्वरूप कीट प्रतिरोध हुआ है और फसल की पैदावार में वृद्धि हुई है। मशीनीकरण के कारण कुशल जुताई, कटाई और शारीरिक श्रम में कमी सिंचाई के तरीकों और परिवहन प्रणालियों में सुधार हुआ है, प्रसंस्करण मशीनरी से बर्बादी कम हुई है और इसका प्रभाव सभी क्षेत्रों में दिखाई दे रहा है। नए ज प्रौद्योगिकियों रोबोटिक्स, सटीक कृषि, कृत्रिम बुद्धिमत्ता, ब्लॉकचेन तकनीक और बहुत कुछ पर ध्यान केंद्रित करती हैं। 1960 में, हरित क्रांति के दौरान, भा के आधुनिक तरीकों जैसे रासायनिक उर्वरकों और कीटनाशकों, उच्च गुणवत्ता वाले बीजों और उचित सिंचाई का लाभ उठाकर खाद्यान्न उत्पादन में आत्म हासिल करने में कामयाब रहा। अंततः भारत में कृषि विकास में तकनीकी प्रगति सामने आई। ट्रैक्टरों की शुरूआत के बाद नए जुताई और कटाई के उ सिंचाई के तरीके और वायु बीजारोपण तकनीक का आगमन हुआ, जिससे भोजन और फाइबर की गुणवत्ता में सुधार हुआ। किसान फसल की पैदावार बढ़ा खेती के अत्याधुनिक तरीकों से खुद को परिचित रखने के लिए वैज्ञानिक डेटा और प्रौद्योगिकी का लाभ उठा सकते हैं।

भारत में कृषि में आधुनिक प्रौद्योगिकी का उपयोग

प्रौद्योगिकियों क्षेत्र में आधुनिक कृषि के परिवर्तन को सक्षम कर सकती हैं। जबकि कुछ प्रौद्योगिकियों ने हमारे काम करने के तरीके को बदल दिया है, तकनीकी प्रगति फैलाने की आवश्यकता है, जैसे कृत्रिम बुद्धिमत्ता और मशीन विज्ञान। कृषि में आधुनिक तकनीक का उपयोग लाखों किसानों को वास्तविक कृषि जानकारी प्राप्त करने से लाभान्वित करने में सक्षम बना सकता है। किसानों को मौसम की जानकारी और आपदा चेतावनियों की तत्काल उपलब्धता है, और कृषि डेटा तक त्वरित पहुंच भी हो सकती है।

भारत में डिजिटल कृषि का भविष्य

डिजिटल परिवर्तन अब लगभग एक दशक से कृषि-खाद्य क्षेत्र में हलचल पैदा कर रहा है। इसने निजी और सरकारी संस्थाओं को प्रक्रियाओं को सुधा नए व्यापार मॉडल की पहचान करने के लिए डिजिटल प्रौद्योगिकी में नवाचारों को लागू करने में सक्षम बनाया है। भारत में भविष्य में डिजिटल कृषि को अ सार्वजनिक-निजी भागीदारी (पीपीपी) मॉड के तहत विकसित कर उपयोग किया जाएगा। डिजिटल टेक्नोलॉजी सुदूर संवेदन, मृदा संवेदकों, मानव रहित हवाई और बाजार अंतर्दृष्टि आदि पर आधारित तकनीकी हस्तक्षेप, किसानों को सुविधाजनक तरीके से उत्पादन लागत को कम करने, उत्पादन के विभिन्न चरणों और मिट्टी के स्वास्थ्य के आँकड़ों को इकट्ठा करने, अनुमान करने और मूल्यांकन करने की सुविधा देती है। आर्टिफिशियल इंटेलिजेंस/मशीन लर्निंग (एआई, एल्गोरिदम फसल की उपज में सुधार, कीटों को नियंत्रित करने, मिट्टी की जांच में सहायता करने, किसानों के लिए कार्रवाई योग्य डेटा प्रदान करने और कार्यभार को कम करने में मदद करने के लिए वास्तविक समय पर कार्रवाई योग्य अंतर्दृष्टि प्रदान कर सकती हैं।

ब्लॉकचेन टेक्नोलॉजी खेतों, इन्वेंट्री, त्वरित और सुरक्षित लेनदेन और खाद्य ट्रैकिंग के बारे में छेड़छाड़-सबूत आदि का सटीक डेटा प्रदान करती प्रकार, किसानों को महत्वपूर्ण डेटा रिकॉर्ड करने और संग्रहीत करने के लिए कागजी कार्रवाई या फाइलों पर निर्भर नहीं रहना पड़ता है। मोबाइल-आधारित व सेंसर, ड्रोन, कृषि उपकरण और मशीनरी, रोबोट डिवाइस उपकरणों सहित स्रोतों के संयोजन से प्राप्त फार्म-स्तरीय डेटा उत्पादकों के लिए महत्वपूर्ण कृषि चौबीसों घंटे कैचर करना संभव बनाता है।

सरकार द्वारा उठाए गए कदम

एग्रीस्टैक: कृषि एवं किसान कल्याण मंत्रालय ने 'एग्रीस्टैक' के निर्माण की योजना बनाई है, जो कि कृषि में प्रौद्योगिकी आधारित हस्तक्षेपों का : यह किसानों को कृषि खाद्य मूल्य भ्रूखला में एंड टू एंड सेवाएँ प्रदान करने हेतु एक एकीकृत मंच का निर्माण करेगा। एग्रीस्टैक कृषि क्षेत्र में तकनीकों और डिजिटल समाधानों का एक संग्रह है। यह उत्पादकता और उत्पाद क्षमता में सुधार के लिए उपयोगी है।

डिजिटल कृषि मिशन: कृषि क्षेत्र में कृत्रिम बुद्धिमत्ता, ब्लॉकचेन, रिमोट सेंसिंग और GIS तकनीक, ड्रोन व रोबोट के उपयोग जैसी नई त पर आधारित परियोजनाओं को बढ़ावा देने हेतु सरकार द्वारा वर्ष 2021 से वर्ष 2025 तक के लिये यह पहल शुरू की गई है। डिजिटल कृषि मि लक्ष्य कृषि सेक्टर में डिजिटल प्रौद्योगिकी का उपयोग बढ़ाना है।

एकीकृत किसान सेवा मंच (UFSP): यह एक प्लेटफॉर्म है जो कृषि क्षेत्र के किसानों को विभिन्न सेवाओं और संसाधनों तक पहुंचने में मद है। यह उन्हें बेहतर कृषि प्रविधि, बाजार जानकारी, संसाधनों के लिए सही स्रोत, और सरकारी योजनाओं के लिए जानकारी प्रदान करता है।

कृषि यांत्रिकीकरण :- कृषि यंत्र सेवा केंद्रों की स्थापना से कृषि कार्यों की सुगमता और उत्पादन में वृद्धि हो रही है। लघु सीमांत किसानों क कृषि यंत्रों की सुविधा मिल रही है, और ग्रामीण युवाओं को स्वरोजगार के अवसर प्राप्त हो रहे हैं। छ.ग. राज्य में अब तक 3473 कृषि यंत्र सेवा वे स्थापना की जा चुकी है (छ.ग. आर्थिक सर्वेक्षण : 2021-22)।

साहित्य की समीक्षा -

जितेन्द्र यादव (2022), ने अपने अध्ययन *भारतीय किसान की चुनौतियाँ और संभावनाएँ* में बताया कि भारतीय किसान आर्थिक रूप से आज भी अंधि भारत में व्यक्तिगत कृषि जोत कम हो गई है, इसलिए ज्यादातर किसान खुद के लिए ही पैदा कर पाते हैं, उनके पास कृषि से आय की संभावना कम हो सरकार को ऐसी नीति बनाने की जरूरत है जिससे किसानों के बजाय किसान की आय में बढ़ोत्तरी हो सके।

शोध आलेख आधुनिक टेक्नोलॉजी और किसान संभवनाएँ और चुनौतियाँ (छत्तीसगढ़ राज्य के विशेष संदर्भ में) / कलेक्ट कुमर एवं डी एल एस गण्डवाल

सुरेश कुमार भावरिया (2022), ने अपने अध्ययन किसानों पर आधुनिकीकरण, पश्चिमीकरण एवं वैश्वीकरण के प्रभावों का एक समावर्तनात्मक आ-
धुनिकीकरण, पश्चिमीकरण एवं वैश्वीकरण से तकनीकी ज्ञान का प्रसार हुआ है और किसानों के जीवन में आशातीत परिवर्तन हुआ है।
धीर सिंह शेखावत (2018), ने अपने अध्ययन 'कृषि का आधुनिकीकरण - आलोचनात्मक अध्ययन' में बताया कि आधुनिक वैज्ञानिक प्रयास से आ-
धुनिकीकरण एवं मशीनों का प्रादुर्भाव हुआ है, जिसमें ट्रैक्टर, हार्वैस्टर, नलकूप, प्रेसर, स्पिंकलर सिस्टम आदि के साथ ऊर्जा के साधन एवं राश-

दिवाकर दिव्य दिव्यांशु (2017), ने अपने अध्ययन बदलते सामाजिक परिदृश्य और किसान में बताया कि आज जरूरत है उन द्वांघगत विकास व
अजाम तक पहुँचाने का जिससे कृषि योग्य परिस्थिति सिंचाई के साधन विकसित हो सकें।

अध्ययन का महत्व -

यह अध्ययन किसानों की जीवन गुणवत्ता में सुधार लाने के लिए है। यह अध्ययन किसानों को उनके कृषि कार्यों को सुधारने के लिए नवीनतम तकनीक
में जागरूक करेगा। साथ ही, यह उनके लिए उपलब्ध तकनीक के उपयोग के लाभ का मूल्यांकन करेगा और विभिन्न चुनौतियों का समाधान ढूँढेगा। इससे कृषि
उत्पादकता और आय में वृद्धि होगी और किसानों की आर्थिक स्थिति में सुधार होगा। इसके अलावा, यह अध्ययन संबंधित निकायों और सरकारी अधिकारियों
नीतियों और कार्यक्रमों के आविष्कार के लिए प्रेरित करेगा जो किसानों के हित में होंगे।

अध्ययन का उद्देश्य -

1. नवीनतम तकनीक के प्रति किसानों में जागरूकता कि स्थिति को ज्ञात करना।
2. तकनीक का उपयोग करके कृषि उत्पादन में वृद्धि का मूल्यांकन करना।
3. किसानों को तकनीकी और आर्थिक परिवेश में आने वाली चुनौतियों का अध्ययन करना।

शोध पद्धति - प्रस्तुत शोध हेतु अन्वेषणात्मक एवं वर्णात्मक शोध विधि का प्रयोग किया गया है।

1. **अध्ययन क्षेत्र** - छ.ग. देश के सबसे सम्पन्न जैव विविध क्षेत्रों में से एक है, प्रस्तुत शोध कार्य के लिए छ.ग. राज्य के 4 जिला रायपुर, राजनन्दगाँव, व
चांपा एवं दंतेवाड़ा के कुल 8 गांव का चयन किया गया है।
2. **उत्तरदाताओं का चुनाव** - प्रस्तुत अध्ययन में छत्तीसगढ़ राज्य के 8 गांव का चयन किया गया है, जिसमें प्रत्येक गांव से एक-एक (कुल 8) उत्तरदा
चयन असंभावना निर्देशन के उद्देश्यपूर्ण प्रणाली द्वारा किया गया है।
3. **तथ्य संकलन की प्रविधि एवं उपकरण प्रविधि** - प्रस्तुत अध्ययन हेतु चयनित उत्तरदाताओं से प्राथमिक आंकड़ों को एकल विषय अध्ययन एवं साक्षा
माध्यम से एकत्र किया गया है। साथ ही आंकड़ों के संतुष्टि के लिए अवलोकन तथा अनुभावणात्मक पद्धति का प्रयोग किया गया है। अध्ययन को पूर्ण
लिए द्वितीय स्तरीय विभिन्न विभागों द्वारा प्रकाशित हुआ प्रकाशित स्त्रोतों से एकत्र किया गया है।

तथ्यों का विश्लेषण और व्याख्या -

1. **केस स्टडी - रमेश (परिवर्तित नाम)**, छत्तीसगढ़ के रायपुर जिले के मुररा गाँव के एक साधारण किसान है जो पारंपरिक तरीके से कृषि व्यवसाय च
उनकी मासिक आय केवल 10000/- थी। उन्होंने 12 तक कि शिक्षा प्राप्त किया है। घर में माँ, पत्नी और दो बच्चे हैं। उनकी जमीन का आकार 5 एकड़
वे कृषि और उत्पादकता में संघर्ष कर रहे थे। रमेश के लिए विकास का मार्ग खोजना मुश्किल था। पारंपरिक तरीके से कृषि करने के कारण उन्हें प्र
आपातकाल, मंदी और ऊपरी हवाओं के असरों से जूझना पड़ रहा था। उनकी कम आय से उन्हें परिवार के जीवन निर्धारित करने में मुश्किल हो रही
एक दिन, उन्हें छत्तीसगढ़ सौर ऊर्जा योजना के बारे में सुना। इसके तहत, सरकार सौर ऊर्जा के उत्पादन और उपयोग के लिए वित्तीय सहायता प्रदा
है। रमेश ने इस योजना का लाभ लेने का निर्णय किया और अपने खेतों पर सौर पैनल लगाने का काम शुरू किया। सौर ऊर्जा योजना के फलस्वरूप,
जीवन में बड़ा बदलाव आया। सौर पैनलों के उपयोग से उन्होंने अपने खेतों को सस्ते और स्थायी ऊर्जा सप्लाई की आपूर्ति की। इससे उनकी उत्पादक
और वे अधिक समय और ध्यान कृषि में लगा सके। उनकी आय में भी वृद्धि हुई और उनका परिवार अब अधिक सुख और सुरक्षित महसूस कर रहा है
रमेश ने न केवल अपने व्यक्तिगत जीवन को सुधारा, बल्कि अपने समुदाय को भी प्रेरित किया है कि वे आधुनिक तकनीक के लाभों को अपनाएं और
कृषि उत्पादन को सुधारें।

2. **केस स्टडी - सीमा (परिवर्तित नाम)**, छत्तीसगढ़ के रायपुर जिले के कांदुल गाँव के एक साधारण महिला किसान है, वह अपने परिवार के साथ रहती है
परिवार खेती पर निर्भर है और उनकी मुख्य आय कृषि से होती है। सीमा की शिक्षा स्तर 8वीं कक्षा तक की है और उनके परिवार में चार सदस्य हैं।
लिए सबसे बड़ी समस्या थी उनकी कम उत्पादकता और उत्पादन की कमी। वे पारंपरिक तरीके से कृषि करती थीं, लेकिन उत्पादकता में कमी और
उनकी फसलों की कम डिमांड के कारण उनकी आर्थिक स्थिति मजबूत नहीं थी। सीमा ने आधुनिक तकनीक का अध्ययन किया और उसे अपने कृषि
में शामिल करने का निर्णय लिया। उन्होंने बीजों की अधिक संशोधित विधियों का उपयोग किया, सही खाद और पानी की प्रबंधन किया और आधुनि
उपकरणों का उपयोग किया। उन्होंने अपनी फसलों का उत्पादन बढ़ाने के लिए उत्पादकता और क्वालिटी में सुधार किया। सीमा के उपायों के परिणाम
उनके द्वारा अपनाई गई आधुनिक तकनीक ने उन्हें अधिक उत्पादक बनाया और उनकी आर्थिक स्थिति मजबूत की। उनकी आय में वृद्धि हुई और
परिवार अब अधिक सुरक्षित महसूस कर रहा है। उन्होंने न केवल अपने स्वार्थ की पूर्ति की, बल्कि वे अपने समुदाय के लिए भी एक प्रेरणा स्त्रोत
आधुनिक तकनीकों को समझने और उन्हें अपनाने के लिए प्रेरित किया है।

केस स्टडी - सुरेश (परिवर्तित नाम), छत्तीसगढ़ के जंजगीर-चांपा जिले के देवरी गाँव का एक किसान है। उनका परिवार कृषि पर निर्भर है और उनका
आय कृषि से होती है। उनकी शिक्षा स्तर 10वीं कक्षा तक का है और उनके परिवार में पांच सदस्य हैं। सुरेश के लिए मौसम आपदाओं से निपटना मुश्
गया है। अनियमित बारिश और तूफानों के कारण उनकी फसलें नुकसान उठा रही हैं, जिससे उनकी आय में कमी हो रही है। इस समस्या का समाधान
के लिए, सुरेश ने आधुनिक तकनीक का सहारा लिया। उन्होंने मौसम पूर्वानुमान तकनीक का उपयोग किया, जिससे वे बारिश के आने की संभाव
तूफानों के आगमन को पहले ही पहचान सके। इसके अलावा, उन्होंने बीजों को बेहतर तरीके से चुनने और खेतों का सही से संचालन करने के लिए
कृषि उपकरणों का उपयोग किया। सुरेश के उपायों का परिणाम स्पष्ट रूप से दिखाई दिया। उनके द्वारा अपनाई गई आधुनिक तकनीक ने उन

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शोध आलेख : आधुनिक टेक्नोलॉजी और किसान : संभावनाएं और चुनौतियाँ (छत्तीसगढ़ राज्य के विशेष संदर्भ में) / फलेन्द्र कुमार एवं प्रो. एल. एस. गजपाल

आपदाओं के खिलाफ बेहतर तैयारी की सामर्थ्य प्रदान की और उनकी फसलों को सुरक्षित रखा। उनकी उत्पादनता में वृद्धि हुई और उनकी आय हुआ। आधुनिक तकनीक का उपयोग करके, सुरेश ने न केवल अपनी फसलों को सुरक्षित बनाया, बल्कि उनकी आय में भी वृद्धि की।

4. **केस स्टडी - सीताराम (परिवर्तित नाम).** छत्तीसगढ़ के जंजगीर-चांपा जिले के फरहदा गाँव में निवास करते हैं। उनका शिक्षा स्तर हाईस्कूल तक है और परिवार छोटा है। वह अपने परिवार का मुख्य आय अभिभावकों के साथ कृषि से हासिल करते हैं। सीताराम के लिए कृषि कार्यों को समय पर सम्पन्न मुश्किल हो रहा था। उनके पास पर्याप्त कृषि उपकरण नहीं थे और मनुअल काम करने से उन्हें समय भी ज्यादा लग रहा था। इस समस्या को हल करने के लिए, सीताराम ने सरकार की ट्रैक्टर सब्सिडी योजना का लाभ उठाया। उन्होंने सब्सिडी के साथ एक ट्रैक्टर खरीदा और अब उन्हें कृषि के कार्यों को सम्पन्न करने में मदद मिल रही है। नतीजा: सीताराम के द्वारा ट्रैक्टर की खरीद करने से उनका कृषि कार्य अब अधिक अद्यतन और तेज हो गया है। मनुअल काम करने की आवश्यकता नहीं है और अब वे अपने खेतों को और भी प्रभावी ढंग से प्रबंधित कर सकते हैं। ट्रैक्टर के साथ सब्सिडी का लाभ: सीताराम ने अपने कृषि उत्पादन को बढ़ावा दिया और अपने परिवार की आर्थिक स्थिति को मजबूत किया।

5. **केस स्टडी - मीनाक्षी (परिवर्तित नाम).** एक छत्तीसगढ़ के राजनन्दगाँव जिले के नावागाँव की महिला किसान हैं, जो अपने परिवार के साथ एक छोटे रेंग रही हैं। वह अपने परिवार का सहारा बनाने के लिए कृषि कार्यों में सक्रिय रहती हैं। मीनाक्षी के लिए फसलों को कीटों से बचना मुश्किल हो रहा है। अपने पिछले कुछ सीजनों में कई फसलों को कीटों और कीटाणुओं के हमले का सामना करना पड़ा था, जिससे उनकी उत्पादकता पर असर पड़ा था। वे आधुनिक तकनीक का सहारा लिया और कीटों से बचाव के लिए उपयोगी फसलों को बुआई करने का निर्णय लिया। उन्होंने उचित समय पर पेस्टिसाइड का उपयोग करने के लिए अद्यतन तकनीक का भी उपयोग किया। इसके अलावा, वह मशीनरी का उपयोग कर फसलों की बुआई और काटने के कार्य को सुगम बना रही हैं। मीनाक्षी के द्वारा अपनाए गए उपायों ने उन्हें कीटों और अन्य नुकसानकारी कीटाणुओं से फसलों को सुरक्षित मदद की। उनकी उत्पादकता में वृद्धि हुई और उनकी आर्थिक स्थिति में सुधार हुआ। इस अनुभव ने मीनाक्षी को आधुनिक तकनीक के लाभों को सम्पन्न अपने कृषि प्रयासों को बेहतर बनाने की प्रेरणा दी।

6. **केस स्टडी - सुनील (परिवर्तित नाम).** छत्तीसगढ़ के राजनन्दगाँव के एक छोटे से गाँव रेंगकठेरा के एक मशरूम उत्पादक हैं। उनका परिवार कृषि पर और उनकी मुख्य आय मशरूम उत्पादन से होती है। उनका शिक्षा स्तर 12वीं कक्षा तक का है और उनके परिवार में पांच सदस्य हैं। सुनील के लिए समस्या थी उनकी फसलों की उत्पादनता में कमी और उत्पादन में वृद्धि की कमी। उनकी मशरूम उत्पादन कम था और वह उसे बढ़ाने के लिए उपाय थे। सुनील ने आधुनिक तकनीक का सहारा लिया और अपने मशरूम उत्पादन को बढ़ाने के लिए विभिन्न तकनीकों का उपयोग किया। उन्होंने अपने की खेती में हाइड्रोपोनिक्स का उपयोग किया, जिससे वे मशरूमों को समृद्धि से उत्पादित कर सकें। इसके अलावा, उन्होंने उत्पादित मशरूम की बेहतर मार्गदर्शन के लिए आधुनिक विपणन तकनीकों का भी उपयोग किया। सुनील के उपायों के परिणाम स्पष्ट हैं। उनके द्वारा अपनाई गई आधुनिक ने उन्हें मशरूम उत्पादन की उत्पादकता में वृद्धि दिखाई और उनकी आय में वृद्धि हुई। इससे उनका परिवार अब अधिक सुरक्षित और समृद्ध महसूस है। उनके उत्पादन और आय में वृद्धि का परिणाम है कि उन्होंने अपने समुदाय को भी सशक्त बनाया है और आधुनिक तकनीक के लाभों को सम्पन्न अपने लिए प्रेरित किया है।

7. **केस स्टडी - रामलाल (परिवर्तित नाम).** जनजाति बाहुल्य जिले दाँतेवाड़ा के पोन्डम गाँव के एक मुड़िया जनजाति के किसान हैं। उनका परिवार बहुत और उनकी मुख्य आय कृषि से होती है। उनके पास केवल एक एकड़ जमीन है और उन्हें बहुत संकटों का सामना करना पड़ता है। वह अपने जीवन वनोपज के माध्यम से भी आधारित किसान हैं। रामलाल के लिए जीवन बहुत ही कठिन है। उनकी जमीन में अपर्याप्त जल होने के कारण फसलों में की कमी होती है। वे ट्रेसिशनल तरीके से कृषि करते हैं और नई तकनीक का उपयोग नहीं कर पाते हैं। इसके अलावा, उन्हें वनोपज से जुड़ी समस्या सामना करना पड़ता है। रामलाल ने अपने समस्याओं का समाधान करने के लिए साहाय्यक संगठनों का सहारा लिया। उन्होंने अपनी जमीन पर सिंचना प्रणाली स्थापित की और जल संरक्षण के उपायों का अनुसरण किया। इसके अलावा, वह उन्नत बीजों का उपयोग करने लगे और खेती के लिए तकनीक का उपयोग करने लगे। वह वनोपज के माध्यम से भी अपने आय को बढ़ाने का प्रयास करते हैं। रामलाल के उपायों ने उनके जीवन में बड़ा लाया। उनकी फसलों की उत्पादनता में वृद्धि हुई और उनकी आय में सुधार हुआ। उन्होंने अपने परिवार को सुरक्षित रखने के लिए आत्मनिर्भर बनने का किया और अपनी समाज के लिए एक आदर्श बने। उनकी कहानी बताती है कि जीवन की कठिनाइयों का सामना करने के लिए साहाय्यक संगठनों का लेकर और आधुनिक तकनीक का उपयोग करके, किसान अपने जीवन को सुधार सकते हैं। वनोपज के माध्यम से भी उन्होंने अपने आय को बढ़ाने का दिखाया।

8. **केस स्टडी - सविता (परिवर्तित नाम).** एक आदिवासी महिला, दाँतेवाड़ा जिले के चंदेनाल गाँव के हलबा जनजाति की निवासी हैं। उनका शिक्षा स्तर म है और उनके पास तीन बच्चे हैं। स्थानीय स्तर पर, वह स्वसहायता समूह के सक्रिय सदस्य हैं। सविता के लिए रोजगार की समस्या सदैव थी। उन इलाकों में रोजगार के अवसर कम थे, जिससे उनकी आर्थिक स्थिति मजबूत नहीं थी। सविता ने स्वसहायता समूह के सहयोग से स्वरोजगार का अवसर उन्होंने आधुनिक पाठ्यक्रमों के माध्यम से हस्तशिल्प और बुनाई का प्रशिक्षण प्राप्त किया। उन्होंने गाँव के बाजारों में अपने निर्मित उत्पादों की बिक्री और इंटरनेट के माध्यम से ऑनलाइन बिक्री को भी बढ़ावा दिया। सविता के प्रयासों ने उन्हें आत्मनिर्भर बनाया और उनकी आर्थिक स्थिति में सुधार उनके स्वरोजगार के प्रयास ने गाँव के साथी आदिवासियों को भी प्रेरित किया और समुदाय के विकास में मदद की। इससे न केवल सविता का आत्मविश्वास बढ़ा, बल्कि उनके स्वरोजगार के प्रयास ने उनके परिवार को भी सशक्त बनाया।

निष्कर्ष : आधुनिक टेक्नोलॉजी का कृषि क्षेत्र में उपयोग व्यापक रूप से बदल रहा है। छत्तीसगढ़ राज्य के 4 जिलों में स्थित 8 गाँवों के किसानों का केस स्टडी यह अध्ययन ने कृषि क्षेत्र में आधुनिक तकनीकों के प्रयोग की संभावनाओं और चुनौतियों को प्रकट किया है। आधुनिक टेक्नोलॉजी के उपयोग से कृषि क्षेत्र लाभ हो रहे हैं। सौर ऊर्जा प्रणालियों, सिंचाई के उन्नत प्रणालियों, और अद्यतन खेती के तरीकों का उपयोग किया जा रहा है। इन तकनीकों के प्रयोग से कृषि उत्पादकता और आय में वृद्धि हो रही है। हालांकि, इस प्रक्रिया में कई चुनौतियाँ भी हैं। कृषकों के पास तकनीकी ज्ञान की कमी और वित्तीय संसाधनों की अ समर्थन की असमानता। इस अध्ययन से, ज्ञात होता है कि कृषि निकायों, सरकारी अधिकारियों, और सामाजिक संगठनों को आधुनिक तकनीक के उपयोग किसानों को प्रेरित करने, तकनीकी ज्ञान को बढ़ावा देने, और संभावित समस्याओं का समाधान करने के लिए सक्रिय भूमिका निभानी चाहिए। नई नीति कार्यक्रमों के आविष्कार से, हम संभावित सुधार की दिशा में कदम बढ़ा सकते हैं, जो किसानों के जीवन को सुधार सकते हैं और उन्हें संतुष्टि प्रदान कर सकते

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The Occupational Structure of Hill Korwa with Reference to Sarguja District

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Abstract: Tribals are an inseparable part of Indian society, and despite living in remote areas, their contribution to Indian culture and society is unparalleled. The development of these individuals is critical to India's long-term development goals. A sizable proportion of this population lives in far-flung and remote areas with hilly terrain. They primarily rely on forest products and agriculture for a living. The research focuses on their occupational structure as well as the impact of today's rapidly changing modern ecosystem on these individuals. The purpose of this study is to draw the attention of government officials to the research and development of the tribal people who live there.

Keywords: Hill Korwa, Occupational Structure, Sarguja, Minor Forest Produce, Agriculture, Animal Husbandry, Minor Forest Produce

Introduction

There is no precise definition or criterion for classifying a tribe as a human group. However, different researchers defined it in different ways at different times. They referred to "Tribe" as "aboriginal," "depressed classes," or "Adivasis" at times. Typically, a 'tribe' is a group of people who acknowledge the authority of a chief and regard themselves as descended from the same ancestor during a primitive or barbarous stage of development.

The United Nations Organization give the definition of Indigenous people as "Indigenous peoples are inheritors and practitioners of unique cultures and ways of relating to people and the environment. They have retained social, cultural, economic, and political characteristics that are distinct from those of the dominant societies in which they live. Despite their cultural differences, indigenous peoples from around the world share common problems related to the protection of their rights as distinct peoples." (United Nations Organisation, n.d.)

In the Indian Context, T.B Naik has given the following features of tribes:

A tribe should have the least functional interdependence within the community.

Economically backward (i.e., primitive and traditional means of exploiting natural resources, the tribal economy should be at an underdeveloped stage and have multifarious economic pursuits).

A comparative geographical isolation of its people.

Having a common dialect.

Politically unorganized, and community panchayat should be influential.

Have their own customary laws. (Tribal society, Definition of tribal society, Meaning of tribal society, tribal problems in India, Indian tribes, Tribal way of life in India, n.d.)

As per Ralph Linton Tribe may be a group of bands occupying a contiguous territory or territories and having a feeling or sense of unity deriving from numerous similarities in culture, frequent contacts, and a certain community of interests.

L.M Lewis believes that tribal societies are small in scale, are restricted within the spatial and temporal range of their social, political, and legal relations, and possess a morality, religion, and broader view of corresponding dimensions. Tribal languages are unwritten; hence, the extent of communication in time and space is integrally narrow. On the other hand, tribal societies exhibit a remarkable economy of design and have a compactness and self-sufficiency lacking in modern society.

The Korwa community is basically Munda which resides primarily between the border of Chhattisgarh and Jharkhand, with an uneven population in north-central India (Deogaonkar, 1986). The Korwa ST community is divided into two major Sub-groups The Dih or DihadiKorwa (Korwaof the Plains) And the PahadiKorwa (Korwaof the Hills). In Chhattisgarh, the Hill Korwa Population is concentrated in the northern districts Such Sarguja, Korba, Balrampur, Jashpur, with traces also living in the Raigarhand Sakti districts. The community of Korwais subdivided into tribal clans; the main Clans of Korwaare the Hasadwar, Mudhiyar, Idgewar, and Sammathwar.


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The proportion of a country's workforce involved in various economic activities is referred to as its occupational structure. The percentage of the total working population engaged in agriculture and closely related activities and the percentage in manufacturing and service industries can be calculated using the country's occupational structure. In India, some 64 percent of the population is engaged in agriculture alone. The proportion of the population is dependent upon the secondary and tertiary sectors.

The occupational structure of a country's workforce is a key indicator of its economic development. A well-developed workforce is able to contribute to the growth of the economy and provide the necessary skills and knowledge to support new industries. A country with a poorly developed workforce, on the other hand, will struggle to compete in the global marketplace and may find it difficult to attract foreign investment. (Boskin, 1974) (al, 1980) (Filer, 1986) (Gill, 1989)

There are a number of factors that contribute to a country's occupational structure. The most important of these is the level of education and training of the workforce. A country with a highly educated and skilled workforce will be able to take advantage of new technologies and industries, whereas a country with a poorly educated workforce will be at a disadvantage. Another important factor is the age of the workforce. A country with a young workforce will have a greater potential for growth than a country with an older workforce. This is because younger workers are more likely to be able to learn new skills and adapt to new technologies. The size of the workforce is also a key factor. A country with a large workforce will be able to produce more goods and services than a country with a smaller workforce. This is because a larger workforce can be divided into more specialized groups, each of which can focus on a particular task. Finally, the composition of the workforce is also important. A country with a workforce that is heavily biased towards one particular industry or sector will find it difficult to diversify its economy. On the other hand, a more diversified workforce will be better equipped to handle economic shocks and adapt to changing conditions. A well-developed workforce is essential for a country to compete in the global marketplace and attract foreign investment.

In rural tribal India, the occupational structure is dominated by agriculture. Other important occupations include forestry, animal husbandry, and fishing. A small minority of the population is engaged in manufacturing and other industrial activities. Trade and transportation are also important, although to a lesser extent.

In a tribal society, the primary source of livelihood is agriculture and the collection of forest produce. Casual vocational labor is performed by mostly unorganized and unskilled people.

Methodology

Taking all the surveyed facts and figures into consideration, this present study outlines the following objectives –

Objectives

- To collect information and analyze them as per the situation of the area.
- To understand the occupational patterns of the tribals
- To analyze the impact of covid 19 pandemic on the occupational patterns
- To access a clearer picture of the economic conditions of the Hill Korwa Tribals
- To study the ground reality of the socio-economic conditions of the tribals.
- To suggest and recommend for the future action plans.
- To test the effectiveness of the welfare schemes of government with relation to hill Korwa tribals

Research Design

The Research was conducted in the Tribal Areas of Sarguja District. A descriptive design-based study was conducted to gain insights into the subjects. Primary information was derived through the interview of the individuals, using an interview schedule.

Sampling

While following a random sampling procedure, the samples were taken from 88 households from 13 villages of the various development block of Sarguja District, these being Ambikapur, Lundra, Batauli, Sitapur, Mainpat, and Lakhanpur to conduct the study in the universe. The universe consists of a combined population of 10632, with Total households being 2659 and no of villages being 127; the sample comes to 10% representation of the total villages under study.

Primary Sources

Individual Interview: The data used in the study is collected by the method of direct interviews taken from households. Where the criteria for the interview were set to anyone from the family who has or had been getting income from any source at a certain point in time. The respondents were asked about their family, monthly or yearly income, ration card type, occupation, current employment status, educational status, etc.

Observation

The non-participant observation was conducted in addition to the abovementioned approaches to get additional insights and round out the collected data.


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Secondary Sources

Data on the concept and setting of the developmental activities were gathered from secondary sources. The published works, peer-reviewed articles, and unpublished documents were all used as sources of support. For the aforementioned reason, records from the relevant district-level government department were also consulted.

Points in the study

- It is assumed that participating subjects are, or at any point in time, earning income for the family
- The supplementary income of the family is also clubbed into the family income

Limitations of the Study

The present piece of research has certain limitations, which the authors feel free to share:

- Hesitance and misinformation were also prevalent among villagers. People were skeptical about giving information. However, care was taken to ensure the participation of highly discreet individuals by structuring discussions and soliciting the opinions of these members.

Study Area

Sarguja is a coastal district situated on the northern side of Chhattisgarh. It lies between 23 degrees 37 minutes 25 seconds and 2 degrees 6 minutes 17 seconds north latitude and 81 degrees 3 minutes 0 seconds and 8 degrees minutes 0 seconds east longitude. The district area is 15,732 square kilometers (9795 square miles). It is one of the areas with a very rich biodiversity of flora and fauna in Chhattisgarh. It is divided into eight tehsils Or Administrative Blocks, namely Ambikapur, Lundra, Batauli, Sitapur, Mainpat, Udaipur, and Lakhanpur. There are three river basins in the Sarguja district – of the Hasdeo River, the Rihand River, and the Kanhar River. In winters temperature dips to below 5 °C (41 °F), and in summers, it rises above 46 °C (115 °F). The soil of the Sarguja district can be classified into four main categories: red and yellow soils, alluvial soils, laterite soils, and medium green soils. Tribal people make up the majority of the population. These primitive tribes include the Pando and Korwa, who continue to live in the forest. The Pando tribe considers themselves to be a member of the Mahabharata's "Pandav" clan. The Korwa tribes consider themselves to be "Kauravs" from the Mahabharata.

5. Trends in population

5.1 Total no. of the population of the universe

The universe consists of a combined population of 10632, Total households being 2659 and no of villages being 127 in the tribal areas of Sarguja, Chhattisgarh, their houses are scattered, and they are mostly dependent on the forest produce for their livelihood. The combined total Hill Korwa population of the 12 villages is 1997, out of which the male population is 992, and the female population is 1005. The sex ratio of the total universe is 1013, a little higher than the national sex ratio, i.e., 940, as per the 2011 census.

Villages	Development Block	Total No. of Households	Hill Korwa Total Population	Male Population	Female Population	No of Subjects
Ganjadhad=1	Lundra	35	121	58	63	8
Govindpur=2	Batauli	95	399	202	197	6
Govindpur=3	Batauli	76	273	138	135	7
Jamhariya=4	Sitapur	24	99	51	48	7
Alga=5	Lakhanpur	50	172	80	92	5
Losangi=6	Lakhanpur	27	43	20	23	8
Lalmati=7	Lundra	80	280	141	139	5
Pahadchiranga=8	Batauli	42	146	79	67	8
Kantiprakashpur=9	Ambikapur	29	110	53	57	11
Bendopani-beldagi=10	Lakhanpur	14	45	25	20	8
Kunia-musakhol=11	Mainpat	26	114	46	68	10
Maltipur=12	Mainpat	44	195	99	96	5
Total		88	1997	992	1005	88



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Level OF Education

The level of education is the primary indicator of the development of a society. The Literacy level of respondents is found to be acutely low; however, the increase of local primary schools and residential schools has contributed a lot to educate the rising young generation. The Education level among the young generation is found to be higher as compared to the older generations.

The result showed that out of the total samples, only 50% population is literate. Only 29.5 %of them have completed their primary school, followed by 25% of respondents who have passed Middle school. 0% of the respondent has managed to do their graduation. This shows that the area's literacy rate is very low and miserable.

Villages	Primary	Middle school	High school	Higher secondry	Graduate	Illiterate	
Ganjadhad=1	3	0	0	0	0	4	7
Govindpur=2	1	0	1	2	0	2	6
Ramnagar=3	2	2	0	0	0	3	7
Jamjhariya=4	2	1	1	0	0	3	7
Alga=5	2	0	0	0	0	3	5
Losangi=6	1	1	0	0	0	6	8
Lalmati=7	2	1	0	0	0	2	5
Pahadchiranga=8	3	1	0	1	0	3	8
Kantiprakashpur=9	2	0	1	0	0	9	11
Bendopani-beldagi=10	3	1	0	0	0	4	8
Kunia-musakhol=11	3	1	1	0	0	5	10
Maltipur=12	2	3	0	0	0	0	5
	26	11	4	3	0	44	88


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Monthly Income

The Income reflects the standard of living of the tribals. Rural households receive income from a variety of sources, including agriculture, livestock, wage labour, and other non-farming pursuits. The economic study suggests that most of the villagers earn an income of up to Rs. 3000 per month or Rs. 36000 a year, which is lower than the national rural income of Rs. 5000 per month as determined by the socio-economic caste census. The primary occupation is agriculture and manual labour. The daily mean income of a house hold stood Rs. 10.

Villages	0-999	1000-1999	2000-2999	3000-3999	3999-4999	5000>	total
Ganjadhad=1	3	1	3	0	1	0	
Govindpur=2	1	1	1	0	1	2	
Ramnagar=3	2	1	3	1	0	0	
Jamjhariya=4	1	0	2	3	1	0	
Alga=5	0	2	2	1	0	0	
Losangi=6	2	1	3	2	0	1	
Lalmati=7	1	1	3	1	0	0	
Pahadchiranga=8	1	1	2	1	1	1	
Kantiprakashpur=9	4	1	3	2	0	0	
Bendopani-beldagi=10	2	2	2	2	0	0	
Kunia-musakhol=11	2	2	3	1	1	1	
Maltipur=12	1	0	3	1	0	0	
Total	20	13	30	15	5	5	88

Type of occupation

Hill Korwa is primarily engaged in the primary sector. People are mainly employed in multiple jobs. Agriculture is the largest employer, and farming labor comes in handy; some people also go out of the village in search of employment

Villages	Farming / Labour	Minor Forest produce	Self-employed	Animal Husbandry	Govt Employee	Govt Pension
Ganjadhad=1	7	7	0	6	0	1
Govindpur=2	4	4	0	4	2	0
Ramnagar=3	3	5	0	3	0	2
Jamjhariya=4	6	6	0	5	0	1
Alga=5	5	5	0	3	0	0
Losangi=6	6	6	0	6	0	2
Lalmati=7	5	5	0	5	0	0

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Pahadchiranga=8	5	5	0	4	1	1
Kantiprakashpur=9	9	9	0	6	0	2
Bendopani-beldagi=10	7	7	0	4	0	1
Kunia-musakhol=11	6	6	0	6	1	3
Maltipur=12	5	5	0	5	0	0
Total	68	70	0	57	4	13

Agriculture

Primitive subsistence farming is a type of agriculture that is based on simple tools and methods that are often used by a single family or small group. This type of farming is often done in areas with poor soil and limited water resources. Primitive subsistence farming is still prevalent among the tribals. It is still practiced among the patches of tribals using primitive tools such as hoes, digging sticks, and community labor. This farming method is heavily dependent upon the monsoon, soil fertility of soil and suitability of the environment. It is also affected by the soil type in the area as well as the environmental conditions. It is observed that Hill Korwa completely relies on primitive subsistence farming. The technical advancements in the agricultural sector are known to them, but it is not accessible to them due to the high cost and remoteness of the settlement. Agricultural produce is dominated by Rice. Most people who do not own any agricultural land prefer to work in relatives' fields in order to earn a share out of the agricultural produce. Corn and Arhar Gram are other popular crops that are Preferred by the Hill Korwa. Corn and its remnants are used as animal fodder. Few households also prefer selling corn produce, but only in select urban shops, not government stores.

Collection of minor Forest Produce

The collection of forest produce in rural areas sale of firewood, mahua fruits, tendu leaf, and bamboo to the traders is an important source of income for the Hill Korwa People. This activity provides them with the much-needed financial support to meet their basic needs. The forest produces collection employs all age groups, including old people, children, and women. It acts as a stable income source for them. The sale of timber by rural people is a common practice in many Villages. In some cases, timber is the only source of income for Tribals. In other cases, rural people may sell timber to supplement their income. However, it is highly unorganized, and tribals complain about not getting adequate work remuneration. They tend to sell the minor forest produce in the local market to private individuals and local businesses.

Positive Effect Of MNREGA

The MGNREGA has had a positive impact on the lives of tribals in India. The act has helped to reduce poverty and improve the standard of living of tribals. It has also created employment opportunities for tribals and helped them to become financially independent. The MGNREGA has also helped to improve the infrastructure in rural areas. However, there are some limitations of this policy in this area. These are:-

1. Lack of awareness: Many people are not aware of the scheme and its benefits. This is one of the main reasons for its failure.
2. Lack of skilled workers: The scheme has failed to provide skilled workers. This has led to a decline in the quality of work.
3. Lack of transparency: The scheme has been marred by allegations of corruption and lack of transparency. Delay in the discharge of wages discourages the tribals from opting for MGNREGA scheme.
4. Limited coverage: The scheme has only been able to benefit a limited number of people. Hill-Korwa Tribals Tend to live in remote areas of Forests and hills, where it becomes difficult for local bodies to administer employment to these tribals.
5. Low Wage rate: The scheme is limited by in adequacy of wages provided by the administration. It is observed that even though the wage is provided accurately, the days of employment are less than the days it guarantees
6. Administrative Inefficiencies: such as limitations of Bank transfer, Lack of accurate data

Animal Husbandry

The findings show Animal Husbandry is one of the major activities of the tribals; it engages over 61.36% of the tribals.

Migration

Almost a meager 9% of households migrate to urban areas. Usually, tribals like to sell forest produce for their consumption; therefore, people rarely migrate to other places for their livelihood. The tribals don't want to leave their community. They like to be united with *jal*, *jungle*, and *jameen* in their own area. People choose to live in their own community and practice their traditional occupations rather than move to urban areas for better opportunities.

Conclusion

The study addresses many issues directly related to the socio-economic status of the tribal community of the Surguja district, such as their social institutions, literacy rate, and sources of income. According to the current study, the majority of tribal people are still illiterate and impoverished. It was discovered that food habits were nearly identical in all villages. The effects of planned

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developmental intervention in the tribal communities from 1951 to 2022, a period of 20 years of intervention, did not significantly improve the conditions of the communities. The results show there is barely any change in their primitive habits.

The impact of COVID-19 on the livelihoods of tribals has been significant. Other findings in the research show there is barely any case of infection of covid 19 from the tribals; the separation and remoteness have kept them far from the health impact of covid. But it has added to the problems of hill Korwa tribals economically. This has led to a decline in their overall standard of living. Many tribals have also lost their jobs as a result of the pandemic, further exacerbating the situation. (Kujur, COVID-19 Pandemic and Particularly Vulnerable Tribal Group Hill Korwa of Chhattisgarh: A Pilot Study, 2022)

The traditional beliefs of the Hill Korwa significantly impact the health and lifestyle of the Hill Korwa. The traditional ethos are determined by their surroundings, community, knowledge, beliefs, faith, and ideals. These ideas also determine their livelihood, occupation, transport, migration, and economic patterns. It is necessary to understand their cultural and traditional values which will help in the better sustainable development of this tribe (Kujur).

Fundings and Acknowledgements

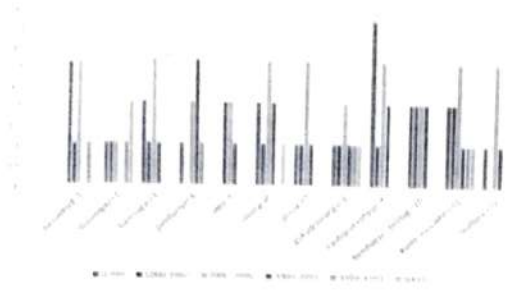
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
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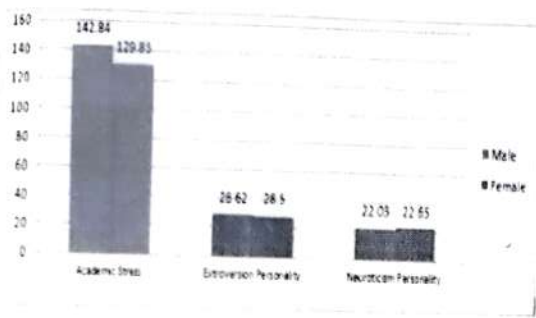

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तालिका 1
सकल घरेलू उत्पाद तथा विकास दर

वर्ष	सकल घरेलू उत्पाद	GDP विकास दर %
2011-12		6.7
2012-13		5.46
2013-14		6.39
2014-15		7.41
2015-16		8.0
2016-17		8.17
2017-18		7.12
2018-19		6.10
2019-20		4.78
2020-21*		3.1

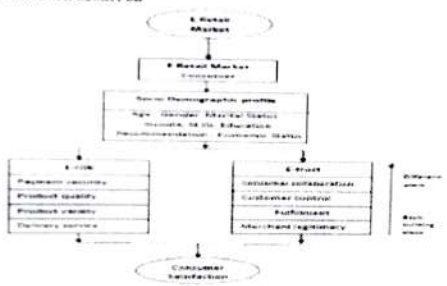
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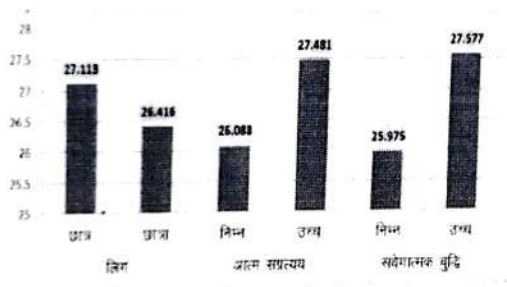


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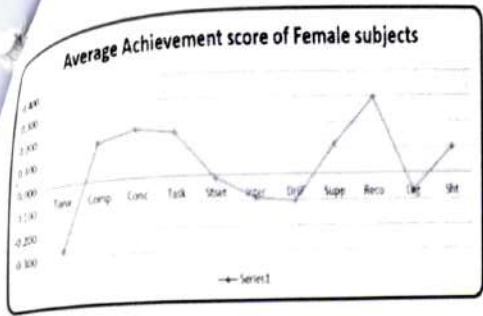
A Portrayal of Nationalism in Rabindranath Tagore's Gora
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A Portrayal of Nationalism in Rabindranath Tagore's Gora
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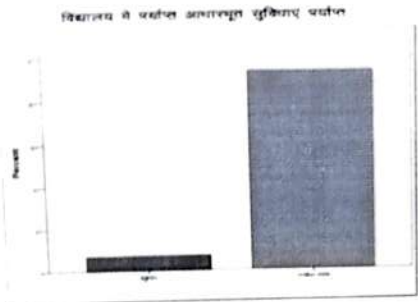
Corresponding Author: meghasinghravipr@gmail.com

Abstract: India witnessed a great many changes in the nineteenth and twentieth century. It first underwent secularization and transformation witnessing social, economic and political changes, religious disintegration, class and conflict in the race, and also rising nationalism to subvert colonialism. Rabindranath Tagore, an eminent writer of great many novels wrote Gora in 1907 during this period, which India had undergone. Gora is Gora portrays Gora as the central character of rising nationalism who voices his concern for the freedom of India from the clutches of British, a revolutionary making effort to transform India and also a sense of self-discovery in the end. Tagore's concern for India is transparently depicted in the book.

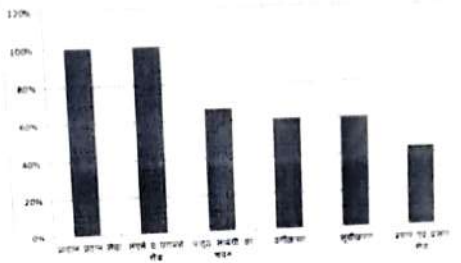
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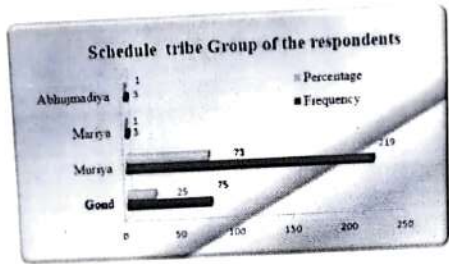
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 विशेष पिछड़ी जनजाति बौद्धों में शिक्षा की समस्या का एक अध्ययन: छत्तीसगढ़ राज्य के कबीरधाम जिले के विशेष संदर्भ में
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बैगा जनजाति के प्रमुख तीज त्यौहार एवं बदलते प्रतिमान का एक नृजातीय अध्ययन | (कबीरधाम एवं मुंगेली जिला के विशेष संदर्भ में)

डॉ. रश्मि कुजूर¹ | डॉ संजय कुमार सिंह² | डॉ. एन. कुजूर³ | चम्पा साहू⁴

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- 2 सहायक प्राध्यापक शास.प.श्यामाचरण शुक्ल महाविद्यालय धरसीवा रायपुर, छत्तीसगढ़.
- 3 प्राध्यापक एवं विभागाध्यक्ष समाजशास्त्र एवं समाजकार्य अध्ययन शाला प.रविशंकर शुक्ल वि.वि. रायपुर (छ.ग.)
- 4 शोधार्थी समाजशास्त्र एवं समाज कार्य अध्ययन शाला प.रविशंकर शुक्ल विध्वविद्यालय रायपुर, छत्तीसगढ़.

ABSTRACT:

प्रस्तुत शोध अध्ययन छत्तीसगढ़ राज्य के विशेष पिछड़ी जनजाति बैगा के प्रमुख तीज-त्यौहार एवं बदलते प्रतिमान का एक नृजातीय अध्ययन पर आधारित है। जिसके अंतर्गत बैगा जनजाति की प्रमुख पारंपरिक सांस्कृतिक तीज-त्यौहारों का अध्ययन कर उसमें होने वाले वर्तमान परिवर्तन को भी दर्शाया गया है। प्रस्तुत अध्ययन कबीरधाम एवं मुंगेली जिले के बोडला एवं लोरमी विकासखण्ड के बैगा निवासित गाँव बोदलपानी, सोनवाही, टिगीपुर, एवं सुहीगाँव के अध्ययन पर आधारित है। अध्ययन में तथ्य संकलन हेतु प्राथमिक एवं द्वितीयक तथ्यों का संकलन किया गया है प्राथमिक तथ्य संकलन हेतु साक्षात्कार निर्देशिका, डायरी, समूह वार्ता तथा द्वितीयक तथ्यों के संकलन हेतु विभिन्न पूर्व में किये गये शोध पत्र-पत्रिकाएँ, पुस्तक एवं इंटरनेट का उपयोग किया गया है। शोध अध्ययन से प्राप्त जानकारी के अनुसार बैगा जनजाति विभिन्न सांस्कृतिक तीज-त्यौहारों जैसे, बिदरी, छेता, फाग, छाया दरना, नवाखाई (धान नवाखाई, मक्का नवाखाई, भाजी नवाखाई) आठ साल नौ कार्तिक आदि पारंपरिक पर्वों का आयोजन करते हैं, जिसमें कुछ आंशिक परिवर्तन भी दिखाई दे रहा है जो इनके जीवन में विशेष महत्त्व रखते हैं।

KEYWORDS:

बैगा जनजाति, प्रमुख सांस्कृतिक तीज-त्यौहार एवं परिवर्तन।

प्रस्तावना:-

Kaufmann, W. (1941). Folk-Songs of the Gond and Baiga. The Musical Quarterly 1 में बैगा जनजाति को मध्य भारत की जनजाति बताया है जिसका निवास स्थान सतपुड़ा पर्वत के पूर्वी छोर मैकाल श्रेणी है बैगा जनजाति देश के मुल निवासी है जो आक्रमणकारियों के भय के कारण पहाड़ों एवं जंगलों में शरण ले लिया। वर्तमान में बैगा जनजाति अपनी सभी प्राचीन आदतों को बरकरार रखते हुए हिन्दू धर्म को अपना लिया है लेकिन अपनी प्राचीन रीति-रिवाजों को संरक्षित रखे हुए है। वर्तमान में बैगा जनजाति भारत देश के विभिन्न राज्यों मध्य प्रदेश, बिहार, झारखण्ड, पश्चिम बंगाल, एवं छत्तीसगढ़ में निवास करते हैं, जो एक अत्यंत पिछड़ी एवं विलुप्तप्राय जनजाति है। एल्विन 2 ने अपने अध्ययन में बताया कि छत्तीसगढ़ में बैगा जनजाति सबसे पहले छोटा नागपुर के रास्ते से प्रवेश किया जो वर्तमान में छत्तीसगढ़ राज्य के विभिन्न जिलों कबीरधाम, मुंगेली, बिलासपुर, गौरिलारपेंडामारवाही, राजनादगाँव, कोरिया, आदि क्षेत्रों में निवास करती है। बैगा आधुनिकता से दूर दुर्गम स्थानों जंगलों पहाड़ों में निवास करती है जो संस्कृति रूप से समृद्ध मानी जाती है जिनकी जीवन शैली संस्कार, कला, परम्परा एवं तीज-त्यौहारों, नीति नियम आदि अलग विशिष्ट होते हैं। जो बैगा जनजाति को एक अलग पहचान दिलाती है। प्रत्येक समाज का अपना एक सांस्कृतिक पक्ष होता है जिसके द्वारा हम किसी भी समाज को बेहतर ढंग से समझ सकते हैं, और इन्ही सांस्कृतिक पक्षों का एक विशिष्ट अंग होता है तीज-त्यौहार। सांस्कृतिक पक्ष किसी भी समाज की प्रतिबिम्ब को दर्शाता है। बैगा जनजाति की संस्कृति परम्परागत एवं प्राचीन है जो बैगा जनजाति को एक विशिष्ट पहचान दिलाती है, वर्तमान में हम अपनी प्राचीन परम्पराओं एवं संस्कारों में आधुनिकता को समाहित करते जा रहे हैं वैसे ही बैगा जनजाति के लोग आज भी अपनी परम्परा एवं प्राचीनता को बनाये हुए आधुनिक एवं हिन्दू परम्पराओं को आंशिक मात्रा में सम्मिलित करते जा रहे हैं। चौरसिया (2009)³ बैगा जनजाति को प्राकृतिक पुत्र कहा है क्योंकि बैगा जनजाति प्राकृतिक के बहुत करीब होते हैं तथा पृथ्वी को अपनी माँ कहते हैं, और पृथ्वी पर हल नहीं चलाते हैं। क्योंकि इनकी मान्यता है की हम अपनी माँ के सीने पर हल नहीं चलाते हैं, इसके साथ ही बैगा जनजाति प्राकृतिक औषधियों जड़ी-बूटियों के बारे में अधिक जानकारी रखते हैं। बैगा जनजाति के लोग अपने स्वास्थ्य से सम्बंधित समस्याओं का उपचार जड़ी-बूटियों एवं झाड़-फुसक से करते हैं।

शोध अध्ययनों की समीक्षा - जैसा की हमें ज्ञात है की बैगा जनजाति देश की एक अत्यंत पिछड़ी जनजाति है, इनका रहन-सहन, स्वास्थ्य, शिक्षा पेयजल की समस्या, सामाजिक-आर्थिक स्थिति, परम्परागत चिकित्सकीय ज्ञान ने कई शोधार्थियों का ध्यान अपनी ओर आकर्षित किया है जिसमें मानवशास्त्री, समाजशास्त्री, अर्थशास्त्री एवं मनोवैज्ञानिक के द्वारा शोध अध्ययन किये हैं प्रस्तुत शोध अध्ययन में पूर्व में किये गये शोध साहित्यों का पुनरावलोकन करने का प्रयास किया गया है जो निम्न है-

भागवत डी. (1957)⁴ ने द करमा में करमा अनुष्ठान, नृत्य, गीत के साथ करमा नृत्य के विभिन्न रूपों का वर्णन किया है जिसमें इन्होंने करमा को गोंड संस्कृति का स्वदेशी हिस्सा नहीं माना है बल्कि कोलारियान या मुंडा संस्कृति का उत्पाद माना है। इन्होंने अपने अध्ययन में स्पष्ट किया है की बैगा, मझवार और सावर वे लोग है जो मुख्य रूप से करमा का अभ्यास करते है और बाकि जनजातियों ने उनकी नकल की है, इसके साथ ही यह भी कहा है की करमा नृत्य केवल बिलासपुर कि जनजातियों द्वारा मनाया जाता है जिसे पूर्वी अनुष्ठानों के साथ मिला दिया गया है। यह नृत्य पुरे प्रान्त एवं हिन्दुओं में बहुत ही लोगप्रिय है जिसे गोलाकार प्रदर्शन की तकनीक के आकार में भिन्न-भिन्न चरण में प्रदर्शन करते हैं।

भागवत डी. (1968)⁵ ने जनजाति त्यौहार का उल्लेख करते हुए कहा की जनजातियाँ त्यौहारों के लिए उतने ही शौकीन है जितनी हम है फिर भी वे हमसे कहीं अधिक बेहतर त्यौहारों के बारे में जानते हैं कि उनका आनंद कैसे लेना है। जनजातियों में त्यौहार के अवसरों पर मदिरा अपरिहार्य है। वहां रात भर नाच-गाना चलता रहता है और स्त्री-पुरुष व्यवहार प्रायः असमित रहता है जहाँ इनके त्यौहारों का हिस्सा अश्लील झगारे और अश्लील गाने भी होते हैं। इनके कई अनुष्ठानों और रीति-रिवाजों जैसे विवाह, अत्येष्टि संस्कारों, फसल उत्सव फाग और सुअर बलि आदि में ऐसे औपचारिक दुरुपयोग अपरिहार्य है। इसके साथ ही साथ जनजाति अपने समारोहों एवं त्यौहार में अपने कुल देवी-देवताओं को रक्त और शराव अर्पित करते है, सभी जनजाति अपने इष्ट देवताओं को सुअर, बकरे, मुर्गा आदि चढ़ाते है।

1. रसेल हीरालाल (1936)⁶ मध्य प्रदेश की जनजाति का सबसे पहली बार चार खंडों में क्रमबद्ध विवरण प्रकाशित "कस्टम एंड ट्राइब्स इन सेन्ट्रल प्रोविसेज पुस्तक में किया।
2. एल्विन (1939)⁷ ने "द बैगा" में बैगा जनजाति को मिडिसीन में कहा है। उन्होंने बैगा जनजाति के वंश गोत्र समूह उत्पत्ति एवं सम्पूर्ण जीवन शैली का गहन अध्ययन कर बताया की बैगा जनजाति जो है छत्तीसगढ़ में सबसे पहले छोटा नागपुर के रास्ते से प्रवेश किया था जो वर्तमान में छत्तीसगढ़ राज्य के विभिन्न जिलों कबीरधाम, बिलासपुर, राजनादगाँव, कोरिया, मुंगेली आदि क्षेत्रों में निवास

करती है

- कोठारी सी.आर.रिसेर्च मेथेडोलोजी (2004)⁸ न्यू एज इंटरनेशनल पब्लिकेशन न्यू दिल्ली शोध अध्ययन को सुगम बनाने के लिए शोध से सम्बंधित विभिन्न आयाम एवं विषय से सम्बंधित महत्वपूर्ण जानकारी प्राप्त किया गया है।
- अली सी.ए. (2011)⁹ ने FESTIVAL AS A SOURCE FOR RECONSTRUCTING TRIBAL ETHNOHISTORY: "THE NILAMBUR PAATTU में केरल के मलपुम जिले की नीलाम्बुर जनजाति जो नीलाम्बुर पश्चिमी घाटी में निवास करती है के द्वारा मनाये जाने वाले प्रसिद्ध त्यौहार नीलाम्बुर पाट्टू के अध्ययन के आधार पर स्पष्ट किया की स्थानीय त्यौहार को केवल मनोरंजन और पूजा का साधन न मानकर इसका उपयोग किसी क्षेत्र एवं उसके लोगों के जातीय इतिहास का पता लगाने के स्रोत में किया जा सकता है इन्होंने बताया की नीलाम्बुर पाट्टू त्यौहार नीलाम्बुर जनजाति की संस्कृति और परम्पराओं के कुछ पहलुओं को उजागर करने में सहायक है।
- गुमा पारुल एवं डेविड अल्का (2017)¹⁰ के शोध अध्ययन से बैगा जनजाति के पर्व -त्योहारों के महत्व एवं उनमें होने वाले परिवर्तन के बारे में प्राप्त हुई है।
- कुमार गजेन्द्र (2020)¹¹ का बैगा जनजाति के सामाजिक सांस्कृतिक और आर्थिक अध्ययन से बैगा जनजाति की परम्पराओं, सामाजिक व्यवस्था, शिक्षा की स्तर, औषधि ज्ञान आदि की जानकारी प्राप्त होती है

अध्ययन का उद्देश्य :-

- बैगा जनजाति की सामाजिक एवं सांस्कृतिक स्थिति का अध्ययन करना।
- बैगा जनजाति के प्रमुख तीज-त्योहारों का अध्ययन करना।
- बैगा जनजाति के तीज-त्यौहार एवं बदलते प्रतिमान का अध्ययन करना

शोध पद्धति एवं उतरदाताओं का चयन | छत्तीसगढ़ राज्य में वर्तमान में कुल 33 जिलों हैं, इनमें से 06 जिलों कबीरधाम, बिलासपुर, कोरिया, राजनांदगांव मुंगेली एवं गौरिला पेंड्रा मारवाही में बैगा जनजाति निवास करती है। बैगा जनजाति निवासरत जिलों में से दो जिले कबीरधाम एवं मुंगेली का चयन उद्देश्य पूर्ण निदर्शन के माध्यम से किया गया है। चयनित जिलों में कुल 07 विकासखण्ड है इसमें बोडला, पंडरिया, कबीरधाम, सहस-लोहार, मुंगेली, लोरमी तथा पथरिया प्रमुख है इसमें से 2 विकास खण्ड का उद्देश्यपूर्ण निदर्शन के द्वारा चयन किया गया है इनमें कबीरधाम से बोडला और मुंगेली जिला से लोरमी विकासखण्ड का चुनाव किया गया है। बोडला विकासखण्ड में कुल 182 गाँव और लोरमी विकासखण्ड में कुल 41 गाँव है जिसमें से दो गाँवों का चयन दूरी को आधार मानकर उद्देश्य पूर्ण निदर्शन के माध्यम से किया गया है। जिसमें दो गाँवों की दूरी विकासखण्ड मुख्यालय से 20-30 किलोमीटर तक एवं दो गाँवों की दूरी 30-50 किलोमीटर की दूरी तक लिया जाएगा। चयनित गाँवों में कुल 379 परिवार है जिसमें से अध्ययन हेतु Krejcie and Morgan सूची का प्रयोग करते हुए अधिकतम 265 परिवारों का चयन किया जायेगा एवं उतरदाताओं का चयन दैवनिदर्शन की लॉटरी प्रणाली से किया जाएगा। चयनित परिवार के मुखिया को अध्ययन इकाई के रूप में लिया जायेगा।

उतरदाताओं का चयन विवरण निम्नानुसार है-

क्रमांक	जिले का नाम	विकासखण्ड का नाम	वि.ख.से गाँव की दुरी	ग्राम का नाम	कुल परिवार की संख्या	चयनित परिवार की संख्या 70 प्रतिशत
1.	कबीरधाम	बोडला	20-30 कि.मी. तक	बोदलपानी	88	62
			30-50 कि.मी. तक	सोनवाही	124	86
2.	मुंगेली	लोरमी	20-30 कि.मी. तक	टिगीपुर	74	52
			30-50 कि.मी. तक	सुरही	93	65
योग	02	02		04	379	265

तथ्यों का संकलन एवं उपकरण :- तथ्यों के संकलन हेतु प्राथमिक एवं द्वितीयक तथ्यों का प्रयोग किया गया है। प्राथमिक तथ्य संकलन हेतु साक्षात्कार, निर्देशिका, डायरी का उपकरण के रूप में प्रयोग किया गया है, इसके साथ ही समूहवार्ता, अवलोकन पद्धति का भी प्रयोग हुआ है। द्वितीयक तथ्यों के संकलन हेतु विभिन्न शोध अध्ययन, पत्र-पत्रिका, शोध आलेख, शासन द्वारा प्रसारित सूचनाओं, इंटरनेट आदि का प्रयोग किया गया है।

बैगा जनजाति की सामाजिक सांस्कृतिक अध्ययन :- बैगा का अर्थ ओझा या शमन होता है, बैगा जनजाति के लोग झाड़-फुंक और अंध विश्वास जैसी परम्पराओं में अधिक विश्वास करते हैं। बैगा जनजाति दुर्गम क्षेत्रों पहाड़ों जंगलों में प्राकृतिक के करीब निवास करते हैं, जो सामान्यतः सावले रंग, माध्यम कद और गठिला शारीरिक बनावट के होते हैं, इनकी उत्पत्ति से सम्बंधित कोई विशेष प्रमाणिक साक्ष्य उपलब्ध नहीं है। बैगा जनजाति के लोग परम्परागत रूप से संयुक्त परिवार में रहना पसंद करते हैं, लेकिन वर्तमान में सरकारी योजनाओं के लाभ से वंचित होने के डर से स्वयं को एकाकी परिवार बताते हैं परन्तु वास्तविक रूप में वे वर्तमान समय में भी ज्यादातर संयुक्त परिवार में ही रहते हैं एक परिवार में करीब 8-10 सदस्य होते हैं जिसमें औसतन एक परिवार में 3-4 बच्चे होते हैं। बैगा जनजातियों में गाँव के मुखिया को मुक्कदम, दीवान या समरथ कहा जाता है, जो अनुभववी और वृद्ध व्यक्ति होते हैं। इनकी स्थिति समाज में ऊच्च होते हैं जिनका सभी लोग सम्मान

करते हैं। गाँव में किसी भी प्रकार के सामाजिक, पारिवारिक विवादों का निपटारा मुक्कदम द्वारा किया जाता है। बैगा जनजाति के परम्परागत मकान का स्वरूप कच्चा होता है जो प्रायः लकड़ी, बांस घास और मिट्टी के बने होते हैं, वर्तमान में आधुनिकता के कारण या सरकारी योजनाओं के कारण कुछ लोगों की मकान का स्वरूप पक्के भी देखने को मिलता है। बैगा जनजाति की व्यवसाय मुख्य रूप से झूम खेती एवं शिकार करना है, इसके साथ-साथ बनोपाज संग्रह, पशुपालन तथा ओझा का कार्य करते हैं। बैगा जनजाति की प्रमुख भाषा बैगानी है, भाषा की दृष्टि से बैगाओ, में एकरूपता नहीं पाई जाती है, अनेक भाषा समूह से सम्बंधित होने के कारण बैगा जनजाति के लोगों द्वारा अपनी मूल भाषा बैगनी के साथ-साथ छत्तीसगढ़ी, बघेली, गोडबानी, मराठी आदि भाषाओं का भी प्रयोग करते हैं, बैगा जनजाति द्रविड़ भाषायी परिवार में आते हैं।

बैगा जनजाति सामाजिक रूप से अत्यंत पिछड़ी जनजाति मानी जाती है, लेकिन सांस्कृतिक रूप से इन्हें समृद्ध मन जाता है। बैगा जनजाति की संस्कृति बहुत ही प्राचीन एवं परम्परागत है जो इन्हें एक विशेष पहचान दिलाती है, बैगा जनजाति एक गोदना प्रिय जनजाति है जो श्रृंगार के तौर पर बैगा महिलाएँ अपने शरीर पर गोदना बनवाते हैं गोदना को लेकर इनकी मान्यता होती है यदि हम जीते जी अपने जीवन में गोदना न गोदवाये तो मरने के बाद भगवान सबल से गोदना गोदते हैं बैगा जनजाति द्वारा विभिन्न अवसरों जन्म, विवाह, उत्सव आदि में नृत्य करते हैं। बैगा जनजाति द्वारा की जाने वाली प्रमुख नृत्यों में करमा नृत्य,

पहाड़ी, करमा झुलनी, करमा लहकी) बिल्मा आदि है, बिल्मा नृत्य बैगा जनजाति के युवा-युवतियों द्वारा टोली बनाकर दशहरे के दिन से प्रारंभ करते हैं जिसे 02-03 माह तक किया जाता है।

बैगा जनजाति त्यौहार :-

Bhagvat, D. (1968). Tribal Gods and Festivals in Central India. *Asian Folklore Studies*.¹⁰ में जनजाति त्यौहार का उल्लेख करते हुए कहा की जनजातियां त्यौहारों के लिए उतने ही शौकीन है जितनी हम है फिर भी वे हमसे कहीं अधिक बेहतर त्यौहारों के बारे में जानते हैं कि उनका आनंद कैसे लेना है। जनजातियों में त्यौहार के अवसरों पर मदिरा अपरिहार्य है। जहां रात भर नाच-गाना चलता रहता है और स्त्री-पुरुष व्यवहार प्रायः असमित रहता है जहां इनके त्यौहारों का हिस्सा अश्लील इशारे और अश्लील गाने भी होते हैं। इनके कई अनुष्ठानों और रीति-रिवाजों जैसे विवाह, अत्येष्टि संस्कारों, फसल उत्सव फाग और सुअर बलि आदि में ऐसे औपचारिक दुरुपयोग अपरिहार्य है। इसके साथ ही साथ जनजाति अपने समारोहों एवं त्यौहार में अपने कुल देवी-देवताओं को रक्त और शराब अर्पित करते हैं, सभी जनजाति अपने इष्ट देवताओं को सुअर, बकरे, मुर्गी आदि चढ़ाते हैं।

बैगा जनजाति के प्रमुख त्यौहार:-

1) आठ साल नौ कार्तिक या रसनवा:- बैगा जनजाति में यह त्यौहार आठ साल में एक बार मनाया जाता है। आठ कुवार गुजरने के बाद नौवे कार्तिक माह में मोहती की पौधा उगने की खुशी में यह पर्व मनाया जाता है, इनकी मान्यता है की मोहती का पौधा आठ साल में एक बार उगता है। इस त्यौहार को मनाने के लिए इस दिन जंगल से मोहती डाल को काटकर लाया जाता है और इसे आँगन में गाड़ा कर छोटे-छोटे 3-4 कमरे बनाते हैं, जिससे विशेष पूजा की जाती है। और साथ में बांस भी काट कर लाते हैं जिसका बर्तन बनाते हैं और उसी बर्तन में कुटगी को मधुरस के साथ मिला कर खीर बनाते हैं जिसे मोहती पत्ते के बने दोने से रखते हैं जिसका पूजा करते हैं। पूजा करने के बाद इस खीर को केवल कुंवारी-कुंवारा युवा युवती खाते हैं, तथा इस पूजा में नौव लड़के लड़की की आवश्यकता होती है लेकिन बने खीर जिसे केनवा कहा जाता है, को सभी अविवाहित लोग खाते हैं।

2) जवारा पर्व :- जवारा पर्व को बैगा जनजाति में देवी पर्व के रूप में मनाया जाता है। इस त्यौहार या पर्व को चैत से जेठ माह तक और कुवार माह में मनाया जाता है, इस पर्व में खैर माई की पूजा की जाती है प्रारम्भ में नई टोकनी या खप्पर में गेहूँ के बीज को बोये जाते हैं जिसे जवारा बोना कहते हैं। जवारा जो है खैर माई के पूजा स्थल के साथ-साथ, अपने-अपने निजी घरों में भी बोये जाते हैं, नवे दिन नाचते-गाते नाकड़ा डोल जुलुस के साथ जवारे को नदी में विसर्जन करते हैं। उसके बाद देवी-देवताओं को बकरा, काली मुर्गी, नारियल आदि की बलि देते हैं, और बलि स्वरूप दी गई बकरा, मुर्गी आदि को आपस में बाटकर खाते हैं।

3) छाया धरना :- हिन्दू धर्म में पितृ मोक्ष के लिए पितृ विसर्जन का त्यौहार मनाया जाता है वैसे ही बैगा जनजाति में भी साल में एक बार अपने पितरों का स्मरण किया जाता है। यह त्यौहार बैगा जनजाति द्वारा जेठ माह के शुक्ल पक्ष के सोमवार, बुधवार और शुक्रवार को मनाया जाता है इस दिन बैगाओं के देवी-देवताओं के लिए विशेष दिन होता है। सभी समान गोत्र के बैगा परिवार एक-एक मुर्गी इकट्ठे करते हैं और उसे अपने पूर्वजों को बलि के रूप में अर्पित करते हैं जिसे उसी गोत्र के लोग आपस में बाटकर खाते हैं।

4) बिदरी :- यह त्यौहार अक्की (अक्षय तृतीया) के दिन मनाया जाता है इस पर्व में बीज बोने से पहले अच्छी फसल की कामना से बीजों की पूजा की जाती है जिसे बिदरी कहा जाता है, इस दिन अच्छी फसल के कामना के साथ इनके फसलों को कोई भी पशु-पक्षी नष्ट न करे इस कामना से बिदरी पर्व का आयोजन करते हैं बीज बोने से पहले प्रत्येक घर में जो मुखिया होता है वह महलॉन के पते से बने दोने में बोये जाने वाले बीज को ठाकुर देव के स्थान पर लेकर जाते हैं। जिसका देवार (पुजारी) पूजा करता है पूजा स्थान पर सभी लोग अपने द्वारा लेकर गए अनाज/बीज को इकट्ठा करते हैं उसके बाद ठाकुर देव में मुर्गी की बली दी जाती है और उसी मुर्गी के खून को अनाज/बीज में मिला दिया जाता है उसके बाद खून से सनी बिज को सभी बैगा कृषक को दिया जाता है जो घर आने के बाद उसमें बोये जाने वाले बीजों को और मिला देते हैं। इस त्यौहार में महिलाये भाग नहीं लेती है।

5) होली :- यह पर्व हिन्दू धर्म के अमरुप सावन अमावस्या के दिन बैगा जनजाति द्वारा मनाया जाता है इस दिन घर की लीपा-पोती की जाती है तथा घर का मुखिया या बुजुर्ग

व्यक्ति सबेरे उठकर जंगल से भीलवा की डाल, जोगी लटी, हसिया डाफर तथा भवर माल की डालिया को काटकर लाते हैं नहाने के बाद सभी को मिलाकर छोटे-छोटे डंडल घर के दरवाजे और जानवर रखने के स्थान, खेत आदि में डाल को खोसता है तथा नेक भी लेता है। यह त्यौहार अच्छी भरपूर फसल के लिए होती है, बैगा जनजाति द्वारा इस दिन अच्छा भोजन तेल रोटी, बाजरा बनाते हैं तथा खेत में ले जा कर अपने खेति डोली से सम्बंधित देवी देवताओं की अच्छी फसल की कामना से पुजा आराधना करते हैं।

6) नवाखाई / नवफसल :- नवाखानी फसल कटाई का पर्व है, बैगा जनजाति के लोगों द्वारा अपने देवी-देवताओं की कृत्यज्ञता के लिए इस पर्व को मनाते हैं। बैगा जनजाति में मान्यता है की वे नई फसल का भोग पहले अपने देवी-देवताओं और पितरों को लगाते हैं। उसके बाद ही नई फसल का उपभोग करते हैं, यह पर्व खरीफ (स्थली फसल) में मनाई जाती है। नवाखाई पर्व मनाने के एक दिन पहले घर का बुजुर्ग व्यक्ति अपने सभी देवी-देवताओं एवं पूर्वजों को नवा खाने का निमंत्रण देते हैं, तथा उनके स्वागत के नाम पर ककड़ी फूल या तिराई (तोरई) फूल आदि को तोड़कर डेहनी एवं चौका (पूजा करने का स्थान) में रखते हैं। इस दिन बने भोजन में नया अनाज मिलाकर बनाते हैं। इस दिन घर में आटे का चौक पुरकर दिया अगरबत्ती कर बने भोजन का देवताओं एवं पूर्वजों को अर्पित करते हैं। बैगा जनजाति द्वारा नवाखाई त्यौहार को मक्का नवाखाई, रवास नवाखाई, भाजी नवाखाई, कांग नवाखाई (कोदो, कुटकी, सावा) आदि विभिन्न स्वरूपों में मनाया जाता है।

7) दशहरा :- बैगा जनजाति द्वारा दशहरा का त्यौहार हिन्दू धर्म के अनुरूप कुवार शुक्ल दशमी को मनाया जाता है। दशहरा पर्व को बैगाओं का नृत्य आरम्भ करने का पर्व कहा जाता है हिन्दू दशहरा का दिन तिथि समान है लेकिन इनका आपस में कोई संबंध नहीं होता है। दशहरा पर्व के रूप में बैगा जनजाति अपनी रक्षा की देवी खैर माता की नारियल अगरबत्ती एवं धुप से पुजा आराधना करने के बाद रमतिला का फुल अर्पित करते हैं जिसे फुल चढ़ाना कहा जाता है इस दिन के बाद से बैगा जनजाति में कर्मा नृत्य प्रारम्भ होता है तथा इसी दिन से बैगा समुदाय के लोग कोठार बनाना प्रारंभ करते हैं खैर माता से फसल की सुरक्षा की आशीर्वाद लेकर।

8) देवारी :- बैगा जनजाति की परम्परागत पर्व नहीं है, बल्कि यह हिन्दू समाज के देखा-देखि मनाने वाला पर्व है। इस दिन बैगा समुदाय के लोग मिट्टी या चावल आटे का दीया बनाते हैं चावल आटे के बने दिया को भाप में पकाते हैं तथा उसमें तेल या घी डाल कर प्रज्वलित कर अपने देवी-देवताओं के सामने रखते हैं एवं आटे से बने दीया को खाया जाता है। इसी दिन बैगा जनजाति के लोग बच्चे की अच्छी स्वास्थ्य की कामना से घी के दिए से बच्चों के पेट को डाभा जाता है। तथा दिवाली के दिन बैगा जनजाति अपने पालतू पशु गाय एवं बैलो को कुम्हड़ा भात या खिचड़ी भात खिलाते हैं, शाम को जंगल से लौटी गाय एवं बैलो का मुंह धुलाते हैं, उसके बाद गायों को कुम्हड़ा भात नई सुपा में खिलते हैं, यदि गाय-बैलो की संख्या अधिक होती है तो खाट में केला पान बिछा कर खिलाया जाता है और रात में परिवार के सभी लोग दाल-भात खाते हैं।

9) छेरता :- यह पर्व बैगा जनजाति द्वारा भी पौष पूर्णिमा के दिन मनाया जाता है जो विशेष रूप से बच्चों का पर्व है। परन्तु इस त्यौहार को मनाने के तौर तरीके बैगा समुदाय में अलग है पौष पूर्णिमा के दो-तीन दिन पहले से बैगा जनजाति के बच्चे घर-घर जा कर अनाज, नमक, मिर्ची आदि खाद्य सामग्री का मांग करते हैं जिसे छेरता कहते हैं। छेरता से प्राप्त सभी सामग्री को नदी किनारे झिरिया किनारे या घर के बहार बाड़ी में जा कर पकाते हैं, और वही से खाना पीना करके वापस घर लौट आते हैं। वर्तमान में बैगा बच्चों द्वारा छेरता से प्राप्त अनाज को कुछ मात्रा में दुकानों में बेचा जाता है और जरूरत की समान खरीदा जाता है।

10) फाग :- होली पर्व को बैगा जनजाति फाग पर्व के रूप में फागुन पूर्णिमा के दिन मनाते हैं। पूर्णिमा के दो-चार दिन पहले जंगल से लकड़ी काट कर लाते हैं और गाँव के बहार स्थान पर गाड़ा जाता है लकड़ी गाड़ने से पहले गाड़ने में मुर्गी का अंडा, अगुली का छल्ला तांबे का और पैसा डाला जाता है उसके बाद रात भर गाड़े गए लकड़ी के चारों-ओर फाग गीत गाकर नाचते हैं और मदिरा का सेवन करते हैं उसके बाद सुबह चार बजे पूर्णिमा की रात अंतिम पहर में गाँव का मुखिया होली दहन करता है। होली के दिन एक छोटा बैल गाड़ी बनाया जाता जिसमें लाल, काला और सफ़ेद रंग का ध्वजा लगाया जाता है तथा गाँव के पटेल द्वारा पूजा-पाठ इस उद्देश्य से किया जाता है गाँव एवं घरों में जो भी बीमारी है वह दूर हो जाये और गाँव में ऐसी बीमारी फिर न आये इसी उद्देश्य बैलगाड़ी और एक जीवित मुर्गी गाँव से बहार सूर्य उदय से पहले पूर्व दिशा में छोड़ा जाता है और पांच मुर्गी की बलि दिया जाता है। होली का प्रारंभ होली दहन की राख को एक दुसरे को लगा कर करते हैं। बैगा जनजाति

करती है

- कोठारी सी.आर.रिसेच मेयेडोलोजी (2004)⁸ न्यू एज इंटरनेशनल पब्लिकेशन न्यू दिल्ली शोध अध्ययन को सुगम बनाने के लिए शोध से सम्बंधित विभिन्न आयाम एवं विषय से सम्बंधित महत्वपूर्ण जानकारी प्राप्त किया गया है।
- अली सी.ए. (2011)⁹ ने FESTIVAL AS A SOURCE FOR RECONSTRUCTING TRIBAL ETHNOHISTORY: "THE NILAMBUR PAATTU में केरल के मलपुम जिले की नीलाम्बुर जनजाति जो नीलाम्बुर पश्चिमी घाटी में निवास करती है के द्वारा मनाये जाने वाले प्रसिद्ध त्यौहार नीलाम्बुर पाट्टू के अध्ययन के आधार पर स्पष्ट किया की स्थानीय त्यौहार को केवल मनोरंजन और पुजा का साधन न मानकर इसका उपयोग किसी क्षेत्र एवं उसके लोगों के जातीय इतिहास का पता लगाने के स्रोत में किया जा सकता है इन्होंने बताया की नीलाम्बुर पाट्टू त्यौहार नीलाम्बुर जनजाति की संस्कृति और परम्पराओं के कुछ पहलुओं को उजागर करने में सहायक है।
- गुप्ता पारुल एवं डेविड अल्का (2017)¹⁰ के शोध अध्ययन से बैगा जनजाति के पर्व -त्योहारों के महत्व एवं उनमें होने वाले परिवर्तन के बारे में प्राप्त हुई है।
- कुमार गजेन्द्र (2020)¹¹ का बैगा जनजाति के सामाजिक सांस्कृतिक और आर्थिक अध्ययन से बैगा जनजाति की परम्पराओं, सामाजिक व्यवस्था, शिक्षा की स्तर, औषधि ज्ञान आदि की जानकारी प्राप्त होती है

अध्ययन का उद्देश्य :-

- बैगा जनजाति की सामाजिक एवं सांस्कृतिक स्थिति का अध्ययन करना।
- बैगा जनजाति के प्रमुख तीज-त्योहारों का अध्ययन करना।
- बैगा जनजाति के तीज-त्योहार एवं बदलते प्रतिमान का अध्ययन करना

शोध पद्धति एवं उतरदाताओं का चयन। छत्तीसगढ़ राज्य में वर्तमान में कुल 33 जिलों हैं, इनमें से 06 जिलों कबीरधाम, बिलासपुर, कोरिया, राजनांदगांव मुंगेली एवं गौरिला पेंड्रा मारवाही में बैगा जनजाति निवास करती है। बैगा जनजाति निवासरत जिलों में से दो जिले कबीरधाम एवं मुंगेली का चयन उद्देश्य पूर्ण निदर्शन के माध्यम से किया गया है। चयनित जिलों में कुल 07 विकासखण्ड है इसमें बोडला, पंडरिया, कबीरधाम, सहस-लोहरा, मुंगेली, लोरमी तथा पथरिया प्रमुख है इसमें से 2 विकास खण्ड का उद्देश्यपूर्ण निदर्शन के द्वारा चयन किया गया है इनमें कबीरधाम से बोडला और मुंगेली जिला से लोरमी विकासखण्ड का चुनाव किया गया है। बोडला विकासखंड में कुल 182 गाँव और लोरमी विकासखंड में कुल 41 गाँव है जिसमें से दो गाँवों का चयन दूरी को आधार मानकर उद्देश्य पूर्ण निदर्शन के माध्यम से किया गया है। जिसमें दो गाँवों की दूरी विकासखंड मुख्यालय से 20-30 किलोमीटर तक एवं दो गाँवों की दूरी 30-50 किलोमीटर की दूरी तक लिया जाएगा। चयनित गाँवों में कुल 379 परिवार है जिसमें से अध्ययन हेतु Krejcie and Morgan सूची का प्रयोग करते हुए अधिकतम 265 परिवारों का चयन किया जायेगा एवं उतरदाताओं का चयन दैनिकनिदर्शन की लांटीरी प्रणाली से किया जाएगा। चयनित परिवार के मुखिया को अध्ययन इकाई के रूप में लिया जायेगा।

उतरदाताओं का चयन विवरण निम्नानुसार है-

क्रमांक	जिले का नाम	विकासखंड का नाम	वि.ख.से गाँव की दूरी	ग्राम का नाम	कुल परिवार की संख्या	चयनित परिवार की संख्या 70 प्रतिशत
1.	कबीरधाम	बोडला	20-30 कि.मी. तक	बोदलपानी	88	62
			30-50 कि.मी. तक	सोनवाही	124	86
2.	मुंगेली	लोरमी	20-30 कि.मी. तक	टिगीपुर	74	52
			30-50 कि.मी. तक	सुरही	93	65
योग	02	02		04	379	265

तथ्यों का संकलन एवं उपकरण :- तथ्यों के संकलन हेतु प्राथमिक एवं द्वितीयक तथ्यों का प्रयोग किया गया है। प्राथमिक तथ्य संकलन हेतु साक्षात्कार निर्देशिका, डायरी का उपकरण के रूप में प्रयोग किया गया है, इसके साथ ही समूहवार्ता, अवलोकन पद्धति का भी प्रयोग हुआ है। द्वितीयक तथ्यों के संकलन हेतु विभिन्न शोध अध्ययन, पत्र-पत्रिका, शोध आलेख, शासन द्वारा प्रसारित सूचनाओं, इंटरनेट आदि का प्रयोग किया गया है।

बैगा जनजाति की सामाजिक सांस्कृतिक अध्ययन :- बैगा का अर्थ ओझा या शमन होता है, बैगा जनजाति के लोग झाड़-फुक और अंध विश्वास जैसी परम्पराओं में अधिक विश्वास करते हैं। बैगा जनजाति दुर्गम क्षेत्रों पहाड़ों जंगलों में प्राकृतिक के करीब निवास करते हैं, जो सामान्यतः सावले रंग, मध्यम कद और गठिला शारीरिक बनावट के होते हैं, इनकी उत्पत्ति से सम्बंधित कोई विशेष प्रमाणिक साक्ष्य उपलब्ध नहीं है। बैगा जनजाति के लोग परम्परागत रूप से संयुक्त परिवार में रहना पसंद करते हैं, लेकिन वर्तमान में सरकारी योजनाओं के लाभ से वंचित होने के डर से स्वयं को एकाकी परिवार बताते हैं परन्तु वास्तविक रूप में वे वर्तमान समय में भी ज्यादातर संयुक्त परिवार में ही रहते हैं एक परिवार में करीब 8-10 सदस्य होते हैं जिसमें औसतन एक परिवार में 3-4 बच्चे होते हैं। बैगा जनजातियों में गाँव के मुखिया को मुक्कदम, दीवान या समर्थ कहा जाता है, जो अनुभवी और वृद्ध व्यक्ति होते हैं। इनकी स्थिति समाज में ऊच्च होते हैं जिनका सभी लोग सम्मान

करते हैं। गाँव में किसी भी प्रकार के सामाजिक, पारिवारिक विवादों का निपटारा मुक्कदम द्वारा किया जाता है। बैगा जनजाति के परम्परागत मकान का स्वरूप कच्चा होता है जो प्रायः लकड़ी, बांस घास और मिट्टी के बने होते हैं, वर्तमान में आधुनिकता के कारण या सरकारी योजनाओं के कारण कुछ लोगों की मकान का स्वरूप पक्के भी देखने को मिलता है। बैगा जनजाति की व्यवसाय मुख्य रूप से झूम खेती एवं शिकार करना है, इसके साथ-साथ वनोपाज संग्रह, पशुपालन तथा ओझा का कार्य करते हैं। बैगा जनजाति की प्रमुख भाषा बैगानी है, भाषा की दृष्टि से बैगाओ, में एकरूपता नहीं पाई जाती है, अनेक भाषा समूह से सम्बंधित होने के कारण बैगा जनजाति के लोगों द्वारा अपनी मूल भाषा बैगानी के साथ-साथ छत्तीसगढ़ी, बघेली, गोडवानी, मराठी आदि भाषाओं का भी प्रयोग करते हैं, बैगा जनजाति द्रविड़ भाषायी परिवार में आते हैं।

बैगा जनजाति सामाजिक रूप से अत्यंत पिछड़ी जनजाति मानी जाती है, लेकिन सांस्कृतिक रूप से इन्हें समृद्ध मन जाता है। बैगा जनजाति की संस्कृति बहुत ही प्राचीन एवं परम्परागत है जो इन्हें एक विशेष पहचान दिलाती है, बैगा जनजाति एक गोदना प्रिय जनजाति है जो श्रृंगार के तौर पर बैगा महिलाएँ अपने शरीर पर गोदना बनवाते हैं गोदना को लेकर इनकी मान्यता होती है यदि हम जीते जी अपने जीवन में गोदना न गोदवाये तो मरने क बाद भगवान सबल से गोदना गोदते हैं बैगा जनजाति द्वारा विभिन्न अवसरों जन्म, विवाह, उत्सव आदि में नृत्य करते हैं। बैगा जनजाति द्वारा की जाने वाली प्रमुख नृत्यों में करमा नृत्य,

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भारतीय शिक्षा शोध पत्रिका

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बी.एड. प्रशिक्षण महाविद्यालयों में अध्ययनरत पुरुष एवं महिला प्रशिक्षार्थियों के मध्य संवेगात्मक परिपक्वता का एक तुलनात्मक अध्ययन

* प्रीति सिंह

सारांश

प्रस्तुत अध्ययन में बी.एड. प्रशिक्षण महाविद्यालयों में अध्ययनरत पुरुष बी.एड. प्रशिक्षार्थी एवं महिला बी.एड. प्रशिक्षार्थी के मध्य संवेगात्मक परिपक्वता का तुलनात्मक अध्ययन किया गया है। संवेगात्मक परिपक्वता से तात्पर्य अपनी और दूसरों की भावनाओं को समझने और प्रबंधित करने की क्षमता से है। संवेगात्मक परिपक्वता का अर्थ है संतुलित व्यक्तित्व। एक शिक्षक का संवेगात्मक रूप से परिपक्व होना आवश्यक है। अध्ययन का उद्देश्य बी.एड. प्रशिक्षण महाविद्यालयों में अध्ययनरत पुरुष बी.एड. प्रशिक्षार्थी एवं महिला बी.एड. प्रशिक्षार्थी के मध्य संवेगात्मक परिपक्वता, एवं संवेगात्मक परिपक्वता के विभिन्न आयाम सांवेगिक स्थिरता, सांवेगिक प्रगति, सामाजिक समायोजन, व्यक्तित्व एकीकरण, और अनाश्रित को ज्ञात करना है। अध्ययन हेतु रायपुर जिले में स्थित बी.एड. प्रशिक्षण महाविद्यालयों में अध्ययनरत 30 पुरुष बी.एड. प्रशिक्षार्थी एवं 30 महिला बी.एड. प्रशिक्षार्थी का चयन संभाव्य न्यायदर्श से किया गया है। प्रदत्तों के संकलन हेतु डॉ. यशवीर सिंह एवं डॉ. महेश भार्गव द्वारा निर्मित संवेगात्मक परिपक्वता मापनी का प्रयोग किया गया है। प्रदत्तों का सांख्यिकीय विश्लेषण करने पर परिणाम प्राप्त हुआ कि पुरुष बी.एड. प्रशिक्षार्थी एवं महिला बी.एड. प्रशिक्षार्थी के मध्य संवेगात्मक परिपक्वता में सार्थक अंतर नहीं है। इसी प्रकार पुरुष बी.एड. प्रशिक्षार्थी एवं महिला बी.एड. प्रशिक्षार्थी के मध्य संवेगात्मक परिपक्वता के विभिन्न आयाम सांवेगिक स्थिरता, सांवेगिक प्रगति, सामाजिक समायोजन, व्यक्तित्व एकीकरण, अनाश्रित में भी सार्थक अंतर नहीं पाया गया है।

प्रस्तावना

संवेग आंतरिक भावों का बाह्य प्रकाशन है। भावों का तीव्र होना ही वास्तव में संवेग है। संवेग मानव जीवन के लिए महत्वपूर्ण है। संवेग व्यक्ति को समुचित विचार किए बिना कार्य करने को उत्तेजित करते हैं तथा उस उत्तेजना में व्यक्ति प्रशंसनीय एवं निंदनीय दोनों ही प्रकार के कार्य करता है। व्यक्ति अपने जीवन में समय-समय पर अनेक भावों का अनुभव करता है जैसे भय, क्रोध, प्रेम, घृणा, हर्ष, क्षोभ, दया, कामुकता आदि। संवेग के उदय होने पर व्यक्ति में आंतरिक शक्ति का संचार होता है तथा वह ऐसे कार्य को भी कर दिखाता है जो सामान्य परिस्थिति में संभव नहीं होता है। बालक में जन्म से ही कुछ न कुछ संवेग होते हैं। शैशवावस्था से संवेगात्मक विकास प्रारंभ हो जाता है जो कि प्रौढ़ावस्था तक चलता रहता है। संवेगात्मक विकास प्रौढ़ावस्था आरंभ होने तक पूर्ण हो चुका होता है। इस समय तक संवेगात्मक परिपक्वता आ जाती है। यह वह समय होता है जब व्यक्ति अपने संवेगों पर नियन्त्रण रखना सीख जाता है एवं अपने निर्णय विवेक के आधार पर लेना प्रारंभ कर देता है। समय, स्थान व अवसर को ध्यान में रखते हुए व्यक्ति उचित ढंग से संवेगों की अभिव्यक्ति करता है। इसे ही संवेगात्मक परिपक्वता कहा जाता है। इस प्रकार जो व्यक्ति अपने संवेगों पर उचित अंकुश रखते हुए उन्हें भली-भांति अभिव्यक्त कर सके उसे संवेगात्मक रूप से परिपक्व कहा जा सकता है।

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संबंधित शोध अध्ययन

सुखारायण एवं विश्वनाथन (2011) ने कॉलेज के छात्रों की संवेगात्मक परिपक्वता पर एक अध्ययन करके निष्कर्ष निकाला कि कॉलेज के छात्रों की संवेगात्मक परिपक्वता बेहद अस्थिर होती है। लिंग, समुदाय और परिवार के प्रकार का कॉलेज के छात्रों की संवेगात्मक परिपक्वता में कोई भूमिका नहीं है। कॉलेज के छात्र जो अलग-अलग धर्मों के हैं, उनके संवेगात्मक परिपक्वता में महत्वपूर्ण अंतर है। सिंह, कौर एवं दुरेजा (2012) ने विश्वविद्यालय के छात्रों के बीच संवेगात्मक परिपक्वता का अध्ययन करके निष्कर्ष ज्ञात किया कि पुरुष खिलाड़ियों और महिला खिलाड़ियों के बीच भावनात्मक अस्थिरता, भावात्मक प्रतिगमन, सामाजिक कुसमायोजन, व्यक्तित्व विघटन, स्वतंत्रता की कमी, और संवेगात्मक परिपक्वता के संबंध में महत्वपूर्ण अंतर है। नुजहत (2013) ने भारत के कश्मीर विश्वविद्यालय में पुरुष और महिला दूरस्थ शिक्षार्थियों की संवेगात्मक परिपक्वता का तुलनात्मक अध्ययन करके बताया कि विश्वविद्यालय के पुरुष दूरस्थ शिक्षार्थियों एवं महिला दूरस्थ शिक्षार्थियों के संवेगात्मक परिपक्वता में कोई खास अंतर नहीं है एवं महिला दूरस्थ शिक्षार्थियों में पुरुष दूरस्थ शिक्षार्थियों की तुलना में संवेगात्मक अस्थिरता होती है। रानी एवं कुमारी (2014) ने डी.एड. विद्यार्थियों की संवेगात्मक परिपक्वता का उनके समायोजन के संबंध में एक



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Skill test battery in Kho-Kho for women

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Abstract

The purpose of the study was to develop test for assessment of skill ability of women Kho-Kho players. Kho-Kho playing ability demands speed, agility, coordination, balances and flexibility. The test items constructed were administered to 60 female Kho-Kho players, age range between 17 to 25 years. Factor analysis was employed to analyze the data. Two factors were identified offensive skill test with five items and defensive skill test with three items. The test constructed will help the coaches, trainer and teachers for selection, of the players, to monitor performance to predict the performance and for other purposes.

Keywords: Kho-Kho, indigenous sports and women players

Introduction

Skill test is a tool which can be used to assess performance of a player and provides unbiased and validated evaluation. Skill test assess a player in variety of positions and situations which actually occurs during play. This kind of tests which assess skill outcomes in games and sports are used by coaches and researchers, to estimate player's ability and also for talent identification. Sports specific technical skill test is important to differentiate among the players of different caliber and also useful in predicting performance [1].

Kho-Kho is one of the popular traditional sports in India. The origin of Kho-Kho is difficult to trace, but many historians believe, that it is a modified form of 'Run Chase', which in its simplest form involves chasing and touching a person [2]. KhoKho is a traditional Indian sport that dates back to ancient India and is believed to have been mentioned in the Mahabharata, an epic that narrates the war between two sets of royal cousins [3].

With its origins in Maharashtra, Kho-Kho in ancient times, was played on 'raths' or chariots, in premorden times and was known as RATHERA [2, 3]. The present form of the game, played by individuals on foot, was invented in 1914 by Pune's Deccan Gymkhana club [2]. Kho-Kho is a tag game where one team tries to chase and touch the members of the other team while the other team tries to avoid being touched [4, 5, 6].

Like other indigenous games, Kho-Kho is simple, inexpensive and enjoyable and game of high alertness. The game demands high level of physical fitness specifically speed, agility and endurance, dodging and feinting along with mental toughness. Kho Kho is widely played across South Asia and also has a presence in some regions outside South Asia, such as South Africa and England [4]. It is a competitive game and has been demonstrated at the 1936 Berlin Olympics and the 1982 Asian Games [5]. It is also a medal sport in the South Asian Games [2]. The first league of its kind called Ultimate Kho-Kho was launched in India in August 2021 [1]. Kho-Kho has been recognized by the International Kho-Kho Federation (IKF) and is played at the national and international levels [3, 4]. In India, the Kho-Kho Federation of India (KKFI) governs the sport and organizes national championships and selection trials for international competitions [5, 6, 7].

Assessing sports-specific technical skills plays a vital role in classifying players, selecting individuals for teams, and designing effective training programs [7, 8, 9]. The evaluation of these skills provides insights into an athlete's unique abilities and their capacity to perform in specific positions. Consequently, researchers continuously strive to develop comprehensive tests that accurately assess performance across a wide range of sports and games [10, 11, 12]. Skill test in Kho-Kho for different age and gender have developed. Test items were also developed for female players in Kho-Kho and other indigenous sports like Kabaddi [14, 15, 16].

Objective of study

The objective of the study was to develop instrument to measure performance in Kho-Kho.

Selection of subject

For the purpose of the study 60 female Kho-Kho players age group from 18 to 25 years were selected.

Selected test item

For present study of 12 skill test were developed, items were as follows- Ball touch Kho, Tapping, Covering, Fast attack Kho, Shuttle Run, Reaction Time, Pole Turn, Squat Sit, Cone zigzag run, Fast attack run, Ring game, Dozing & Running

In preparing test battery to measure playing ability of Kho-Kho the principal axis factor (PAF) with a varimax of (orthogonal) rotation of 12 items was conducted on data obtained. The tests were conducted and data was collected on 60 Kho-Kho female players age between 18-25 years. The data was analyzed and initial results showed that the variables under study co-related with each other which indicates that the variables measures similar underlying attribute that is playing ability in Kho-Kho, further the results showed that the co-relation was neither too high or too low, which qualifies the data for factor analysis.

An examination of Kaiser-Meyer-Olkin measure of sampling adequacy on selected skill item suggested that the sample was factorable (KMO=.654). In the next stage of factor analysis test one explains 37.61% of total variance.

Table 1: Communalities before and after extraction

Variables	Initial Values	Extraction Values
Cone Zig-Zag Run	1	.367
Pole Turn	1	.583
Ball Touch Kho	1	.692
Tapping	1	.518
Squat Sit	1	.312*
Shuttle Run	1	.236*
Doze Run	1	.573
Reaction Time	1	.132*
Covering	1	.546
Fast Attack Kho	1	.528
Ring Game	1	.152*
Fast Attack Run	1	.555

*standard value taken .35 factor loading level (Stevens field, 2000)

The communalities before and after extraction is shown in table 1. 4 Principal component analysis is based on initial assumption that all variance is common hence before extraction communalities are one for all. The extraction value shows that 37.617% variance is common or shared, the values in extraction can be explained in terms of proportion of variance by underlying factors.

Table:2 explains that two factors have been extracted. The rotated components matrix gives same information as component matrix. When loading less than 0.35 were excluded the analysis yielded two-factor solution with a simple structure (factor loading \Rightarrow .35).

Two factors with Eigen values greater than one have been extracted (3.009) here factor one explains 37.617% variance, whereas factor two explains 20.224% (1.069) variance, after rotation we can observe the eigenvalues are presented in the table. Rotation has the effect of optimizing the factor structure and relative importance of the two

factors is equalized, after extraction it accounts for 32.58% (2.607) and 25.054% (2.004).

Table 2: Principal axis factor (PAF) with a varimax of (orthogonal) rotation matrix of 12 items

Variables	Factor 1	Factor 2
Cone Zig-Zag Run		.367
Pole Turn	.583	
Ball Touch Kho		.692
Tapping	.518	
Squat Sit	.312	
Shuttle Run	.236	
Doze Run		.573
Reaction Time	.132	
Covering	.546	
Fast Attack Kho	.528	
Ring Game	.152	
Fast Attack Run	.555	
Eigenvalues	3.009	1.602
Percentage of total variance	32.588	25.054
Number of test measures	05	03

The two-factor skill test

Five Test items loaded into factor 1 It is clear from table 1 that these 5 tests all related to attacking skill of the players where the player's ability to give Kho, touch the defensive player, attack the player by covering the allowed area, ability to attack with high speed and to use the pole effectively to turn and touch the defensive player (Items Ball touch kho, Tapping, Covering, Fast attack kho, Pole turn respectively). This factor was labeled as Offensive Skill Test.

Three test items

(Cone zigzag Run, Fast attack Run, and Dozing & Running) load on to second factor related to the ability of players to stay in field for longer duration and running away from the chasers during the game, the ability to change the running path with in the field, speed and ability to give dodge to chaser and run. This factor was labeled as Defensive Skill Test.

Table 3: Two factor classification of tests.

Offensive Skill Test		Defensive Skill Test,	
Pole Turn	.583	Cone Zig-Zag Run	.367
Tapping	.518	Ball Touch Kho	.692
Covering	.546	Doze Run	.573
Fast Attack Kho	.528		
Fast Attack Run	.555		
Eigenvalues	3.009		1.602
Percentage of total variance	32.588		25.054
Number of test measures	05		03

Skill Test: The detailed description the tests are given below

A: Offensive Skill Tests

Ball touch Kho

Objective of the test is to measure, ability to give correct Kho with speed.

Tools: Stop watch, measuring tap, Lime, whistle, 8 balls, marked Kho-Kho court.

Administration Process: 8 balls are placed in each square box of all the blocks. On command the player start running

from starting point at pole, the player touches the first ball and calls Kho loudly. When the player touches the ball it moves from its place and the player sits in the place of the ball, player repeat the action with with all the next seven balls. A particular player is given 2 trials.

Score: Best time in seconds out of two trials.

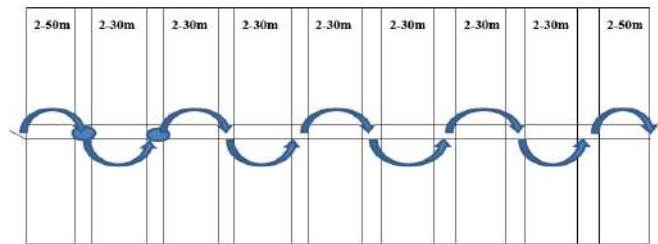


Fig 1: Ball Touch Kho: Measurements

Tapping

Objective: Objective of the test is to measure capacity to deaccelerate with coordination, body balances, flexibility and reaction time.

Tools: Stop watch, measuring tap, Lime, whistle, 4 cone.

Ground: Kho-Kho court, 23.50 meter & 4meter, pole to first block 2.50 meter, 2nd block to 7th block 2.30 meter, and 8th to 2nd pole 2.50 meter distance, and square box 3*3 c.m.

Administration Process

4 cone are placed in between first & eight sitting blocks alternatively, from the starting point at pole. On command go the player starts running from one side of the starting line, he has to touch all the four cone one by one during the running, while checking the speed, controlling the body and lunging forward with maximum flexibility after reaching the pole the players turns back from opposite side and repeats the same and complete the test. Two trials are given.

Score: Time in second of best out of two trial is the score.

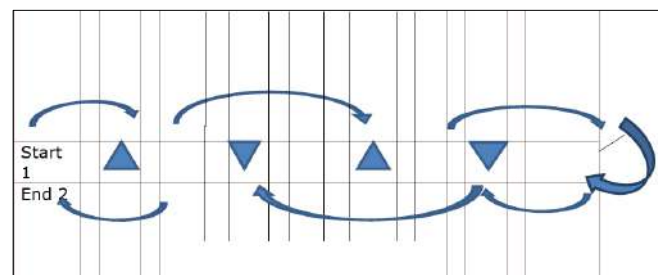


Fig 2: Drawing Showing Ground Position

Covering: Covering Skill Test

Objective: Objective of the test ability of player to attack when the defender is trying dodge with out changing direction.

Tools: Stop watch, measuring tap, Lime, whistle.

Administration Process: For the test the player who is tested sits in block three, other player assist by sitting in block five, the player assist by touching the first player and pounces Kho. On listening Kho first player move three steps forward (assuming chaser is 3 meter at right side) and move speedily right side to sit in box no 5. Two trials are given, best is recorded.

Measurement: Time in seconds taken to complete the work.

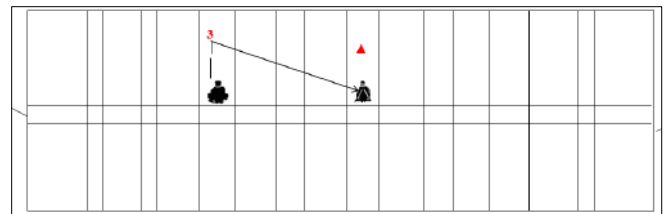


Fig 3: Drawing Showing Ground Position

Fast attack Kho

Objective: Objective of the test to measure ability of player to attack with speed. To measure the immediate given Kho with speed in game condition.

Tools: Stop watch, measuring tap, Lime, whistle, ect.

Administration Process: On command the player starts sprinting from starting line at pole, the player runs with maximum speed and sit in 3rd box and again, from sitting position again sprints and sit in box no 6, then sprints to pole 2 and repeat the same and finishes at the end point. Two trials are given and best is recorded.

Measurement: Time in second taken to complete the work.

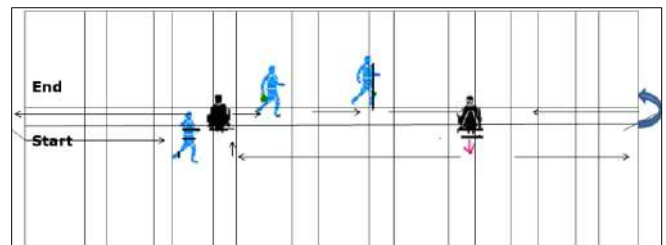


Fig 4: Drawing Showing Ground Position

Pole Turn

Objective: Objective of the test is to test the ability to use the pole effectively to attack.

Tools: Stop watch, measuring tap, Lime, whistle.

Administration Process: A player standing in pole runs and gives Kho to the player sitting on box the sitting player after getting the call Kho runs fast to reach the pole no 1 and hold the pole and turs the body to attack the defender time is noted for the whole action, that is running from the sitting position to turning the body around the pole. Two trials are given and best time is recorded.

Measurement: Time in seconds taken to complete the work.

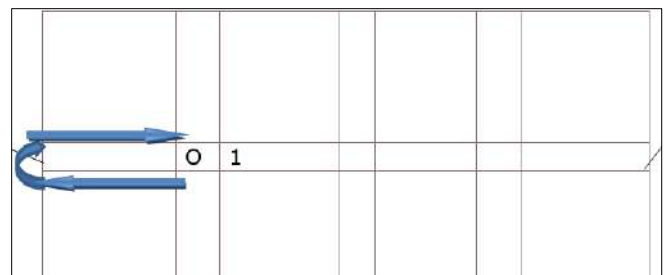


Fig 5: Drawing Showing Ground Position

B: Defensive Skill Tests

1) Cone zigzag run: Cone Zig-Zag Running (Single Chain)

Objective: Objective of the test is measure agility, coordination, alertness and reaction ability, during defensive play.

Tools: Stop watch, measuring tap, Lime, whistle, 8 cone and marked standard Kho-Kho court.

Administration Process: Eight cones are placed in all the sitting box. On command go player starts running from the left side from starting point in the center crosses the cone then runs from right side and reaches to cone two same pattern is repeated in all the cones, and the player return to starting point in the same manner. Two trials are given and best is recorded.

Measurement: Time in second taken to complete the work.

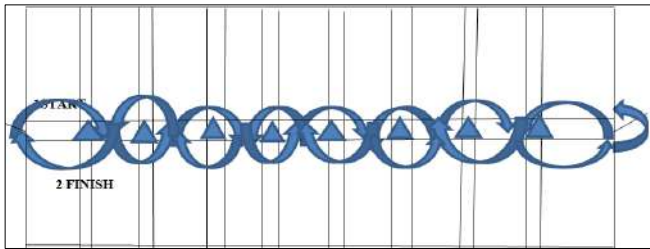


Fig 6: Drawing Showing Ground Position

2) Fast attack run

Objective: Objective of the test is measure ability controlled sprint which is important for offence as well as defense.

Tools: Stop watch, measuring tap, Lime, whistle

Administration Process: Player starts sprinting on command go from starting point at pole one, after reaching second pole holds the pole and take turn at pole and sprints back to pole one to complete the test. Two trials are given and best is recorded.

Measurement: Time in second taken to complete the work.

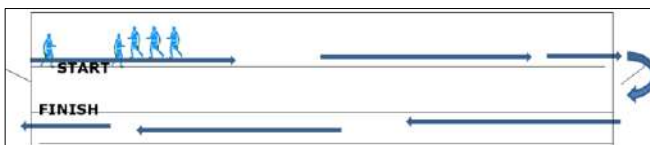


Fig 7: Drawing Showing Ground Position

3) Dozing & Running: skill Test:

Objective: Objective of the test were develop to Dozing Running skill test. A player how much control over running speed, with proper coordination of body balances with flexibility and effectively react with game condition.

Tools: Stop watch, measuring tap, Lime, whistle, 5 cone ect.

Ground: The ground measurements are 30 feet in length & 12 feet in width. At the center point (A) of the 12 feet line, 5 cones are placed at six feet distance each covering thirty feet in length.

Administration Process: On command go player starts side running from point A to B (6 feet) then turns face and again move side running to point C (30 feet) changes face complete side running to point A, then does zigzag running across the cones (5 cones at 6 feet distance total (30 feet) comes back to point A repeats the same other side (A to D and D to E finishes the test E to A side running) and finishes the test at point A. Two trials are given and best is recorded.

Score: Time in seconds taken to complete the work.

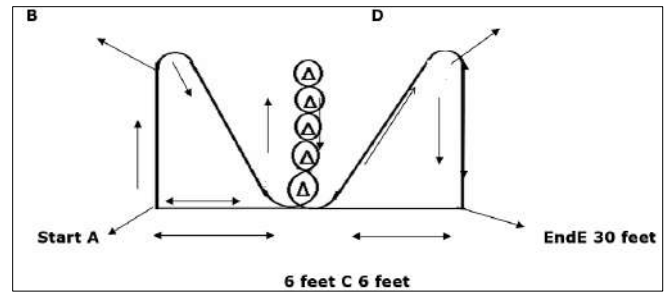


Fig 8: Drawing Showing Ground Position

Conclusion

Offensive Skill Test	Defensive Skill Test.
Pole Turn	Cone Zig-Zag Run
Tapping	Ball Touch Kho
Covering	Doze Run
Fast Attack Kho	
Fast Attack Run	

In conclusion, the assessment of sports-specific technical skills is a critical element in player classification, selection, and training program planning. The development of robust assessment tests in Kho-Kho which includes five offensive and three defensive skill tests will empower decision-makers to identify talented players, optimize team composition, and design targeted training regimes. By incorporating skill assessments into sports management practices, organizations can improve player development and ultimately achieve higher levels of success. The test battery developed and validated, can be used for the evaluation of players.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Anthropometric Indicators Among Adolescent Female Players After Soy Supplement in Chhattisgarh India

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ABSTRACT

Adolescence is a transitional phase from childhood to adulthood. It is a period of development as the gain of anthropometric measurements is increased over this period. India is a country with different tribal groups and Bastar district is a tribal belt of Chhattisgarh state in India. The nutritional status is a major concern among adolescent girls, which affects growth and development and forms basis of adulthood, dietary supplements can play an important role to address the concerns. The study aimed to explore the effect of soy supplement on the anthropometric measurement of tribal girls. A total of 120 female players aged 12 to 18 years from a residential school where the female players take part in sports training as well as attend the school Khel Parisar Kanker (KPK) from the tribal area and female players of Sports Authority of India (SAI) of urban area were selected for the study. Female players of KPK and SAI were divided into Experimental Group (EG) (N=30) and Control Group (CG) (N=30). Soy Supplement in form of Soy Ladoo was provided to the experimental group from August'2018 to March'2019. Before and after experimental design with control groups was used in the study. Height, Weight, Mid Upper Arm Circumference (MUAC), Waist Girth (WG) were measured and BMI was calculated. ANCOVA and trend analysis were used to analyse the data. It was found that Anthropometric measurements (MUAC, WG and BMI) increased significantly in EG than CG in KPK and SAI female players. An upward trend was observed and can be concluded that soy supplement was effective in improving anthropometric measurements.

Keywords: Soy supplement, adolescent girls, anthropometric measurement, Khel Parisar Kanker (KPK), Sports Authority of India (SAI)

INTRODUCTION

A balanced diet is an essential element in the life of one and all, it needs special attention during the adolescent period as it is the period of the growth spurt and developmental stage where physical, physiological and mental changes take place, which requires that each cell of the body is well nourished to work optimally when these adolescents take part in sports the nutritional requirement needs much more attention as per increased demand of the physical activity for optimal performance.

The “dietary supplement” means a product (other than tobacco) intended to supplement the diet that contains one or more dietary ingredients, including a vitamin, minerals, a herb or other botanical substance, an amino acid, a dietary substance, for use by man to supplement the diet by increasing the total dietary intake, or a concentrate, metabolite, constituent, extract or combination of any of aforementioned ingredients.¹ A dietary supplement is also known as a food supplement or nutritional supplement, is a preparation to provide nutrients when it is lacking in the diet.²

Soy supplement is a preparation of soybean has global importance and economic value. It has an excellent source of high quality of all 8 essential amino acid such as cysteine, tryptophan, leucine, isoleucine, lysine, valine, histidine, phenylalanine. It has soluble carbohydrates, dietary fibres, Omega 3 and Omega 6 fats. It also contains minerals such as calcium, iron, copper, zinc, magnesium, phosphorus, potassium and flavonoids which are important for growth and to build lean body mass.³

Adolescence is an intermediate phase between childhood and adulthood. According to WHO the age ranges from 10 to 19 years. It is a period of rapid growth and demand higher nutrition because up to 50% of the height and skeletal mass is gained during this period. Anthropometric measurements are used commonly to assess nutritional status. It displays health, nutritional status and anticipates performance. It also reflects the growth pattern of individuals.

In India adolescent girls aged 11 to 18 years are about 16.75% of the total female population.⁴ Their nutritional status is low and nutritional anaemia is a major health problem, The National Family Health Survey 3 (NFHS 3) data suggests that 56% of girls of 15 to 19 years were anaemic.⁵

Chhattisgarh was established on 1st November 2000 by splitting ten Chhattisgarhi and six Gondi districts of Madhya Pradesh. Bastar district is a tribal belt of Chhattisgarh. The major tribes are Gond, Batra, Muria, Abujmaria, Bison, Hornmaria, Halba, Dhurva.⁶ Almost 70% of the population are tribals. They are an important part of the state population and lives mainly in the dense forest of Bastar. They depend upon primitive agriculture practices and often face problems like scarcity of food, poverty, health problems and improper education facilities.

The plethora of studies revealed that anthropometric measurements were significantly lower among adolescent girls. Kapoor and Aneja reported that 35.5% of adolescent girls aged 11 to 18 yrs of Delhi are undernourished.⁷ Adolescent girls were found to be 3 to 10cm shorter and 3 to 15 Kg lighter than their U.S. counterparts.⁸ A study in nine states of India reported that about 42% of adolescent tribal girls were undernourished.⁹ In another study, 58.44% stunting and 72.71% wasting was found in tribal girls.¹⁰ Sharma et al. (2013) report that 42.6 % of girls were undernourished.¹¹ Venugopal et al (2016) state that weight and height, when compared with NCHS 1987, CDC 20-07-2010, ICMR 2010 growth reference and all the anthropometric measurements, were significantly lower among adolescent girls of Chhattisgarh.¹² Various other studies also revealed that the prevalence of lower nutritional status is common in adolescent girls in Chhattisgarh (C.G.). Kurrey et al. reported underweight 32.5%, stunting 22% and thinness 24% among Bihor tribal children.¹³ A Study has reported 57.1% of children to be thin in the sample.¹⁴ Low BMI was reported in Gond tribes of C.G.¹⁵ Lower weight and height were reported in Kamar children in almost all ages.¹⁶

Insufficient protein intake has been shown to have a negative association with growth indicators and performance of players. Proper nutrition is very crucial for adolescent players, to address the body composition as well as to meet the demand for training and competition load. The players in the tribal area working hard to excel in sports, hence this issue of energy requirement and specifically protein intake were taken into cognizance.

Aim of the study:

- To investigate the effect of SS on anthropometric indicators, selected under study.

MATERIAL AND METHODS:

Selection of Subjects:

A total of 120 players from Khel Parisar Kanker (KPK) and SAI were selected for the study. Participants of both groups were divided into the Experimental group (N=30) EG and Control group (N=30) CG. Soy ladoos prepared from processed soy flour, besan (Bengal gram flour), sugar, almond, cashewnut and ghee were consumed by the experimental group. They consume 50 grams per day which have 10.3gram protein. CG did not consume Soy laddoo. The experimental protocol was approved by the ethical committee (246/IEC/PRSU/2018). All the subjects were trained according to their sports for 4 hours along with their academic engagements. Before testing the written consent form was taken regarding the willingness of participation in the study.

Selection of variables:

Mid upper arm circumference (MUAC), Waist girth (WG) and Body mass index (BMI) are used to identify the status of muscle development, the proportion of abdominal fat and body composition. Height, Weight, MUAC, Waist Girth (WG) was measured with standard techniques and BMI was calculated.

Experimental design:

Experimental design before and after with control group was used. The variables were measured in the beginning and after every three months for the experimental group and control group till 9 months after the supplementation. Data collected was analysed through SPSS package 25 version.

RESULTS:

Table 1. Descriptive statistics of the effect of soy supplement on MUAC, WG and BMI between KPK and SAI girls.

		KPK GIRLS N=30		SAI GIRLS N=30	
MUAC	MEASURES	PRE-TEST	POST-TEST	PRE-TEST	POST-TEST
EXPERIMENTAL GROUP	MEAN	7.87±10	8.98+-.14	8.59+-.17	9.95+-.21
	SD	.59	.77	.93	1.18
CONTROL GROUP	MEAN	9.01+-.17	8.85+-.19	10.07+-.21	9.33+-.17
	SD	.95	1.04	1.17	.95
WG EXPERIMENTAL GROUP	MEAN	23.74+-.32	26.91+-.33	26.36+-.38	28.11+-.40
	SD	1.76	1.83	2.12	2.20
CONTROL GROUP	MEAN	27.30+-.40	26.38+-.47	29.17+-.38	28.06+-.52
	SD	2.21	2.57	2.09	2.87
BMI EXPERIMENTAL GROUP	MEAN	18.48+-.31	0+-.27	20.40+-.50	20.79+-.37
	SD	1.72	1.48	2.74	2.03

CONTROL GROUP	MEAN	18.70+-37	18.18+-40	20.78+-46	20.23+-37
	SD	2.06	2.20	2.52	2.07

Table 1 shows the mean course of MUAC, WG, BMI before and after the soy supplement. Mean score gain in the experimental group of KPK girls and SAI girls in MUAC is 1.11 inches and 1.36 inches, in WG is 3.17 inches and 1.75 inches and in BMI is 1.32 to and 0.39 respectively whereas control groups of KPK and SAI did not show any change in any of the variable selected.

Table 2. Analysis of covariance and comparison of adjusted post-test means of soy supplement on MUAC, WG and BMI between EG and CG of KPK and SAI girls.

MUAC	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG	PARTIAL ETA SQUARED
Contrast	33.208	3	11.069	15.09	.000	0.283
Error	84.335	115	0.733	-	-	-
WG						
Contrast	127.127	3	42.376	11.10	.000	0.225
Error	438.827	115	3.816		-	-
BMI						
Contrast	57.740	3	19.247	11.51	.000	0.231
Error	192.203	115	1.371		-	-

Table 2 reported a significant difference in adjusted post-test mean scores of MUAC between EG and CG ($F(3,115) = 15.09, p < 0.00$). Lower effect (.283) after soy supplement was seen when compared with Cohen's guidelines of effect size (0.2- small effect 0.5- moderate effect, 0.8-large effect). The partial eta squared value of .283 justifies 28.3% effect of soy supplement (Independent variable) on MUAC (Dependent variable) in EG.

The significant difference in the adjusted mean score of WG was also reported between EG and CG ($F(3,115) = 11.10, p < 0.00$). Small effect (.225) after the soy supplementation was seen when compared with Cohen's guidelines of effect size. The partial eta squared justifies 22.5% effect of soy supplement on WG in EG.

Similarly, the significant difference in adjusted post-test mean score of BMI between EG and CG ($F(3,115) = 11.51, P < 0.00$). Small effect (0.231) after the soy supplementation was seen when compared with Cohen's guidelines of effect size. The partial etas squared justifies 23.1% effect of soy supplement on BMI in EG.

Table 3. Trend analysis of the effect of soy supplement on MUAC, WG and BMI of KPK and SAI girls.

Measures	Source of Variation	Type III sum of squares	Df	Mean Square	F – ratio	Sig.
MUAC	Intercept	38952.033	1	38952.033	14663.240	.000
	Group	100.185	3	33.395	12.571	.000
	Error	308.174	116	2.656		
WG	Intercept	345210.951	1	345210.951	24480.473	.000
	Group	761.065	3	253.688	17.990	.000
	Error	1635.772	116	14.101		
BMI	Intercept	185369.123	1	185369.123	11984.725	.000
	Group	367.275	3	122.425	7.915	.000
	Error	1794.185	116	15.467		

Table 3 reported statistically significant improvement in trend on MUAC after Soy Supplement ($F(1,116) = 14663.24, p < .000$) at 1% level of significance. It also shows the statistically significant difference in comparing the trend of MUAC between KPK and SAI girls ($F(3,116) = 12.57, p < .000$) at 1% level of significance.

Similar improvement in trend on WG was seen ($F(1,116) = 2448.047, p < .000$) at 1% level of significance after soy supplement. It also shows the statistically significant difference in comparing the trend of WG between KPK and SAI girls ($F(3,116) = 12.57, p < .000$) at 1% level of significance.

Likewise, improvement in trend on BMI was seen ($F(1,116) = 11984.72, P < .000$) at 1% level of significance after soy supplement. The trend on BMI between KPK and SAI girls ($F(3,116) = 7.91, P < .000$) at 1% level of significance shows a statistically significant difference.

Table 4. Trend analysis of the effect of soy supplement on MUAC, WG AND BMI among KPK and SAI girls.

Source	Factor 1	Type III sum of squares	Df	Mean Square	F-ratio	Sig.
MUAC	Linear	13.054	1	13.054	27.87	.000
	Factor*Group Linear	46.723	3	15.574	33.256	.000
	Error(factor1)	54.324	116	0.468		
WG	Linear	40.119	1	40.119	17.69	.000
	Factor*Group Linear	196.439	3	65.480	28.872	.000
	Error(factor1)	263.079	116	2.268		
BMI	Linear	1.034	1	1.034	0.793	.375
	Factor*Group Linear	36.832	3	12.277	9.417	.000
	Error(factor1)	151.242	116	1.304		

Table 4 supports Linear trend $F(1,116) = 27.87, p < .000$, between independent variable (soy supplement) and dependent variable (MUAC) for EG. It also showed a statistically significant difference in linear trend $F(3,116) = 33.25, p < .000$, between KPK and SAI female players.

Similarly, the table supports the linear trend $F(1,116) = 17.69, p < .000$, between the independent variable (soy supplement) and dependent variable (WG) for EG. It also showed a statistically significant difference in linear trend $F(3,116) = 28.87, p < .000$ between both the groups.

In case of the linear trend $F(1,116) = .793, p < 0.05$, did not support between the independent variable (soy supplement) and dependent variable (BMI) for EG whereas it showed a statistically significant difference in the linear trend $F(3,116) = 9.41, p < .000$ on BMI between the KPK and SAI players.

DISCUSSION:

Anthropometric measurements are important indicators of growth and optimal growth can contribute to better performance. MUCA, WG and 8 BMI showed significant improvement in EG of KPK and SAI female players which can be considered as a factor for performance

improvement. A large number of studies indicates that players need to ingest protein two times of RDA (1.5 to 2.0 kg/d) to maintain protein balance.^{17,18,19,20} An overview that soy being a dense source of protein with all essential amino acid helps to attain protein requirements before, during and after exercise.²¹ Studies have shown that soy protein contributes to optimising muscle performance during and after exercise²² and promotes lean body mass gain.^{23,24,25,26} Munson States 20 to 25 gram of protein every 3 hours is needed to maintain muscle protein synthesis.²⁷ Low protein consumption ($0.86\text{kg}^{-1}\text{day}^{-1}$) by strength-trained athletes results in reduced protein synthesis compared with medium and high $1.4\text{g kg}^{-1}\text{day}^{-1}$ and $2.4\text{g.kg}^{-1}\text{day}^{-1}$ protein diets respectively.²⁸ Soy has antioxidant properties and similar digestibility and absorption properties like animal protein, so it is good for vegans. Thus, soy supplement is implemented to the sportsperson.

CONCLUSIONS AND RECOMMENDATIONS:

MUAC, WG and BMI are the important anthropometric indicators and significant improvement have been observed in these indicators after nine months of soy supplementation in the diet of the experimental groups. Soy supplement can be included in the diet of adolescent female players to improve body composition, which may in turn be helpful in better performance.

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Competing Interest:

Authors acknowledge that no competing interest exists.

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Growth and Nutritional Status of the Gond tribe of Chhattisgarh, India

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Abstract- Objective - To assess the growth and nutritional status of the Gond children.

Methods - A cross sectional study of the physical growth was conducted on 409 Gond children (194 boys and 215 girls), aged 12 to 17 years, in the Bastar district of Chhattisgarh. The study aimed to find out the growth pattern of the Gond children, which is considered to be a primitive tribe of Chhattisgarh, India and was compared with other Indian tribe and the official data of NCHS1987, CDC 2007-2010 & all India (ICMR 2010). Anthropometric measurements included height, weight, sitting height, and measurements of the biceps, triceps and subscapula, supraspinale and calf skinfolds.

Results - All anthropometric measurements except skinfold thickness exhibited uniform increase with age in both sexes. Gond boys showed higher anthropometric values than girls in height, weight and sitting height whereas in all the skinfolds measurements mean values of girls were higher as compared to boys. The Gond children showed lower mean values as compared to NCHS & CDC 2007-2010 where as height & weight were at par with ICMR 2010 and higher than Kamar tribe. Around 47% boys & 72% girls reported to be in various category of malnutrition.

Conclusion - Poor socio-economic status of this primitive tribe may be one of the reasons for this poor nutritional status & growth pattern as compared to NCHS 1987. However, further study can be conducted to get more insight

Key Words – Growth Status and Nutritional Status, Gond Tribe.

INTRODUCTION

The nutritional status of growing children in a population indirectly determines the standard of living. Nutritional inadequacy slows down the growth

of children and which is observable response. Therefore, determination of nutritional status may prove to be a powerful tool to identify the health status of any population.

Tribal populations are isolated from general population with their own physical, socioeconomic and cultural environment. They are the most backward section of the society, due to various factors like ignorance, poverty, lack of development in the inaccessible areas, illiteracy and exploitation. Several studies have documented a close relationship between tribal ecosystem and their health and nutritional status.¹ The habitat of the tribe has conferred certain advantages. The dietary habits and other related modes of life contributed to their better nutritional and health status in some tribal groups, while in other groups these practices are not conducive to good health. ²

Many studies based on published data have indicated patterns of anthropometric variation along ethnic, geographic, latitude, longitude and altitude, nutrition and several confounding variables.³ This work is an attempt to study the growth status through anthropometric measurement of Gond, children a primitive tribe of Bastar district, Chhattisgarh state and to compare their growth & nutritional status with other studies.

The Gonds are one of the most famous and important tribes in India, known for their unique customs and traditions. They are mainly a nomadic tribe and call themselves as Koytoria. The term 'Gond' is derived from the Telugu word 'Konda' which means hill. Gond Tribes are primarily found in Madhya Pradesh, Chhattisgarh, eastern Maharashtra, northern Andhra Pradesh and Western Orissa. With a population of over

4 millions, Gonds also form the largest tribal group in central India⁴, which is around 55% within the tribal population.⁵ In Chhattisgarh Gond population are found in Bastar, Dantewada, Kanker, Suurguja and Raipur districts. The total population of Gond is 42,98,404 consisting of 21,20,974 males and 21,77,430 females (Census of India 2011).⁶ The staple food of Gonds tribes in Bastar district are Kodo or Kutki (millet), they are usually meat consumers.

MATERIAL AND METHODS

The present study was based on cross-sectional samples of 409 apparently healthy Gond children (194 boys and 215 girls), aged 12+ to 17+ years. The subjects were selected from various tribal schools of Bastar district, Chhattisgarh. Anthropometric measurements such as body weight, height, sitting height, biceps, triceps, subscapular and calf thickness were the variable measured, according to the standard

technique (Weiner and Lourie 1981 and Singh and Bhasin 1987).^{7,8} Standing and sitting height were measured to the nearest cms. using a wall-mounted stadiometer (manufactured by Harpenden). Weight was measured with a physician’s beam balance scale to the nearest 0.5 kg. A skin fold caliper was used to measure the skinfold thickness to the nearest mm.

Height and weight are basic measurement to understand the growth pattern and the nutritional status, separately as well through BMI (WHO 2004).⁹ Skinfold thickness are indirect but authentic method of assessment of body fat percentage in body.

Data on Anthropometric measurements were analyzed using descriptive statistics. Weight and height of the present data were compared with NCHS (1987)¹⁰, ICMR (2010)^{11,12}, CDC (2007-2010)¹³ and Mitra et al.(2002).¹⁴ Analysis was done by using Windows Microsoft Excel and SPSS.

RESULT

TABLE 1. Descriptive Statistics of Weight, Height and Sitting Height of Gond Boys and Girls.

Girls							
Age group	N	Weight(kg)		Height (cm)		Sitting height (cm)	
		Mean	SD	Mean	SD	Mean	SD
12+	28	32.6	5.91	137.6	7.7	53.0	4.90
13+	39	36.0	5.59	142.7	4.9	56.6	2.71
14+	37	37.0	5.72	146.7	5.6	55.7	3.70
15+	40	39.9	4.22	148.5	5.8	58.3	3.23
16+	35	41.7	4.43	150.0	4.8	58.7	3.16
17+	36	42.3	3.57	150.6	5.0	60.7	2.69
Boys							
12+	30	36.1	7.56	147.9	9.3	57.9	9.08
13+	35	38.0	7.69	148.0	8.4	58.1	7.50
14+	30	46.6	6.01	156.5	6.7	63.5	4.49
15+	35	47.7	5.24	158.7	6.7	65.5	1.00
16+	31	51.7	4.65	161.0	6.2	64.9	6.16
17+	33	52.3	5.98	163.3	5.3	64.8	4.00

Table 1 Steady increment in mean weight was observed in the present study from 12+ to 17+ years of age. In case of girls minimum weight was 32.6 kg in 12+ year & maximum 42.3 at the age of 17+ years, difference of 9.7 kg was observed between 12+ to 17+ years. Mean weight of boys at 12+ was recorded to be 36.1 kg where as at 17+ year the weight was 52.3 kg weight gain of 16.2 kg was recorded in boys from 12+ to 17+ years. Higher weight was noted in boys as compared to girls in all the age.

Mean height of 12+ year girls was 137.6 cm which increased gradually and was 150.6 cm at the 17+ year, increase of total 13 cm was recorded. Growth spurt was noted between 12+ to 13+ years (5.14 cm). In boys the increase of height from 12+ (147.9 cm) to 17+ (163.3 cm) was 15.4 cm.

Mean value for sitting height were 53 cm (12+) & 60.7 (17+) for girls & 57.9 (12+) & 64.8 (17+) for boys. Total increment of 7.7 & 7.6 cm from 12+ to 17+ years were observed for girls & boys respectively.

TABLE 2. Descriptive Statistics of Skin fold measurement of Gond Boys and Girls.

Girls											
Age group	N	Biceps		Triceps		Sub scapular		Suprailac		Calf	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
12+	28	4.99	2.19	6.46	2.50	6.87	2.39	5.62	2.39	12.1	3.64
13+	39	4.72	2.05	9.27	3.24	8.21	2.37	7.13	2.75	12.9	3.39
14+	37	5.24	2.28	8.20	2.79	8.03	2.14	7.16	2.47	13.3	3.97
15+	40	5.11	2.33	8.70	1.98	8.42	1.68	8.05	2.59	12.9	3.39
16+	35	4.65	1.74	10.0	3.50	8.66	2.95	7.56	2.65	13.6	3.69
17+	36	4.25	1.72	9.36	2.82	8.67	2.69	8.00	2.64	13.4	4.78
Boys											
12+	30	2.63	.41	4.52	.96	5.03	1.31	3.60	1.53	8.45	2.52
13+	35	2.88	.81	5.27	1.91	5.10	1.39	3.75	1.76	8.45	2.06
14+	30	3.16	1.54	5.84	1.55	5.99	1.38	4.35	1.41	10.1	3.00
15+	35	2.68	.55	5.52	1.56	5.99	1.19	4.16	1.28	8.54	2.40
16+	31	2.83	.42	5.71	1.49	6.51	1.56	4.18	1.10	7.64	1.85
17+	33	3.04	.99	5.73	1.21	7.02	1.38	4.96	2.42	7.65	2.76

Descriptive statistics of skinfold measurement are presented in table 2 all the skin fold measurement showed increment from 12+-17+ years. Mean values of all the skin fold measurement were higher in girls as compared to boys through out 12+ to 17+ years, high SD value in measurements show greater inter

individual variability. Maximum increment observed in biceps triceps, Sub scapular, Suprailiac & Calf skinfold for boys were recorded 3.54 mm, 1.8 mm, 2.74 mm & 4.5 mm respectively, whereas in girls increment recorded to be 16 mm, 1.32 mm, 1.99 mm, 1.36 mm & 1.6 mm respectively from 12+ to 17+ years.

TABLE 3. Test of significance of various anthropometric measurement between the Gond tribe boys and girls

Age Group	Weight	Height	BMI	Sitting height	Biceps	Triceps	Sub scapular	Suprailac	Calf
12+	1.96	2.30*	7.20**	2.52*	5.79**	3.93**	3.65**	3.85**	4.46**
13+	1.23	4.44**	1.30	1.12	4.95**	6.37**	6.77**	6.19**	6.10**
14+	6.62**	5.84**	3.97**	7.73**	4.25**	4.13**	4.50**	5.53**	3.59**
15+	7.10**	5.60**	3.54**	4.30**	6.02**	7.63**	7.11**	8.02**	6.40**
16+	8.95**	6.42**	4.43**	5.27**	5.65**	6.42**	3.62**	6.60**	8.19**
17+	8.52**	8.16**	3.96**	5.02**	3.51**	6.80**	3.14**	4.97**	6.11**

SD – Standard Deviation,

*Significant at 5% and ** Significant at 1% level

Comparison of mean weight, height, sitting height & skin fold measurements between Gond boys & girls are shown in table 3. Statistically significant difference was observed in height between Gond boys & girls, boys being tall than girls at all age group (P<0.01). In case of weight higher mean values are seen in the boys in all the age group and statistically significant difference was observed in 14+, 15+, 16+ &

17+ years of age (P<.01). In sitting height statistically significant difference was observed at all age group between boys & girls (P<0.01) except age group 13+. Mean values of biceps, triceps, sub scapular, suprailiac & calf skinfold measurements were higher in girls in all the age group, statistically significant difference was noted at (P<.01).

TABLE 4. Distribution of Body Mass Index value of Gond boys and girls (According to WHO 2004 Standard)

Boys				Age in Years	Girls			
Normal Range (18.50-24.99)	Mild Thinness (17.00-18.49)	Moderate Thinness (16.00-16.99)	Severe Thinness <16.00		Normal Range (18.50-24.99)	Mild Thinness (17.00-18.49)	Moderate Thinness (16.00-16.99)	Severe Thinness <16.00
4 (13.3)	7 (23.3)	2 (6.6)	17 (56.6)	12+	4(14.2)	2(7.1)	3(10.7)	19 (67.8)

7 (20)	11 (31.4)	9 (25.7)	8 (22.8)	13+	6(15.3)	10 (26.4)	5 (12.8)	18(46.1)
19 (63.3)	6 (20)	4 (13.3)	1 (3.3)	14+	12 (32.4)	5 (13.5)	8(21.6)	12(32.4)
22 (62.8)	9 (25.7)	3 (8.5)	1 (2.8)	15+	11(27.5)	13(32.5)	10(25)	6(15)
26 (83.8)	4 (12.9)	1 (3.2)	0	16+	15(42.8)	9(25.7)	6(17.1)	5(14.2)
24 (72.7)	9 (27.2)	0	0	17+	12(33.3)	15(41.6)	6(16.6)	3(8.3)
102 (52.5)	46 (23.7)	19 (9.7)	27 (13.9)	Total	60(28.0)	54(25.1)	38 (17.6)	63 (29.3)

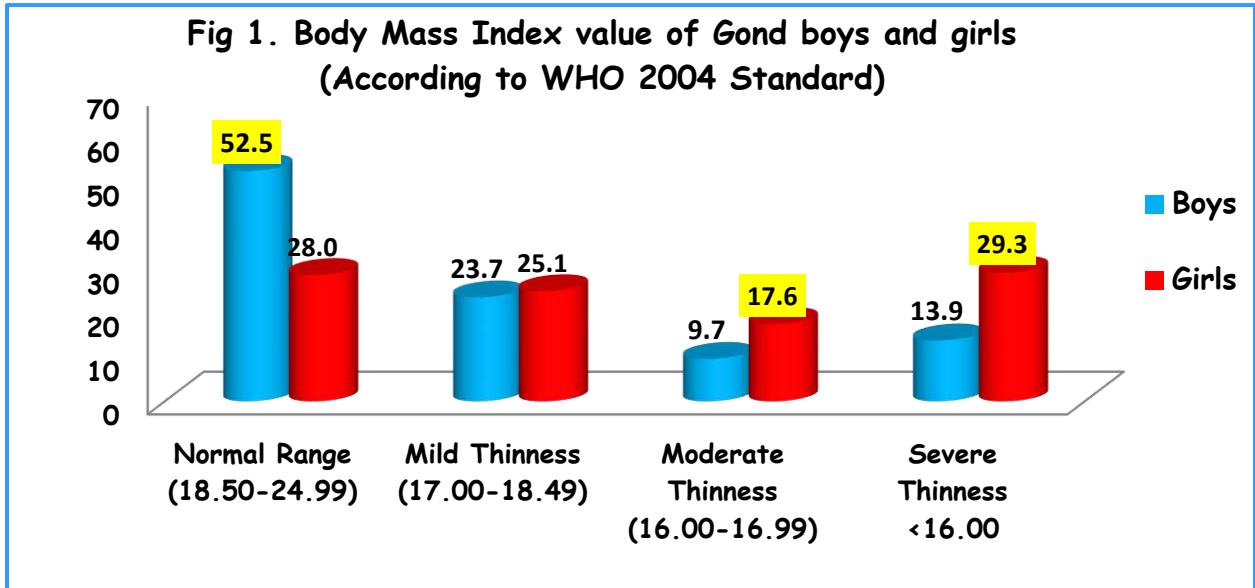


Table 4 & fig 1. shows the BMI according to WHO 2004 standard of malnutrition. BMI reveals that 52.5 % boys and 28.0% girls are classified under the normal category. 23.7 % boys and 25.1% girls suffered mild thinness 9.7% boys and 17.6 % girls suffered from moderate thinness and 13.9% boys and 29.3% girls suffered with severe thinness category of

malnutrition. Distribution of girls & boys in various nutritional categories showed different trend for different age group at age 12+ 56.6 % of boys 67.8 % of girls fell in severe malnutrition categories with increases in age malnutrition status in boys and girls improved. Which is evident from the reduced number of boys and girls in severe malnutrition categories.

TABLE 5. Comparison of mean of Weight of present Study with Other Studies

Age in Years	Present study	ICMR 2010	NCHS 1987	M.Mitra 2002	CDC 2007-2010
Boys					
12+	36.1	29.2	44.2	24.8	49.1
13+	38.0	32.6	49.6	25.7	54.0
14+	46.6	36.7	56.9	26.9	64.1
15+	47.7	41.1	61.0	31.0	66.9
16+	51.7	44.2	66.8	34.1	68.8
17+	52.3	47.1	67.5	37.2	72.9
Girls					
12+	32.6	29.6	47.10	23.60	49.0
13+	36.0	33.6	51.50	25.43	55.8
14+	37.0	37.2	54.70	27.25	58.5
15+	39.9	39.8	56.40	29.84	58.1
16+	41.7	42.0	58.20	31.82	61.3
17+	42.3	43.2	59.70	34.00	62.4

FIG 2. Comparison of mean of Weight of Boys in present Study with Other Studies

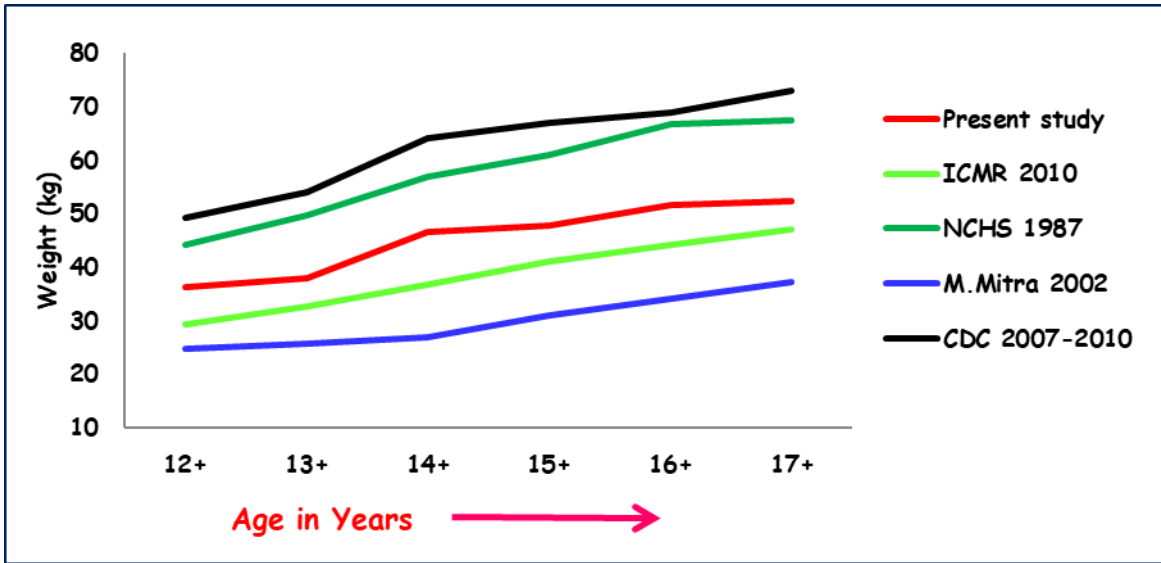


FIG 3. Comparison of mean of Weight of Girls in present Study with Other Studies

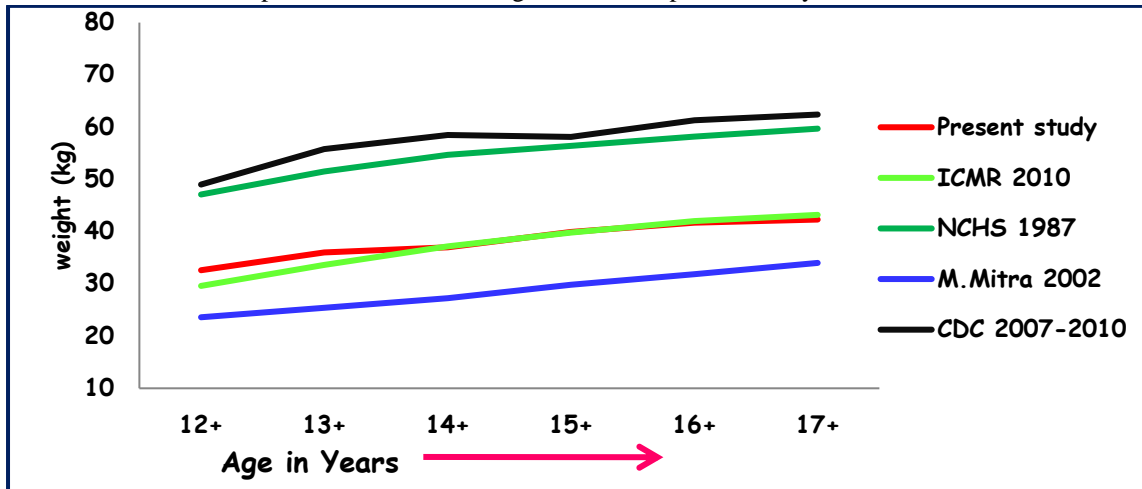


Table 5 & fig 2-3. shows the comparison of body weight of boys and girls of present study with other studies ie. reference data of NCHS (1987), ICMR (2010), CDC (2007-2010) and Mitra et al. (2002). It is

revealed from the table that present study mean were lower than NCHS (1987), and CDC (2007-2010) and higher than ICMR (2010) and Mitra et al. (2002).

TABLE 6. Comparative Analysis of Height of present Study with Other Studies

Age in Years	Present study	ICMR 2010	NCHS 1987	M.Mitra 2002	CDC 2007-2010
Boys					
12+	147.9	137.4	152.2	132.5	155.5
13+	148.0	142.7	159.2	137.1	161.6
14+	156.5	148.5	167.1	140.5	169.0
15+	158.7	153.8	170.8	144.7	172.8
16+	161.0	156.9	174.5	151.8	175.0
17+	163.3	159.7	175.5	155.9	176.5
Girls					
12+	142.7	137.6	154.6	130.6	156.1
13+	147.3	142.7	158.8	133.7	160
14+	147.7	146.7	160.9	140.3	161.6
15+	150.6	148.5	163.2	145	162.9
16+	152.1	150.0	162.2	147.9	162.2
17+	153.2	150.6	162.7	150.1	163.1

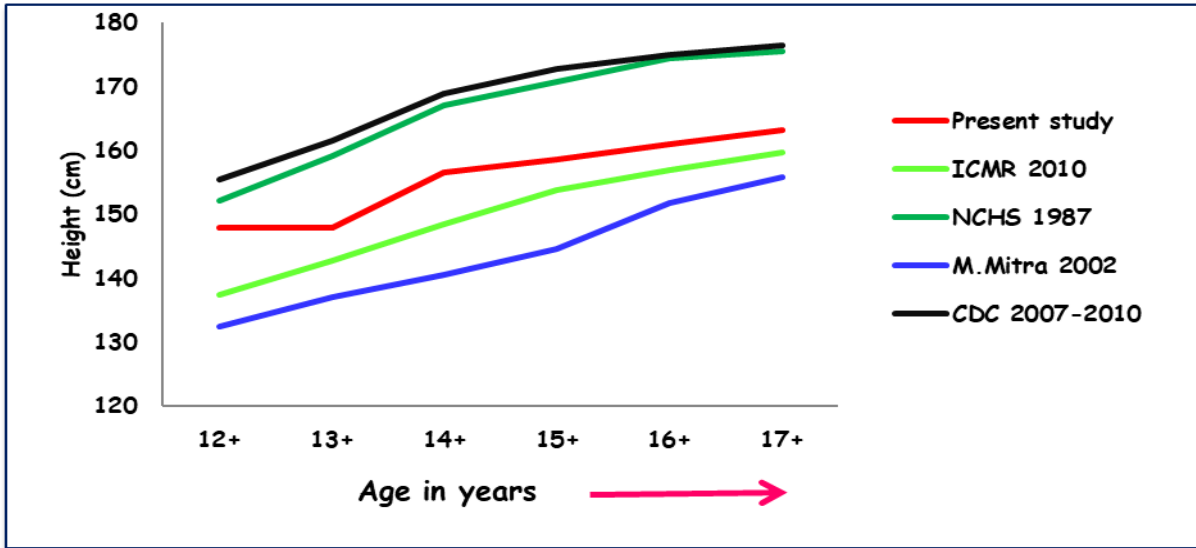


FIG 4. Comparison of mean of Height of Boys of present Study with Other Studies

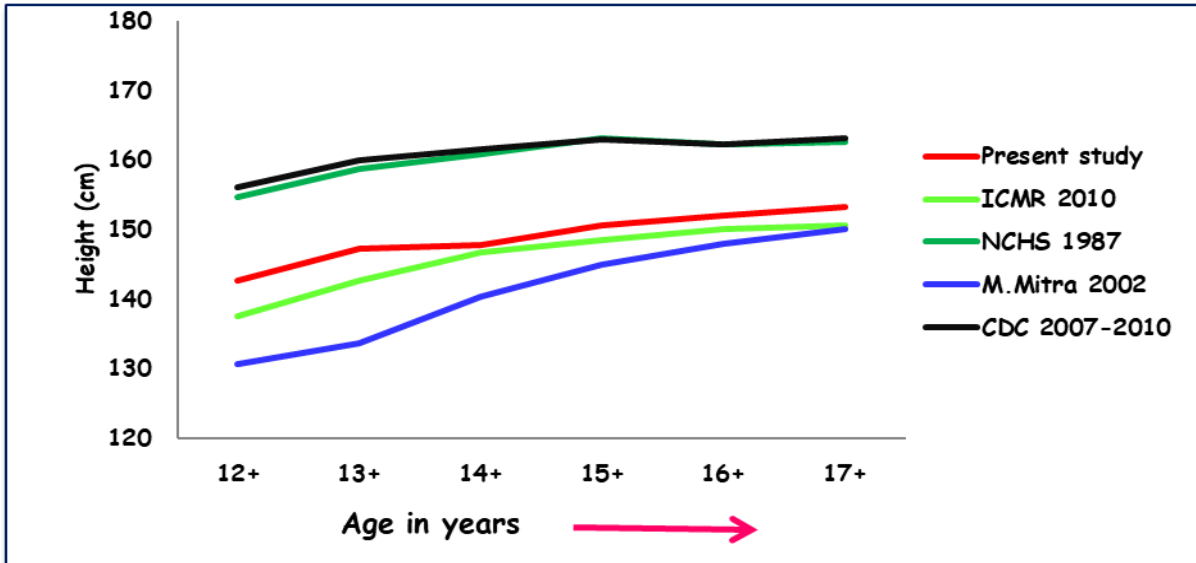


FIG 5. Comparison of mean of Height of Girls in present Study with Other Studies

Height of the boys and girls of present study were compared with reference data it was revealed that means of present study were lower than NCHS (1987), and CDC (2007-2010) and higher than ICMR (2010) and Mitra et al. (2002).

TABLE 7. Period of Occurrence of Adolescent Spurt As Indicated By »Hpv« In Different Body Measurements Among the Gond tribe of Chhattisgarh

Measurement	Boys adolescents spurt		Girls adolescents spurt	
	Age Group	HPV	Age Group	HPV
Body weight	13-14	8.6 kg	12-13	3.4 kg
Height	13-14	8.5 cm	12-13	4.6 cm
Sitting height	13-14	5.4 cm	12-13	3.6 cm
Biceps	14-15	0.48 mm	15-16	0.46 mm
Triceps	12-13	0.75 mm	12-13	2.81 mm
Sub Scapular	13-14	0.89 mm	12-13	1.34 mm
Supraspinale	16-17	0.78 mm	12-13	1.51 mm
Calf	13-14	1.65 mm	12-13	0.80 mm

HPV – Highest peak velocity

DISCUSSION

The present study examined growth and nutritional status of children from 12+-17+ years and increase in all anthropometric measurements under study was observed with increase in age. Weight and height of the Gond boys and girls were higher than Kamar boys and girls(Mitra et al 2002),¹⁴ another primitive tribe of central India where as it was lower as compared to CDC 2007-2010 & NCHS 1987 data.

The growth pattern of Gond boys and girls showed increasing trend in almost all the variables, the rate of increase showed different pattern for different variables. Highest peak velocity corresponding to the occurrence of growth spurt was observed between 12+ - 15+ years in girls and 12+ - 16+ years in boys. Among the boys out of eight body measurements five measurements (Weight, Height, Sitting height, Sub Scapular, Calf) showed the highest peak velocity between 13-14 years indicating an adolescent spurt in these measurements. Highest peak velocity was observed in the 12+ -13+ for Triceps Skinfold at 14+ - 15+ for Biceps Skinfold and at 16+ - 17+ for Supraspinale Skinfold. In case of the girls, highest peak velocity was observed in seven measurements (Weight, Height, Sitting height, Triceps, Sub Scapular, Supraspinale, Calf skinfold) out of eight, between 12+-13+ years. One measurements (Biceps skinfold) indicated highest peak velocity in the 15+-16 + years Present study shows that 28.8% girls were found to be normal. Deshmukh et al (2006)¹⁵ in their study of adolescents in rural Wardha district reported that 44% of adolescents girls to be in normal category of nutrition status. Nagamani et al (2015)¹⁶ in another study on adolescent Girls in Urban Slums of Visakhapatnam City, Andhra Pradesh State reported that 35% girls were chronic energy deficient (BMI<18.5). 80% of the girls were undernourished in a study done by Kalhan et al (2009)¹⁷ on adolescent girls of rural Haryana and 75.5% in a study done by Guduri et al (2014)¹⁸ on early adolescents girls (11-14) attending Government school of Visakhapatnam city.

Present study shows that 47.8% boys were underweight. Hunshal et al. (2010)¹⁹ in a study on subjects of 10 to 13 years in Dharwad district of Karnataka state have reported 82.6% of adolescents boys to be underweight. Similarly Prashant & Shaw (2009)²⁰ reported 42.6% & 22.9% prevalence of under

weight in girls as per NCHS & Indian standard respectively.

CONCLUSION

Height, weight, sitting height and skinfold measurement (Triceps, Biceps, Sub Scapular, Supraspinale, Calf skinfold) of Gond boys & girls were similar to ICMR 2010 and lower as compared to NCHS 1987 & CDC 2007-2010 standards. The Gond tribe when compared to other tribe Chhattisgarh it was found that the height, weight, sitting height and skinfold measurement (Triceps, Biceps, Sub Scapular, Supraspinale, Calf skinfold) of boys and girls of Gond tribes were higher. It is also concluded that 47.3% of boys 72 % girls suffered from different categories of malnutrition it was also observed that the malnutrition status improved with advancement of age.

Conflict of Interest : Authors have no conflicts of interest to disclose.

Author' Contribution: Dr. Manju Sharma –Ph D Scholar. Dr. Reeta Venugopal-Supervisor, Ms Aniksha Varoda- Analysis and Presentation of Data.

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Enhanced antioxidant activity in *Curcuma caesia* Roxb. microrhizomes treated with silver nanoparticles (AbstractView.aspx?PID=2024-37-1-4)

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Enhanced antioxidant activity in *Curcuma caesia* Roxb. microrhizomes treated with silver nanoparticles

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Abstract

Curcuma caesia Roxb. is a highly valuable, endangered herb of therapeutic importance that resides in their rhizomes. In the present investigation, the effect of ½ strength liquid Murashige and Skoog (MS) medium supplemented with 1 mg/l Indole-3-butyric acid (IBA) and different sucrose concentrations (1.5%, 3%, 6%, 9%, or 12%) was studied on microrhizomes induction of *C. caesia*. The shoot length, root length and microrhizomes dry weight of *C. caesia* decreased significantly at 6% sucrose and above. When compared to the control (1.5% sucrose), the current water content significantly decreased at 6% sucrose. The optimum concentration for *in vitro* microrhizomes induction in *C. caesia* was 6% sucrose. Therefore for further experiments, the 6% sucrose was used. We also studied the effect of silver nanoparticles (AgNP) on microrhizome induction and antioxidant activity in *C. caesia* cultures. Field-grown *C. caesia* rhizomes extract was used in the green synthesis of AgNP. The synthesized AgNP was further characterized through scanning electron microscopy and X-ray diffraction. The AgNP, ranging from 0, 0.025, 0.05, 0.075 or 0.1 mg/l was supplemented in ½ strength liquid MS medium with 6% sucrose & 1 mg/l IBA. The MS medium with 0.05 mg/l AgNP found with significant morphological changes in *C. caesia* cultures (root number, root length and microrhizomes fresh weight). For the total phenolic and total terpenoids content estimation as well as for antioxidant activity analysis, the extracts of un-treated cultures (6% sucrose + 1 mg/l IBA, without AgNP), AgNP treated cultures (6% sucrose + 1 mg/l IBA with 0.025 & 0.05 mg/l AgNP) was used. The 0.025 and 0.05 mg/l AgNP enhanced the phenolic and terpenoid content in the cultures compared to the field-grown mother plant. The antioxidant activity of the cultures treated with AgNP also increased compared to un-treated cultures and field-grown mother plant. The **Gas Chromatography-Mass Spectrometry (GC-MS) analysis revealed that the extract treated with 0.05 mg/l AgNP had increased production of monoterpene (camphor) and sesquiterpenes (β-elemenone & curcumenone)**. These increased terpenes could be responsible for the enhanced antioxidant activity of *C. caesia* cultures.

Keywords: Antioxidant activity, Current water content, GC-MS, Indole-3-butyric acid, XRD.

Introduction

Curcuma caesia Roxb., also known as 'Kali Haldi' or 'Black Turmeric,' is an endangered herb belonging to the family Zingiberaceae. It is native to Northeast India and is also distributed in the Himalayan region, Northern Australia, and the tropical and subtropical regions of Asia, especially in Thailand, Indonesia, and Malaysia (Karmakar et al., 2011). The fresh and dried rhizomes of this herb are used for the treatment of various diseases, including asthma, anthelmintic, allergies, aphrodisiac, postpartum uterine abnormalities, bronchitis, cancer, splenomegaly, epilepsy, fertility, gonorrhoeal discharges, impotence, toothache, leukoderma, leprosy, piles, tumours, menstrual disorders, rubefacient, smooth muscle relaxant activity, vomiting, and wounds (Ravindran et al., 2007). *C. caesia* is characterized by tuberous bluish-black rhizomes with a camphoraceous aroma and medicinal properties (Donipati and Sreeramulu, 2015). *C. caesia* exhibits antimicrobial, anti-inflammatory, and antioxidant properties (Mukunthan et al., 2018; Borah et al., 2019; Benya et al., 2023). *C. caesia* contains various phytoconstituents, including curcuminoids, flavonoids, essential amino acids, and high alkaloid content (Baghel et al., 2013). These secondary metabolites are responsible for the pharmaceutical properties, fragrances, and flavouring associated with *C. caesia*.

Sugars are crucial as plant regulators, facilitating numerous physiological processes such as photosynthesis, seed germination, flowering, senescence, and more, especially during abiotic stresses (Sami et al., 2016). The external application of sugars in low concentrations regulates seed germination, flowering, and photosynthesis, while also delaying senescence under various stressful environmental conditions. Above a particular concentration, sucrose induces osmotic stress in the *in vitro* condition (Mehta et al., 2000). Previous research has demonstrated the beneficial impact of sucrose on the formation of storage organs like corms and tubers (Nayak and Naik, 2006).

In recent years, there has been significant interest in the green synthesis of silver nanoparticles (AgNPs) using plants. This method has gained attention due to its cost-effectiveness, non-toxic technology, biocompatibility, and environmentally friendly nature. Studies have shown that AgNPs synthesized using plant extracts are more stable than those synthesized by other organisms, such as fungi and bacteria (Mamidi and Polaki, 2019). Researchers have also been investigating the positive effects of AgNPs on plant growth and development. The present investigation focuses on the impact of sucrose and indole-3-butyric acid on microrhizome induction in *C. caesia* cultures. The effect of the nanoparticles on microrhizome induction in *C. caesia* cultures was also examined. The total phenolic and terpenoid content and the antioxidant activity in *C. caesia* microrhizome extracts after nanoparticles treatment was also investigated.

Materials and Methods

The present work was conducted at the School of Studies in Biotechnology, Pt. Ravishankar Shukla University, Raipur, Chhattisgarh (India). *Curcuma caesia in-vitro* cultures were used for the experimental work, which included the following procedure-

Effect of sucrose on microrhizomes induction of *C. caesia*

To study the effect of sucrose concentration in the growth of microrhizomes of *C. caesia*, *in vitro* experimental work was carried out. ½ strength liquid Murashige and Skoog (1962) (MS) medium supplemented with 1 mg/l IBA (Indole-3-butyric acid) was used along with different concentrations of sucrose ranging from 1.5%, 3%, 6%, 9% or 12%. The selection of 1 mg/l IBA was based on the findings of Anjum et al. (2022). Culture tubes (25 x 150 mm) containing 15 ml liquid MS medium were plugged with cotton and sterilized at 121°C for 20 min in an autoclave. After autoclaving, the medium was stored in a clean, dust-free chamber for a couple of days to check for contamination before use. Then, prior to inoculation, the medium and all other laboratory wares were disinfected by exposure to UV light inside the laminar air flow for 30-35 min. Inoculation was done after two days of medium preparation and six-month-old cultures on the standard medium (Anjum et al., 2022) was used for inoculation. The cultures were incubated for 30 days under white fluorescent light for 16 h dark and a photoperiod of 8 h. Observation of the established cultures was taken after one month. From the observation, the best range of sucrose (6%) was used for further experiments.

Green synthesis of silver nanoparticles (AgNP)

Extract preparation

The field-grown rhizomes of *C. caesia* were dried in a hot air oven at 45°C to remove the moisture completely. The rhizomes were powdered using a mixer grinder. For extract preparation, 5 g of *C. caesia* rhizome powder was added to 100 ml methanol in a 250 ml glass beaker and kept in a magnetic stirrer for 8 h at room temperature. Then the crude methanol extract was filtered through Whatman filter paper (20–24 µm) paper, and the filtered extract was further used for AgNP preparation.

Synthesis of AgNP

To the 2 ml of *C. caesia* rhizome extract, 18 ml of 3 M silver nitrate (AgNO_3) solution was mixed in a 250 ml glass beaker, fully covered with aluminium foil to avoid any photoreactions. It was then thoroughly mixed using a magnetic stirrer for 2 h. The solution was checked every 30 min to monitor the colour change (from colourless to brown), which revealed the reduction of Ag^+ into Ag^0 nanoparticles. The synthesized nanoparticles were first characterized through a UV-visible spectrophotometer. After taking the spectrum, the solution was poured into a petri dish and placed in hot air over. After the solution was dried, the leftover precipitate was scratched to obtain a fine powder. The powder obtained was AgNP, which was used for further experiments.

The further characterization of synthesized nanoparticles was done through scanning electron microscope (SEM), X-ray diffraction (XRD).

Effect of AgNP on microrhizomes induction of *C. caesia*

We studied the effect of AgNP in the microrhizome induction of *C. caesia*. For this, $\frac{1}{2}$ strength liquid MS medium was prepared supplemented with 6% sucrose and 1 mg/l IBA along with different ranges of concentration of AgNP: 0, 0.025, 0.05, 0.075 or 0.1 mg/l. The pH of the medium was adjusted to 5.8 with the help of a pH meter. The medium was poured into clean culture tubes and autoclaved with the rest of the materials required during the inoculation. The two-month-old microrhizome cultures were used for inoculation. After a month, the morphology of the cultures and fresh and dry biomass of the microrhizome was observed.

Water bath-assisted extraction

After the observation, the dried microrhizomes were powdered and extracted using a water bath sonicator for 1 h at a temperature between 30-35°C. The solid-to-liquid ratio was 1:25 (1 g dried powder with 25 ml methanol). The obtained extract was centrifuged at 10,000 rpm for 15 min, and the supernatant was collected and used for further experiments.

Total phenolic content

The total phenolic content of the extract (field grow mother plant, 6% sucrose + 1 mg/l IBA + 0 AgNP, 6% sucrose + 1 mg/l IBA + 0.025 mg/l AgNP, 6% sucrose + 1 mg/l IBA + 0.05 mg/l AgNP) was determined quantitatively by an assay that utilizes the Folin Ciocalteu reagent (Ainsworth and Gillespie, 2007). 100 μ l of the extract was mixed with 200 μ l 10% Folin Ciocalteu reagent and vortexed thoroughly. Then, 800 μ l of 700 mM sodium carbonate was added and incubated at room temperature for 2 h. Then, absorbance was taken at 765 nm using Micro Scan (Electronics Corporation of India Limited) and expressed in mg gallic acid equivalents (GAE)/g dry weight (DW).

Total terpenoids content

Total terpenoid content of the extract (field grow mother plant, 6% sucrose + 1 mg/l IBA + 0 AgNP, 6% sucrose + 1 mg/l IBA + 0.025 mg/l AgNP, 6% sucrose + 1 mg/l IBA + 0.05 mg/l AgNP) was estimated using method of Ghorai et al. (2012). 200 μ l extract mixed with 1.5 ml chloroform and vortex and rested for 3 min. After that, 100 μ l H_2SO_4 was added and again incubated for 2 h in the dark at room temperature. After incubation, reddish-brown precipitation formed. Then all supernatant was decanted carefully, and 1.5 ml of 95% methanol was added to the precipitate and vortex thoroughly till the precipitate dissolved completely. Absorbance was recorded at 538 nm using Micro Scan (Electronics Corporation of India Limited) and expressed in mg abscisic acid equivalents (AAE)/g DW.

In vitro antioxidant activity

DPPH radical scavenging activity

For screening the antioxidant activity of the extract (field grow mother plant, 6% sucrose + 1 mg/l IBA + 0 AgNP, 6% sucrose + 1 mg/l IBA + 0.025 mg/l AgNP, 6% sucrose + 1 mg/l IBA + 0.05 mg/l AgNP), the protocol of DPPH radical scavenging activity given by Blois (1958) was followed. To 1 ml of extract (100 μ g/ml), 1 ml of DPPH (0.1 mM) was added, and the tubes were incubated in the dark for 30 min. Absorbance was recorded at 517 nm using MicroScan (Electronics Corporation of India Limited). Ascorbic acid was used as standard.

Ferric-reducing antioxidant power assay (FRAP)

The reducing power was determined by following the procedure given by Oyaizu (1986). 2.5 ml of phosphate buffer (0.2 M, pH 6.6) and 2.5 ml of 1% potassium ferricyanide were added to 2.5 ml extract (100 μ g/ml). The mixture was placed in the water bath for 20 min at 50°C and was cooled immediately. After cooling, 2.5 ml of 10% trichloroacetic acid was added, then samples were centrifuged at 3,000 rpm for 10 min. 5 ml supernatant was then mixed with 5 ml distilled water, followed by the addition of 1 ml of 0.1% ferric chloride. The absorbance was taken at 700 nm after 10 min using Micro Scan (Electronics Corporation of India Limited). Butylated hydroxytoluene was used as standard.

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

GC-MS analysis was performed using extracts of un-treated cultures and treated cultures with 0.05 mg/l AgNP. GC-MS analysis was done using hired facilities of Sophisticated Analytical Instruments Facility, Indian Institute of Technology-Madras, Chennai, Tamil Nadu.

Statistical analysis

For the microrhizomes induction, each sucrose range had ten replicates repeated three times. Each range of AgNP had ten replicates repeated three times. Antioxidant tests, total phenolic, and total terpenoid content analysis were conducted using three replicates repeated twice. The obtained data were analyzed using analysis of variance (ANOVA) with SPSS software version 20, and mean differences were calculated using Duncan's multiple range test (DMRT) at a significance level of $p \leq 0.05$.

Results and Discussion

Effect of 1 Indole-3-butyric acid (IBA) with different sucrose concentrations on microrhizomes induction of *C. caesia*

To induce microrhizomes in *C. caesia*, six-month-old cultures of *C. caesia* cultures grown on standard medium were used as explants. Sucrose of varied concentrations, 1.5%, 3%, 6%, 9%, or 12% was added to the $\frac{1}{2}$ strength liquid MS medium supplemented with 1 mg/l IBA (Table 1). The cultures treated with 1.5%, 3%, or 6% sucrose had no effect on shoot number, similar to the control (1.5% sucrose). When the concentration of sucrose rose beyond 6%, the shoot number decreased significantly. The least shoot number was observed on medium with 12% sucrose (Table 1). The shoot length was significantly increased with the increasing sucrose concentration from 1.5% to 3%, while there was a decrease in the shoot length when the concentration further increased to 6%, and 9%. The shoot length was statistically the same at 9% and 12% sucrose (Table 1). In the case of root number, there was a significant decrease with the increasing sucrose concentration (1.5% to 12%). There was an increase in the root length when the concentration rose from 1.5% to 3% sucrose; on increasing the concentration beyond 3%, the root length continuously decreased with the increased sucrose concentration (3% to 12%) (Table 1). There was no significant difference in the fresh weight of microrhizomes, while the dry weight of the microrhizomes increased significantly at 6% sucrose and above (Table 1). Similarly, the maximum *in vitro* tubers of *Chlorophytum*

borivilianum was found in MS media that contained 60 g/l of sucrose (Chauhan et al., 2018). A higher intake of sucrose might stimulate enzymatic activity resulting in starch synthesis and accumulation in the storage tissues. Reduced shoot growth observed in culture media with high sucrose concentration, along with a swollen basal region, suggested that sucrose must have been transported to the stem for rhizome formation (Chirangini et al., 2005).

Current water content (CWC)

The CWC of the *C. caesia* cultures at 1.5% and 3% sucrose was the same as that of the control (1.5% sucrose) (Fig. 1). The CWC decreased significantly at 6% sucrose compared to the control. This decrease was more intense at 12% sucrose. Sucrose induces abiotic osmotic stress when added beyond the normal limit (Kim and Kim, 2002). Relative water content in the leaves of maize cultivars decreased after drought treatment (Valentovic et al., 2006). Thus, in the present investigation, based on the morphological parameters (shoot length, root number, and root length) and CWC, 6% of sucrose was best for *C. caesia* micro rhizome formation *in vitro*. Therefore, a further experiment was performed with 6% sucrose.

Green synthesis of silver nanoparticles (AgNP)

The AgNP was successfully synthesized using field-grown *C. caesia* rhizomes extract.

Characterization of AgNP

UV-visible spectroscopy

UV-visible spectrum refers to the absorbance spectra in the UV-visible region. When the light beam passes through the solution, part of the light is absorbed, and the rest is transmitted through the solution. The transmittance is defined as the ratio of light entering the sample to the light that exits the sample at a fixed wavelength. The negative logarithm of transmittance is called absorbance. In the present study, the maximum absorption spectra of the synthesized AgNP were obtained at 400 nm (Fig. 2), which showed the formation of AgNP. It concludes that the AgNP was effectively synthesized using *C. caesia* rhizome powder methanol extract. The formation of AgNP through the reduction of silver ions by plant extract was observed via a UV-visible spectrophotometer (Cittrarasu et al., 2019). When AgNO₃ was added to *C. longa* extract and the suspension stirred for 24 h at room temperature, the emulsion's colour changed from yellow to dark brown. The surface plasmon resonance (SPR) phenomenon is responsible for the colour variations in aqueous solutions (Shameli et al., 2012). UV-visible spectroscopy showed that the SPR sharp peak at 350-430 nm wavelength indicates the formation of AgNP (Naik et al., 2002). Previous research has demonstrated that the spherical Ag-NP contribute to the absorption bands in the UV-visible spectrum at about 400-420 nm (Stepanov, 1997; Shameli et al., 2012). These absorption bands are thought to have extra-fine quality and small size of the Ag-NP. AgNP absorption spectra can be between 330 and 700 nm, with a sharp peak at 432 nm. This peak denotes the formation of AgNPs as it falls within the region of the SPR for AgNP (Logeswari et al., 2013).

Scanning Electron Microscopy (SEM)

Scanning Electron Microscopy (SEM) is a technique that provides an image of the surface morphology of the nanoparticle by providing information about the samples' size, shape, and other physical and chemical properties. An electron beam is generated and passed through the sample, and the scattered electrons from the particle's surface are detected, which creates a high-resolution image. Back scattered electrons can reveal differences in chemical composition because heavier elements reflect more electrons, making them look brighter in the image. Figure 3 displays the SEM image of synthesized silver nanoparticles of size ranging from 60-80 nm. SEM analysis was used to examine silver nanoparticles extracted from *Syzygium aromaticum*, which revealed the formation of spherical nanoparticles with a diameter range of 40-50 nm (Geoprincy et al., 2013).

X-Ray Diffraction

XRD is a technique used to identify the crystalline phases present in a material and can determine the element proportions. The interaction between the X-ray beam and the atomic planes results in partial transmission of the beam, and the rest is absorbed, refracted, scattered, and diffracted by the sample. X-rays are diffracted by each element in a different way, depending on the atomic arrangement and the type of atoms. In our study, the XRD pattern of synthesized AgNP showed sharp peaks at 2θ angles of 35.58°, 35.60°, 35.68°, 43.87°, and 47.87° (Fig 4). The sharp peak can be attributed to the crystalline structure of AgNP. The XRD peaks at 2θ of 38.18°, 44.25°, 64.72°, and 77.40° were each assigned to one of the face-centered cubic silver crystals (Ahmad et al., 2009). In a study performed by Shameli et al. (2012), XRD peaks of AgNP which were synthesized using *C. longa*, obtained at 2θ of 38.18°, 44.25°, 64.72°, and 77.40°, which attributed to face-centered cubic crystals structure of synthesized AgNP.

Effect of AgNP on microrhizomes induction of *C. caesia*

After the selection of the best range of sucrose (6%) for the induction of microrhizomes in *C. caesia*, the cultures were treated with a varied range of AgNP, ranging from 0, 0.025, 0.05, 0.075 or 0.1 mg/l (Table 2). The root number increased significantly when AgNP concentration increased from 0.025 to 0.05 mg/l. When the concentration was increased beyond 0.05 mg/l, the root number decreased. The root length had no significant difference in microrhizomes treated with 0.025 mg/l AgNP compared to the un-treated cultures (without AgNP) (Table 2). But when the concentration was raised from 0.025 to 0.050 mg/l root length increased significantly, again decreasing at 0.075 mg/l AgNP. There was no significant difference in the microrhizomes fresh weight of the cultures treated with 0, 0.025, and 0.05 mg/l AgNP concentration. However, in *Curcuma longa*, compared to the control treatment, zinc oxide NP significantly enhanced the productivity, yield, and curcuminoid content (Khattab et al., 2023).

Total phenolic content

TPC of the extract treated with 0.025 and 0.05 mg/l AgNP had 0.62 folds and 0.59 folds higher phenol content than the field-grown mother plant (Fig. 5). However, this content was comparatively less than the un-treated cultures. On the other hand, Salih et al. (2022) investigated the impact of different concentrations (0.0, 2.5, 5, 10, 25 mg/l) of biogenic AgNP on the antioxidant activity of *Solanum tuberosum in vitro*. They reported that 5 mg/l AgNP showed the highest value of TPC, which was 281.7 mg GAE/g DW. Hasan et al. (2022) hydroponically exposed *Lactuca sativa* seedlings to different concentrations of Ag⁺ ions and AgNP for 25 days. Ag⁺ ions raised the TPC by 18% and flavonoid content by 12% of seedlings, respectively, while AgNP boosted TPC by 12%.

Total terpenoid content

The extract treated with 0.025 and 0.05 mg/l AgNP had the highest terpenoid content (Fig. 6). This content was 3.5 folds and 1.67 folds higher than the field-grown mother plant and un-treated cultures, respectively. Solanki et al. (2023) conducted research to study the synergistic effect of AgNP and fungal symbionts in enhancing the secondary metabolites in leaves of black rice (*Oryza sativa*). Maximum production of secondary metabolites found at 80 ppm of AgNP. AgNP treatment could significantly increase terpenoids such as β-cymene, γ-terpinene, terpinene-4-ol, α-elemene, linalool, caryophyllene, β-cimene, trans linalool, and myrcene.

Antioxidant tests

DPPH radical scavenging activity

The extract treated with 0.05 mg/l AgNP had the DPPH radical scavenging activity similar to the standard ascorbic acid (Fig. 7). The activity of the extract treated with 0.05 mg/l AgNP was significantly higher than the field-grown mother plant and un-treated cultures. However, the activity of extract treated with both the range of AgNP (0.025 and 0.05 mg/l) possessed similar % inhibition of DPPH radical. Selvan et al. (2018) synthesized AgNP by using aqueous extracts of garlic, green tea, and turmeric and assessed the antioxidant potential of the synthesized AgNP. Compared to other nanoparticles, the AgNP synthesized using turmeric extract exhibited excellent antioxidant activity in terms of DPPH assay. Elegbede et al. (2018) synthesized nanoparticles using xylanases from *Trichoderma longibrachiatum* and *Aspergillus niger*. The 100 µg/ml of AgNP had maximum DPPH free radical scavenging activities compared to other tested ranges of AgNP and un-treated cultures.

Ferric-reducing antioxidant power assay (FRAP)

FRAP of the extract treated with 0.025 and 0.05 mg/l AgNP was found to be similar (Fig. 8). The FRAP of both the treated extracts had a similar reducing power as that of standard butylated hydroxytoluene. The reducing power of the un-treated cultures and extract treated with 0.025 mg/l AgNP was the same but was significantly higher than the field-grown mother plant. Zhang and Jiang (2020) used chitosan/tea polyphenols-silver nanoparticles composite film (CS/TP-AgNP) in their studies. CS/TP-AgNPs III (8 ml AgNP) showed the highest FRAP activity, followed by CS/TP-AgNPs II (4 mL AgNPs) > CS/TP-AgNP I (2mL AgNP) nanocomposite film. The least FRAP activity was in un-treated cultures.

GC-MS

GC-MS analysis identified some important monoterpenes i.e. camphor (1.98%) and ethyl N-(o anisyl)formimidate (3.72%), important sesquiterpenes i.e. 1,5-cyclodecadiene, 1,5- dimethyl-8-(1- methylethenyl)-, [S- (1.51%), β-elemenone (3.4%), pentadecanoic acid (8.32%), curcumenone (9.2%) and (4aR,5S)-1-hydroxy-4a,5-dimethyl-3-(propan-2-ylidene)-4,4a, (14.1%) in the control samples (without AgNP) (Fig. 9b). GC-MS analysis of the extract treated with 0.05 mg/l AgNP identified monoterpenes such as camphor (4.15%) and sesquiterpenes such as 1,5-cyclodecadiene, 1,5- dimethyl-8-(1- methylethenyl)-, [S- (1.69%), β-elemenone (5.18%), (4aR,5S)-1-hydroxy-4a,5-dimethyl-3-(propan-2-ylidene) (23.84%) and curcumenone (26.03%) (Fig. 9c). The treatment with 0.05 mg/l AgNP resulted in the enhanced production of monoterpene (camphor) and sesquiterpenes (β-elemenone & curcumenone). The area % of camphor, β-elemenone and curcumenone increased by 2.09, 1.52 and 2.82 times respectively in the extract treated with 0.05 mg/l AgNP compared to un-treated extract. Whereas as compare to field-grown mother plant curcumenone area % increased by 17.46 and 6.17 times in the extract treated with 0.05 mg/l AgNP and un-treated extract respectively (Fig. 9a). The sesquiterpenes are known to possess antitumor properties as had an important role in eliminating reactive oxygen species (Anjum and Quraishi, 2023). Chung et al. (2018) AgNPs at 5 mg/l elicited cell suspension cultures of bitter melon had enhanced amount of phytoconstituents than the control. These changes were responsible for high pharmacological activities (antioxidant, antidiabetic, antibacterial, antifungal and anticancer) in the AgNPs (5 mg/l)-elicited cell suspension cultures of bitter melon. Keshari et al. (2020) reported that the AgNP (synthesized by *Cestrum nocturnum* extract) have more antioxidant activity as compared to vitamin C. The AgNP has 29.55% DPPH radical scavenging activity while vitamin C has 24.28% antioxidant activity.

Conclusions

In the present investigation, the 6% sucrose with 1 mg/l IBA was optimum for *in vitro* microrhizomes induction in *Curcuma caesia*. The effect of AgNP on microrhizome induction and on antioxidant activity in *C. caesia* cultures was evaluated. The 0.025 and 0.05 mg/l AgNP enhanced the phenols and terpenoid content in the cultures compared to the field-grown mother plant. The antioxidant activity of the cultures treated with AgNP also increased compared to un-treated cultures and field-grown mother plant. The application of 0.05 mg/l AgNP to *C. caesia* cultures elicited the terpenoids content (especially curcumenone) which might be responsible for enhanced antioxidant activity.

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Conflict of interest The authors declare no conflicts of interest.

Author contribution SP: Experimentation and Original draft, AA: Methodology, Data curation, Formal analysis, and Editing, VJ: Review and Editing, AQ: Conceptualization, Supervision, Review, and Editing.

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Figure Legends

Fig. 1 Effect of ½ strength liquid Murashige and Skoog (1962) medium with Indole-3-butyric acid and different sucrose concentrations on the current water content of *Curcuma caesia* cultures.

ANOVA	df	F	p
Current water content	5	68.42	<0.0001

Fig. 2 UV-Visible absorption spectra of the synthesized silver nanoparticles (using field-grown *Curcuma caesia* rhizomes extract) with λ_{max} = 400 nm.

Fig. 3 SEM image of the synthesized silver nanoparticles using field-grown *Curcuma caesia* rhizomes extract.

Fig. 4 XRD pattern of the synthesized silver nanoparticles using field-grown *Curcuma caesia* rhizome extract.

Fig. 5 Effect of AgNP-treated extract from field-grown mother plant of *Curcuma caesia* on total phenolic content in cultures after one month.

ANOVA	df	F	p
Total phenolic content	3	48.27	<0.0001

Fig. 6 Effect of AgNP-treated extract from field-grown mother plant of *Curcuma caesia* on total terpenoids content in cultures after one month.

ANOVA	df	F	p
Total terpenoids content	3	48.35	<0.0001

Fig. 7 Effect of AgNP-treated extract from field-grown mother plant of *Curcuma caesia* on DPPH radical scavenging activity in cultures after one month.

ANOVA	df	F	p
DPPH radical scavenging activity	4	9.092	<0.0001

Fig. 8 Effect of AgNP-treated extract from field-grown mother plant of *Curcuma caesia* on ferric reducing antioxidant power assay in cultures after one month.

ANOVA	df	F	p
Ferric reducing antioxidant power assay	4	6.159	0.001

Fig. 9 Chromatogram of *Curcuma caesia* a Field-grown mother plant b Un-treated cultures c Cultures treated with 0.05 mg/l AgNP.

Fig. 10 (a) *Curcuma caesia* cultures with different sucrose concentrations; C. *caesia* cultures with (b) 1.5% sucrose (Control) (c) 1.5% sucrose + 1 IBA (d) 3% sucrose + 1 IBA (e) 6% sucrose + 1 IBA (f) 9% sucrose + 1 IBA (g) 12% sucrose + 1 IBA (h) C. *caesia* cultures with different AgNP concentrations; C. *caesia* cultures with (i) 6% sucrose + 1 IBA + 0 AgNP (j) 6% sucrose + 1 IBA + 0.025 AgNP (k) 6% sucrose + 1 IBA + 0.05 AgNP (l) 6% sucrose + 1 IBA + 0.075 AgNP, and (m) 6% sucrose + 1 IBA + 0.1 AgNP

Table 1 Effect of ½ strength liquid Murashige and Skoog (1962) medium with Indole-3-butyric acid and different sucrose concentrations on the morphology of *Curcuma caesia* cultures.

½ MS liquid medium containing 1 mg/IBA & Sucrose	Shoot Number	Shoot Length (cm)	Root Number	Root Length (cm)	Microrhizome Fresh Weight (mg)	Microrhizome Dry Weight (mg)
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
1.5% Sucrose (Control)	2.40 ±0.13a	1.71 ±0.14c	4.86 ±0.29c	2.32 ±0.11c	28.23 ±3.93a	1.83 ±0.29b
1.5% Sucrose + IBA	2.46 ±0.23a	2.02 ±0.10b	7.80 ±0.39a	3.03 ±0.09b	30.83 ±3.88a	2.06 ±0.37b
3% Sucrose + IBA	2.46 ±0.21a	2.35 ±0.15a	6.40 ±0.23b	5.14 ±0.10a	34.46 ±9.06a	1.73 ±0.30b
6% Sucrose + IBA	2.80 ±0.20a	1.37 ±0.08d	5.86 ±0.37b	1.95 ±0.06d	35.33 ±3.27a	5.13 ±0.44a
9% Sucrose + IBA	1.60 ±0.13b	0.98 ±0.09e	1.53 ±0.13d	0.49 ±0.03e	32.46 ±3.03a	5.60 ±0.58a
12% Sucrose + IBA	1.00 ±0.00c	0.84 ±0.06e	0.06 ±0.04e	0.03 ±0.02f	26.66 ±3.15a	5.40 ±0.68a
ANOVA	df	F	p			
Shoot Number	5	15.61	<0.0001			
Shoot Length	5	28.21	<0.0001			
Root Number	5	118.35	<0.0001			
Root Length	5	539.38	<0.0001			
Microrhizome Fresh Weight	5	0.49	0.78			
Microrhizome DryWeight	5	24.91	<0.0001			

Values are represented as mean ±standard error. Means denoted with different letters are significantly different at $p < 0.05$ (DMRT) compared using ANOVA.

Table 2 Effect of silver nanoparticles (AgNP) with 6% sucrose and 1 mg/l IBA on morphology of *Curcuma caesia* cultures.

½ MS liquid medium with 6% sucrose & 1 mg/l IBA + AgNP (mg/l)	Shoot Number	Shoot Length (cm)	Root Number	Root Length (cm)	Microrhizome Fresh Weight (mg)	Microrhizome Dry Weight (mg)
	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE	Mean ±SE
0	1.03 ±0.03a	1.76 ±0.12a	2.03 ±0.30b	1.01 ±0.08b	53.73 ±4.33bc	7.13 ±0.71b
0.025	1.16 ±0.06a	1.75 ±0.12a	1.93 ±0.25b	0.84 ±0.06b	64.10 ±3.93ab	8.03 ±0.77ab
0.05	1.20 ±0.07a	1.72 ±0.08a	3.00 ±0.39a	1.45 ±0.02a	63.56 ±4.77ab	8.16 ±0.52ab
0.075	1.10 ±0.05a	1.52 ±0.15a	0.96 ±0.25c	0.50 ±0.09c	48.56 ±5.80c	9.60 ±0.96a
0.1	1.23 ±0.09a	1.81 ±0.11a	2.06 ±0.38b	1.36 ±0.09a	73.43 3.52a	9.60 ±0.79a
ANOVA	df	F	p			
Shoot Number	4	1.40	0.23			
Shoot Length	4	0.80	0.52			
Root Number	4	4.87	0.001			
Root Length	4	25.09	<0.0001			
Microrhizome Fresh Weight	4	4.57	0.002			

Microrhizome Dry Weight	4	1.96	0.10			
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Values are represented as mean \pm standard error. Means denoted with different letters are significantly different at $p < 0.05$ (DMRT) compared using ANOVA.

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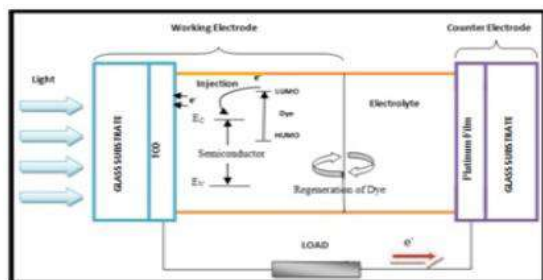
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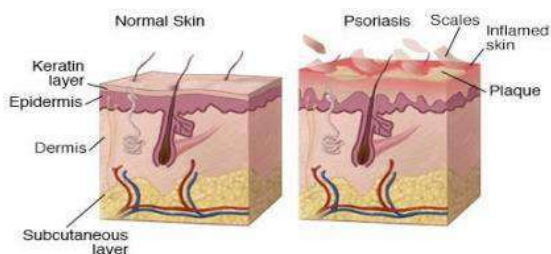
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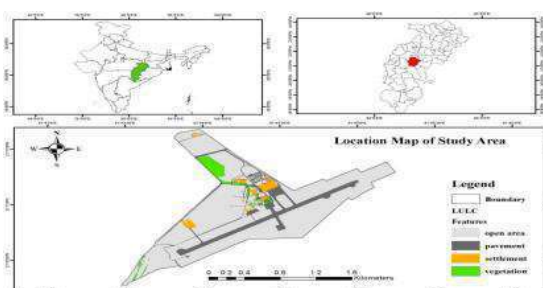
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Response surface optimization of cellulase production by *Aspergillus stellatus* NFCCI 5299 in shake flask submerged fermentation using wheat bran

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Abstract

The expense of cellulase enzymes is the main barrier to the enzymatic saccharification of biomass. Numerous tactics, such as the utilizing inexpensive lignocellulosic substrates as well as economically feasible fermentation techniques for the production of the enzyme may reduce the cost of cellulases. The present investigation was aimed to improve cellulase production employing potential cellulolytic soil fungi, *Aspergillus stellatus* NFCCI 5299 using wheat bran as substrate. Employing response surface methodology (RSM) with central composite design (CCD), the most efficient process parameters were determined. The ideal conditions for the synthesis of carboxy methyl cellulase (CMCase) and filter paper cellulase activity (FPase) were 6 days of incubation, inoculum size of 4 mycelial disc, 125 rpm of agitation, and 3.5% of wheat bran. The significant mycelial development and enzymatic digestion of wheat bran were discovered by scanning electron microscopy (SEM) and fourier transform infrared (FTIR) analysis. The findings suggested that it can be practicable to use wheat bran as substrate under submerged fermentation utilizing *Aspergillusstellatus* NFCCI 5299 for efficient cellulase production.

Keywords *Aspergillus* · Cellulase · CMCase · Fpase · RSM-CCD · Wheat bran

Introduction

An apprehension over pollution caused by agro-industrial waste products has sparked interest in recycling waste materials to produce goods with a high commercial value. Crop leftovers (remaining stalks, rice straw, leaves, corn husks, wheat bran, etc.) are readily available and effortlessly renewable. The food business generates a considerable volume of waste, which can be recycled and converted into the variety of valuable products (Sirohi et al. 2019). Agricultural wastes are huge source of lignocellulosic biomass and can

easily be digested by microorganisms primarily by fungi, making it appropriate for enzyme production. It consists of three major polymers viz., cellulose, hemi-cellulose, and lignin. Huge amount of cellulose is produced every year making this polysaccharide an immense natural carbon repository on the planet (Goukanapalle et al. 2020). Wheat bran is a major contributor of agricultural waste, a key crop grown worldwide, mostly for human consumption and cattle feed. There are three main portions in a wheat kernel, namely endosperm, germ, and bran. Wheat bran consists of a lot of nutrients viz., fibre, minerals, vitamins, as well as phenolic compounds which are all significant components of a healthy diet. Due to its immense nutrition value, it can be utilized as cost effective substrate for production of industrially important enzymes like cellulases (Saini et al. 2017). Cellulases are responsible for digesting the cellulose's β -1, 4-glucosidic linkages to produce glucose, cellobiose, and cello-oligosaccharides as their main by-products. These multi-component enzymes are made up of endoglucanases (EG), cellobiohydrolases (CBH) and β -glucosidases (BGL). Endo-glucanases work on the cellulose polymer to cleave it, exposing the reducing and non-reducing ends. Cellobiohydrolases then act on these ends to

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release cello-oligosaccharides and cellobiose units. Later, cellobiose was broken down by glucosidases into glucose, concluding the hydrolysis. Therefore, this enzyme make complex with components of CBH, EG, and BGL and works to convert crystalline cellulose to glucose. Due to its numerous industrial applications, these enzymes have been ranked as the third-largest industrial enzymes in the World (Castro Ochoa et al. 2023). Submerged fermentation (SmF) has conventionally been used to produce industrially significant enzymes and is mostly favoured due to sufficient agitation and aeration, among other factors. To make the process economically viable, there should be also better control over environmental variables like temperature, pH and they are easy to handle (Matker et al. 2013; Meena et al. 2018). It is necessary to develop an appropriate approach for process optimization that affects the final output of enzyme. The traditional method of optimizing various physicochemical parameters involves adjusting one-factor-at-a-time (OFAT) and it works as long as only a small number of variables have an impact on the production process. This method does not, however, depict the cumulative influence of all the contributing factors. It demands patience and the conduct of numerous tests (Hajji et al. 2008; Braga et al. 2011; Abdullah et al. 2021). As a result, it was discovered that the conventional one-factor-at-a-time (OFAT) technique for the optimization process takes more time. However, it also performs the function of providing a rough estimate of the ideal levels. Response Surface Methodology (RSM), which combines statistical and mathematical methodologies, can be used to circumvent this issue. Researchers can analyze the interactions between all the variables and responses during the experiments by using RSM to construct the experiments (Verma et al. 2020; Shaktimay et al. 2010; Vishwanatha et al. 2010; Nisar et al. 2020). By selecting a fungal strain that is complementary to the substrate, cellulase production can be increased. Different types of agro-industrial waste has been documented in the literature viz., rice straw, rice bran, wheat bran, coir waste, pea hulls, sugarcane bagasse etc., utilizing *Aspergillus* spp. However, the potential of *Aspergillus stellatus* for producing cellulases has not been fully investigated so far. Therefore, the goal of this study is to determine the efficiency of *Aspergillus stellatus* under shake flask submerged fermentation affecting the yield of cellulases utilizing wheat bran.

Material and methods

Chemicals

Carboxy methyl cellulose sodium salt, analytical-grade chemicals were utilized throughout the entire experimental process. Ammonium sulphate, dinitrosalicylic acid,

magnesium sulphate, malt extract, potassium dihydrogen phosphate, potato dextrose agar, tri-sodium citrate, yeast extract were procured from Sigma-Aldrich and Himedia Laboratories Pvt. Ltd. Mumbai, India.

Fungal strain and morphological characterization

The potent cellulolytic fungal strain *Aspergillus stellatus* NFCCI 5299 was isolated from soil sample which was obtained from the vicinity of Pt. Ravishankar Shukla University, India. On the basis of their cultural and morphological traits, the potent cellulolytic fungi was characterized after seven days of incubation on Czapek Dox yeast extract agar (CYA), malt extract agar (MEA), and potato dextrose agar (PDA). The colony's diameter, texture, presence of pigmentation, and exudates were determined. To better recognize conidial traits, the fungal species were identified using both a slide culture technique and an adhesive tape method. The fungal identification was done in accordance with the literature (Klich et al. 2002), Leica DM750 microscope with Leica ICC50 digital camera was used to conduct the identification. Software Leica LAS V. 3.8.0 was used to examine the photos.

Inoculum preparation

The fungus was preserved at 4 °C on potato dextrose agar slants. Inoculum was made by allowing the cultures to grow on malt extract agar at 28 °C for 7 days, until the sufficient fungal growth was observed. For inoculation, a 10 mm diameter mycelial disc was employed.

Preparation of substrate

Wheat bran, one of the most prevalent agro-industrial waste was procured from the nearby farm of Raipur, Chhattisgarh, India. The substrate was washed, allowed to dry in sun and grounded to a fine powder.

Alkaline pre-treatment of wheat bran

Wheat bran along with NaOH (0.2 g NaOH/g dry wheat bran) and de-ionized water (15 g H₂O/g dry wheat bran) were added in a beaker and heated to 100 °C with continuous stirring for 1 h on a hot plate. After this alkaline treatment, pH of the solution was maintained using 0.1N HCl to the final pH of 5. The soluble product of this solution was removed by washing with distilled water and leftover solid biomass was then dried at 50 °C for 12 h in an incubator. This dried biomass was used as a substrate for fermentation (Lodha et al. 2020).

Submerged fermentation

Vogel's media was used for the enzyme production. The media consisted of tri-sodium citrate (0.5%), potassium dihydrogen phosphate (0.5%), ammonium sulphate (0.4%), magnesium sulphate (0.02%), yeast extract (0.1%) dissolved in 100 ml distilled water in a conical flask. In this study, submerged fermentation was used for the synthesis of cellulases. Dried wheat bran was incorporated in the flask containing 50 ml of Vogel's media, mixed gently and autoclaved at standard temperature and pressure. Mycelial disc (10 mm) was inoculated in each flask. However, the concentration of wheat bran and amount inoculum were varied as per experimental design. After the inoculation, flasks were shifted to shaking incubator for different time of incubation, and agitation speed. The culture broth was filtered to obtain crude enzyme which was used further for enzyme assay.

Enzyme assay

CMCase and FPase activity were determined according to the method of Wood and Bhat (1988) and dinitrosalicylic acid (DNSA) method (Miller 1959) was used for the estimation of reducing sugar.

CMCase assay

1 ml of citrate buffer (pH 4.5), 0.5 ml of 1% CMC (w/v) as a substrate, 0.5 ml of enzyme extract and the mixture were incubated at 50 °C for 30 min and further reaction was ceased by the addition of 3 ml DNSA reagent to the mixture. The mixture was boiled for 15 min until color change was observed in the reaction mixture. 1 ml of Rochelle salt and distilled water up to 7 ml were added before the cooling of the reaction mixture for stabilizing the color change formation. 1 ml citrate buffer and 0.5 ml undiluted enzyme extract were used as control and absorbance at 540 nm was noted. One unit of CMCase was defined as the amount of enzyme that release one micromole of glucose performed under standard reaction condition.

FPase assay

Filter paper activity of the culture filtrate was measured. The concoction was prepared by taking 1 ml of citrate buffer (pH 4.5), Whatman no. 1 filter paper (1 × 6), 0.5 ml of crude enzyme, and the mixture was incubated at 50 °C for 60 min. The reaction was ceased by the addition of 3 ml DNSA reagent to the mixture and boiled for 15 min until color change was observed in the reaction mixture. 1 ml of Rochelle salt and distilled water up to 7 ml was added before the cooling

of the reaction mixture for stabilizing the color change formation and absorbance at 540 nm was noted.

Response surface methodology

RSM modelling was used in the current work to optimize the crucial physicochemical parameters. Using the central composite design (CCD) with four independent variables, the statistical model was created. The parameters viz., the incubation period (2–10 days), inoculum size (2–6 mycelial disc, 10 mm), agitation rate (75–175 rpm) and wheat bran (0.5–6.5%) were selected as important factors as per the literature review. Their effect on CMCase and FPase activity was analyzed employing a 2⁴ full factorial central composite design with 30 runs. Under 150 ml of Erlenmeyer flask with 50 ml of production medium in submerged fermentation, the experiments were carried out in triplicates.

The experimental results were fitted using second-order polynomial equation:

$$Y = \beta_0 + \sum \beta_i X_i + \sum \beta_{ij} X_i X_j + \sum \beta_{ii} X_i^2$$

where Y is the predicted response, β_0 is the intercept term, β_i is the linear coefficient, β_{ij} is the quadratic coefficient and β_{ii} is the interaction coefficient.

The analysis of cellulase activities (FPase, CMCase) was done using ANOVA together with the F-test. The model's lack of fit, adequacy in terms of precision, and effectiveness in predicting the response were evaluated. The coefficient of determination (R^2) and adjusted R^2 were used to statistically assess the quality of the polynomial model equation. The design expert software (version 10.0.7.0-×64) was used to create all three-dimensional response surface plots.

Experimental validation

Experiments have been carried out independently with optimal levels of medium components in shake flasks to validate the statistical model and its predictions. The observed ideal levels of parameters were maintained. Following incubation, culture filtrate was removed and tested for CMCase and FPase activity as mentioned earlier.

Degradation study of wheat bran

FTIR spectra was employed to examine the structural alterations in fermented wheat bran samples using Bruker alpha, FTIR spectrophotometer, in the range of 400–4000 cm^{-1} , with resolution of 4 cm^{-1} . Bran specimens were prepared by combining some potassium bromide in moderate amounts.

Sixteen scans were recorded at room temperature to acquire the absorbance. The analysis of degradation in fermented wheat bran was carried out using a Karl and Zeiss (Germany SEM 50) Scanning electron microscope (SEM). Samples were gold coated before observation.

Results

Colonial and morphological characterization of *Aspergillus stellatus* NFCCI 5299

Colonies in CYA had a velvety appearance, were initially slow-growing, sulcate in pattern, and reversed dull brown with pigments present. On PDA, however, colonies showed a darker shade of green, were slightly floccose and velutinous, and had exudates on their surface. On MEA, colonies that were initially yellowish green turned dark green with time. No exudates were discovered, but the colony's reverse was seen to have a dark brown hue due to the presence of pigments. Green colored, radiating conidial heads were observed and were found to be columnar in shape and free forming. The phialides (8.2–9 × 2.6–2.9 μm) were colorless and biseriate along with the presence of metulae (4.2–6.5 × 1.7–2.0 μm). The shape of the phialides was found to be ampuliform. The vesicles observed were hemispherical in shape ranging in diameter from 10–11.5 μm. Green, rough-walled conidia was observed, entirely globose in shape and had a diameter of 2.4 to 3.0 μm. Spherical cleistothecia with many hulle cells (320–400 μm in diameter) were seen along with smooth and straight conidiophores. The hyphae of the fungi were found to be septate (Fig. 1).

Effect of fermentation parameters on CMCase and FPase production using central composite design

Response surface approach incorporates interaction effects between the discrete variables assisting in the simultaneous optimization of several process parameters throughout the course of the fewest possible experimental runs (Table 1). In the current study, *Aspergillus stellatus* NFCCI 5299 was employed to optimize the independent fermentation parameters, including incubation period, inoculum size (10 mm mycelial disc), agitation rate (RPM) and concentration of wheat bran (g/100 ml) using four factor central composite design (CCD). With all of the conceivable combinations of these four independent variables, a series of 30 tests were carried out with four coded levels (−2, −1 and +2, +1). All of the selected factors were discovered to have a favorable impact on the synthesis of cellulases for both CMCase and FPase activities. According

to RSM simulation, the quadratic model was the best strategy for elucidating the relationship between responses and parameters. A second-order polynomial equation demonstrated the experimental relationship between the distinct variables and responses (CMCase and FPase), which are provided in Eq. (1) and Eq. (2).

$$\begin{aligned} \text{CMCase activity: } Y = & +0.51 - 0.057 * A - 7.083E \\ & - 003 * B - 0.016 * C \\ & + 1.667E - 003 * D \\ & - 0.012 * AB - 0.017 * AC \\ & - 5.000E - 003 * AD \\ & + ;0.019 * BC - 8.750E \\ & - 00. * BD - 0.011 * CD \\ & - 0.076 * A^2 - 2.812E \\ & - 003 * B^2 - 8.437E - 003 * C^2 \\ & - 2.187E - 003 * D^2 \end{aligned} \quad (1)$$

$$\begin{aligned} \text{FPase activity: } Y = & +0.62 + 0.018 * A + 0.017 * B \\ & + 3.750E - 003 * C + 8.167E \\ & - 003 * D - 0.026 * AB \\ & - 0.032 * AC - 8.125E \\ & - 003 * AD + 0.028 * BC \\ & + 6.875E - 00. * BD \\ & - 0.022 * CD - 0.11 * A^2 \\ & - 0.013B^2 - 1.625E - 003 * C^2 \\ & + 0.014 * D^2 \end{aligned} \quad (2)$$

where Y is the CMCase/FPase activity (IU/ml), A is incubation period (days), B is inoculum size (10 mm mycelial disc), C is the agitation rate (rpm), D is wheat bran (g/100 ml). AB, AC, AD, BC, BD and CD represent interaction effect among variables, whereas quadratic effect is shown as A^2 , B^2 , C^2 and D^2 .

Using design expert software 10.0.7.0, the F-test (Fischer's test) for ANOVA was employed to statistically evaluate the quadratic model for CMCase and FPase activity as shown in Tables 2 and 3. The findings revealed that the values of "Prob > F" less than 0.0500 indicate highly significant regression model. The resulting F-value of 45.81 and 11.55 inferred that the quadratic model is significant and the large F-value is caused by noise only which happens with a 0.01% chance. A, C, AB, AC, BC, CD, A^2 , C^2 were found to be significant model terms for CMCase activity. However, AC, BC, A^2 were significant model terms for FPase. Values greater than 0.1000 indicate that the model terms are not significant. The "Lack of Fit F-value" of 0.85 and 0.65 for CMCase and FPase indicates that the lack of fit is not

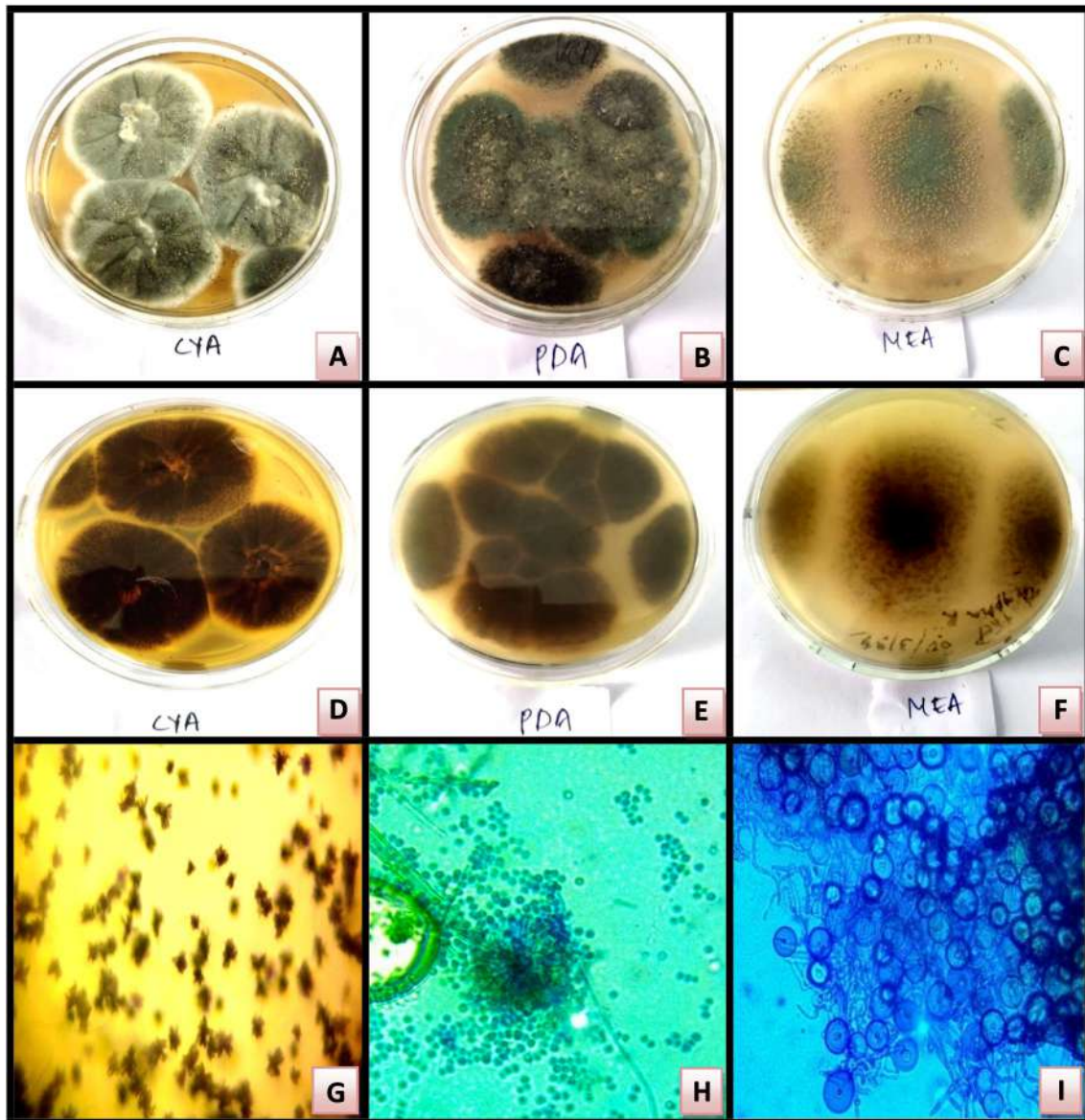


Fig. 1 Colonial characteristics of *A. stellatus* NFCCI 5299 (Obverse and Reverse): CYA (A, D); PDA (B, E); MEA (C, F); (G) conidial heads ($\times 100$); (H) Aspergillus vesicle; (I) Hulle cells

significant relative to the pure error. This demonstrated the model's precision and assisted in fitting the present model. The analysis of coefficient R^2 , predicted R^2 , and an adequate precision helped to identify the model's accuracy and dependability. The signal-to-noise ratio is measured using an indicator termed adequate precision. The ratio greater than 4 is recommended. The calculated ratio of 29.59 and 15.09 for CMCase and FPase activity, suggests a strong signal. Consequently, it is possible to navigate the design space using this approach. In case of CMCase activity, the "Pred R-Squared" value of 0.9051 for CMCase activity was in acceptable agreement with the "Adj R-Squared" of 0.9558, whereas the "Pred R-Squared" of 0.6702 was in acceptable

agreement with the "Adj R-Squared" of 0.8358 for FPase activity i.e., the difference was less than 0.2 which essentially states that the existing model fits the experimental data pretty well. The model's ability to predict the outcome increases as R^2 approaches 1. It has also been confirmed that the expected CMCase and FPase activity closely matched with the activity that was actually observed. Figure 2 shows the experimental and predicted values of the model, and the fact that the data points are clustered along the diagonal line indicates that the model is reliable. To comprehend the impact of variable interactions and to determine the ideal values of each parameter for achieving the highest FPase and CMCase yields, response surface curves were plotted. By

Table 1 Factors and their level used for optimum cellulase production by RSM method

S. No.	Factor 1 incubation days	Factor 2 inoculum 10 mm mycelial disc	Factor 3 agitation rpm	Factor 4 wheat bran (g/100 ml)	Carboxy methyl cellulase activity IU/ml		Filter paper activity FPU/ml	
					Observed	Predicted	Observed	Predicted
1	6	4	125	3.5	0.50	0.50	0.70	0.69
2	2	4	125	3.5	0.35	0.32	0.18	0.14
3	8	3	150	5	0.32	0.32	0.45	0.45
4	4	3	150	2	0.44	0.45	0.50	0.47
5	6	2	125	3.5	0.51	0.51	0.56	0.54
6	8	3	150	2	0.35	0.34	0.52	0.51
7	6	4	125	3.5	0.50	0.51	0.63	0.62
8	6	4	125	3.5	0.50	0.51	0.68	0.62
9	8	3	100	2	0.41	0.42	0.52	0.58
10	8	5	100	2	0.36	0.36	0.52	0.49
11	6	4	125	0.5	0.51	0.50	0.68	0.66
12	6	4	75	3.5	0.51	0.51	0.65	0.61
13	6	4	125	3.5	0.55	0.51	0.62	0.62
14	8	5	150	2	0.35	0.36	0.55	0.54
15	4	5	150	2	0.49	0.51	0.54	0.60
16	4	5	100	5	0.45	0.47	0.49	0.52
17	6	4	125	3.5	0.50	0.51	0.65	0.62
18	4	5	150	5	0.49	0.49	0.65	0.60
19	8	3	100	5	0.47	0.45	0.65	0.61
20	4	5	100	2	0.45	0.45	0.42	0.43
21	6	4	175	3.5	0.45	0.44	0.61	0.62
22	6	6	125	3.5	0.50	0.48	0.61	0.61
23	6	4	125	3.5	0.49	0.51	0.65	0.62
24	4	3	100	2	0.45	0.46	0.39	0.41
25	10	4	125	3.5	0.07	0.09	0.20	0.21
26	6	4	125	3.5	0.51	0.51	0.51	0.62
27	8	5	100	5	0.36	0.36	0.51	0.55
28	8	5	150	5	0.31	0.30	0.51	0.51
29	4	3	100	5	0.51	0.51	0.45	0.47
30	4	3	150	5	0.45	0.46	0.40	0.45

using 3D response surface plots against any two independent factors and their respective enzyme production while keeping other variables at their center (0) level, the interactive effects of variables on the production of these enzymes were examined. The 3D plots revealed that the highest CMCase and FPase activities occurred at moderate levels of the incubation period, inoculum size, and agitation rate and wheat bran concentration. The predictions of the quadratic model indicated highest CMCase and FPase activity of 0.508 IU/ml and 0.623 IU/ml, which is possible with the ideal values of bioprocess parameters viz., incubation period (6 days), inoculum size (4 disc of 10 mm diameter), agitation rate (125 rpm) and 3.5% wheat bran. With the projected optimum values of various parameters, shaking flask experiments were used to validate the final optimized media. The value obtained of 0.508 IU/ml for experimental CMCase activity

as optimized media is in remarkable agreement with the predicted value of 0.500 IU/ml. FPase activity was experimentally determined to be 0.623 IU/ml, which is in line with the predicted value of 0.630 IU/ml (Table 4). It shows that created model was effective and reliable for predicting the biosynthesis of both CMCase and FPase by *Aspergillus stellularis* NFCCI 5299.

Graphical interpretation of 3D response surface plots

The three-dimensional response surface graphs were plotted to comprehend the impacts of variable interactions and to determine the ideal values of each parameter for achieving the highest CMCase and FPase yields. The computed responses from the response surface plots by interactions

Table 2 ANOVA of quadratic model for CMCase activity

Source	Sum of squares	Df	Mean square	F- value	p value	Prob > F
Model	0.26	14	0.019	45.81	<0.0001	<i>Significant</i>
A-Incubation period	0.077	1	0.077	188.16	<0.0001	
B-Inoculum size	1.204E-003	1	1.204E-003	2.94	0.1070	
C-Agitation speed	6.017E-003	1	6.017E-003	14.69	0.0016	
D-Wheat bran	6.667E-005	1	6.667E-005	0.16	0.6923	
AB	2.500E-003	1	2.500E-003	6.10	0.0260	
AC	4.900E-003	1	4.900E-003	11.96	0.0035	
AD	4.000E-004	1	4.000E-004	0.98	0.3387	
BC	5.625E-003	1	5.625E-003	13.73	0.0021	
BD	1.225E-003	1	1.225E-003	2.99	0.1043	
CD	2.025E-003	1	2.025E-003	4.94	0.0420	
A ²	0.16	1	0.16	386.17	<0.0001	
B ²	2.170E-004	1	2.170E-004	0.53	0.4779	
C ²	1.953E-003	1	1.953E-003	4.77	0.0453	
D ²	1.312E-004	1	1.312E-004	0.32	0.5797	
Residual	6.144E-003	15	4.096E-004			
Lack of Fit	3.860E-003	10	3.860E-004	0.85	0.6175	<i>Not significant</i>
Pure error	2.283E-003	5	4.567E-004			
Cor Total	0.27	29				

between the factors are represented in Fig. 3 and 4. Inoculum sizes and incubation time have an impact on CMCase activity as shown in Fig. 3a, and their interactions are shown to be significant. However, in case of FPase activity (Fig. 4a), they were found to be insignificant. The 3D graph shows that CMCase activity rises with longer incubation times and then falls off. Varying the inoculum size does not have any significant effects, however varying incubation period, inoculum size enhanced FPase production at moderate levels and later on declined. Similar outcomes can be seen when incubation time and agitation speed were combined (Figs. 3b, 4b). Both interactions were confirmed to be statistically significant for both CMCase and FPase yield. Although varied levels of agitation rate had no significant impact, further moderate levels of incubation time led to maximal CMCase activity and FPase activity. A 3D plot between CMCase and FPase activity for incubation time vs wheat bran was shown in Figs. 3c and 4c. However, modest levels of incubation period led to elevated CMCase and FPase activity, which dropped after extended incubation period. Both interactions were discovered to be insignificant. Wheat bran also had no noticeable effect on the production of enzymes. Figures 3d and 4d demonstrated the response surface plot as a function of inoculum size vs. agitation speed. CMCase and FPase yield increased marginally at moderate agitation rates, but inoculum size had no discernible effect. A response surface plot as a function of inoculum size and wheat bran was

shown in Figs. 3e and 4e. No enzyme output was seen and the interactions were not statistically significant. A plot was shown in Figs. 3f and 4f as a function of agitation speed and wheat bran.

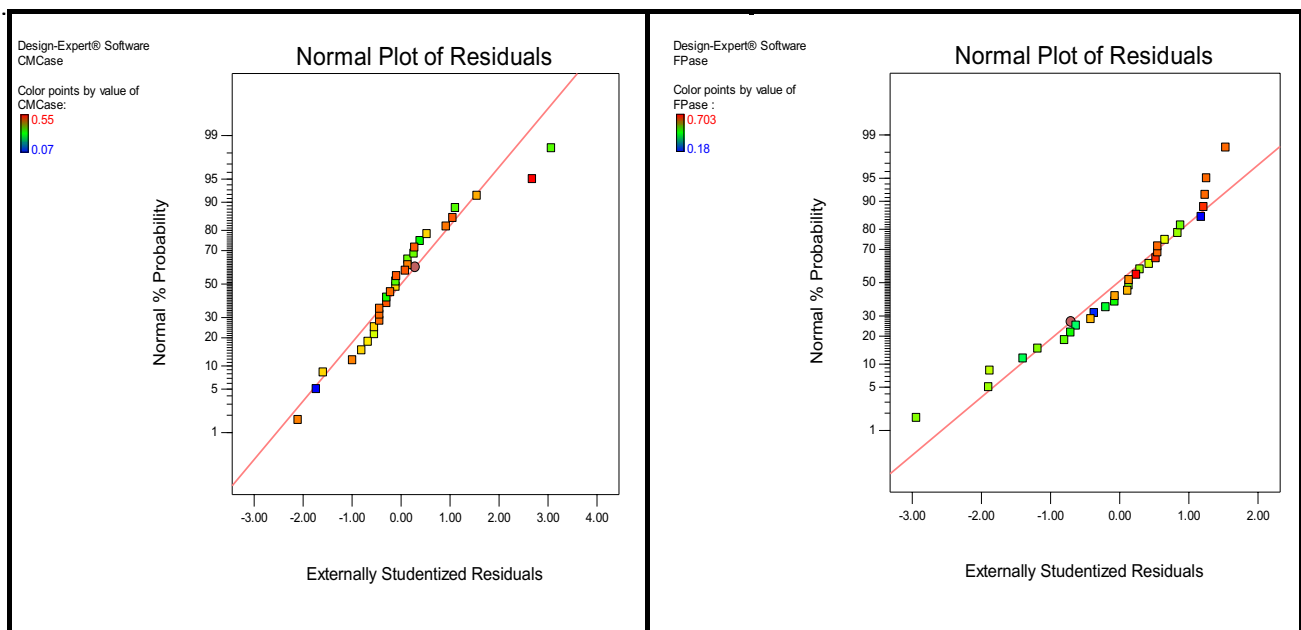
Structural assessment of wheat bran before and after fermentation

FTIR analysis

The findings showed that crude enzyme produced from *Aspergillus stellatus* NFCCI 5299 was good at hydrolyzing wheat bran. According to the FTIR spectra of the unfermented and fermented wheat bran, the modifications to the functional groups of wheat bran after fermentation were examined (Fig. 5). FTIR of pre-treated wheat bran showed medium and sharp peaks at 3562.20, 3552.34, 3518.69, 3364.36, and 3345.61 cm^{-1} indicating O–H stretching. Whereas the new peak of fermented wheat bran was generated due to the degradation of wheat bran at a range at 3209.84 cm^{-1} and 3104.44 cm^{-1} which is an attribute of the stretching vibration of the O–H bond in polysaccharides. This peak includes intermolecular hydrogen bond vibration in cellulose. The medium and sharp absorption bands at 3091.02, 3065.99, 3039.59, 3023.22, 2937.11 and 2908.68 cm^{-1} were also observed in fermented wheat

Table 3 ANOVA of quadratic model for FPase activity

Source	Sum of squares	Df	Mean square	F- value	p value	prob > F
Model	0.44	14	0.031	11.55	<0.0001	<i>Significant</i>
A-Incubation period	7.704E-003	1	7.704E-003	2.86	0.1114	
B-Inoculum Size	7.004E-003	1	7.004E-003	2.60	0.1276	
C-Agitation speed	3.375E-004	1	3.375E-004	0.13	0.7282	
D-Wheat Bran	1.601E-003	1	1.601E-003	0.59	0.4527	
AB	0.011	1	0.011	3.90	0.0669	
AC	0.016	1	0.016	6.04	0.0267	
AD	1.056E-003	1	1.056E-003	0.39	0.5405	
BC	0.013	1	0.013	4.70	0.0466	
BD	7.562E-004	1	7.562E-004	0.28	0.6039	
CD	7.656E-003	1	7.656E-003	2.84	0.1124	
A ²	0.34	1	0.34	126.93	<0.0001	
B ²	4.547E-003	1	4.547E-003	1.69	0.2134	
C ²	7.243E-005	1	7.243E-005	0.027	0.8719	
D ²	5.186E-003	1	5.186E-003	1.93	0.1855	
Residual	0.040	15	2.693E-003			
Lack of Fit	0.023	10	2.285E-003	0.65	0.7364	<i>Not significant</i>
Pure Error	0.018	5	3.507E-003			
Cor Total	0.48	29				

**Fig. 2** Plot depicting the distribution of actual and experimental value of a FPase and CMCCase activity

bran which is attributed to C-H stretching vibration of all hydrocarbon constituents in polysaccharides. More peaks at 1638.51, 1423.23, 1081.15, 407.65, and 433.11 cm^{-1} were observed in unfermented wheat bran. However, after saccharification the fermented wheat bran showed new strong and broad peaks at 1637.15 cm^{-1} and 1661.78 cm^{-1} indicating the C=C stretching which was considered as the

double bond region. Further, sharp band at 1401.33 cm^{-1} in fermented wheat bran indicated O-H bending and medium to broad absorbance peak at the range of 1092 cm^{-1} indicated C-O-C stretching, this region indicated the fingerprint region. The signal at 634.59 cm^{-1} , 618.09 cm^{-1} indicated the C-OH out-of-plane bending mode. The absorption band at

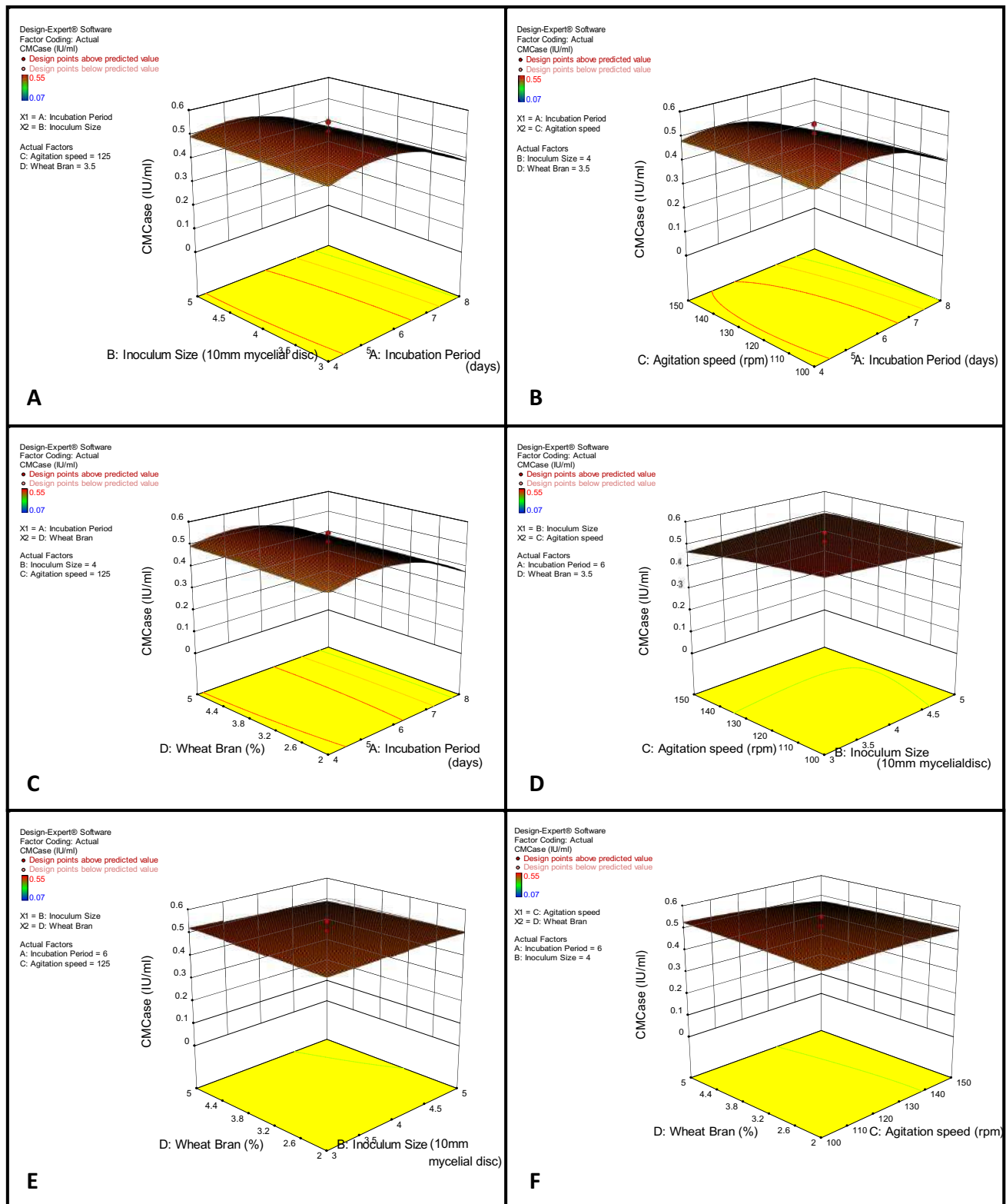


Fig. 3 For optimal CMCase production: Response surface graphs illustrating the interactions between factors in the cellulose conversion to reducing sugars: interaction between (A) inoculum size & incubation period (B) agitation speed & incubation period (C) wheat

bran (%) & incubation period (D) agitation speed & inoculum size (E) wheat bran (%) & inoculum size (F) wheat bran (%) & agitation speed

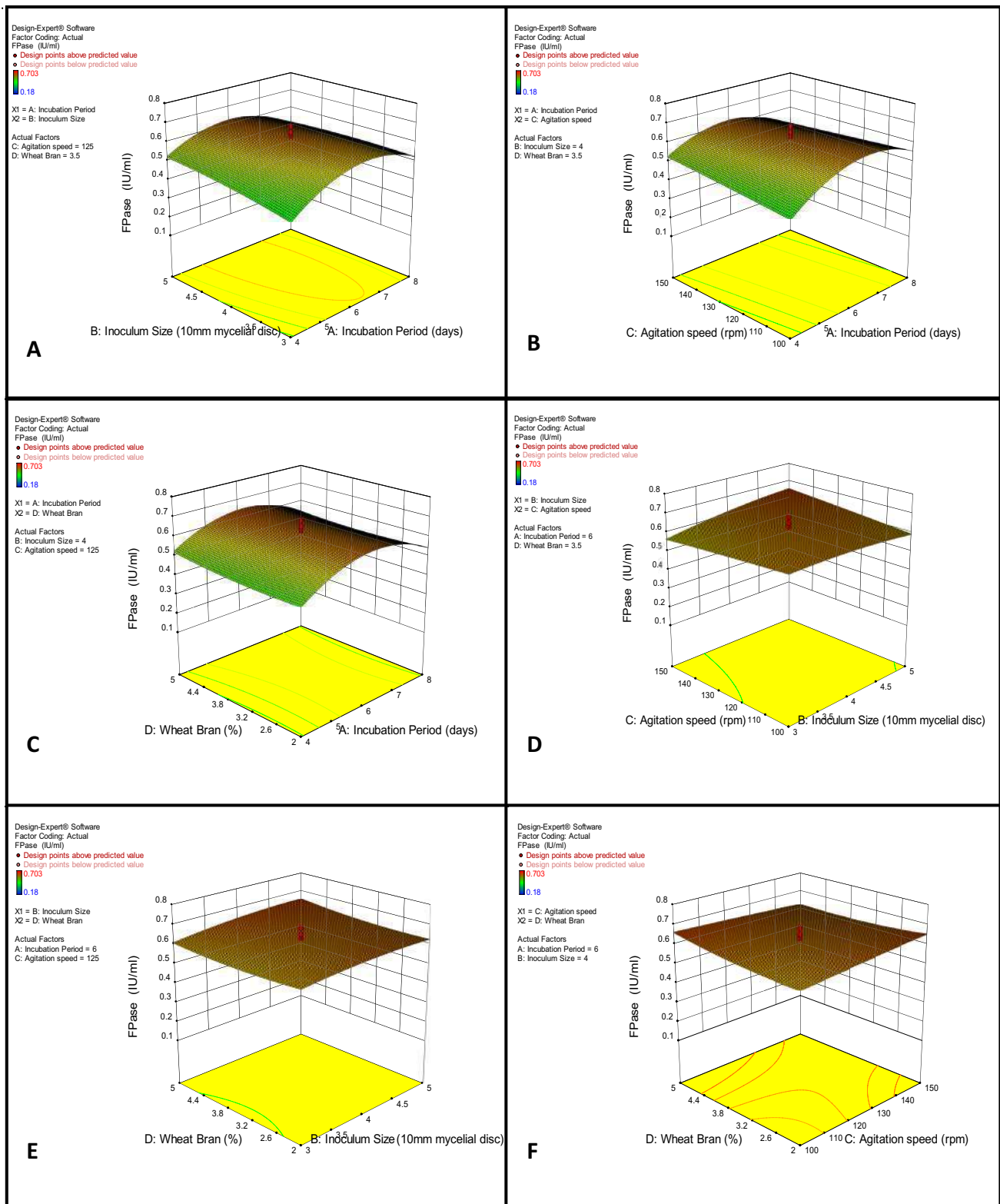
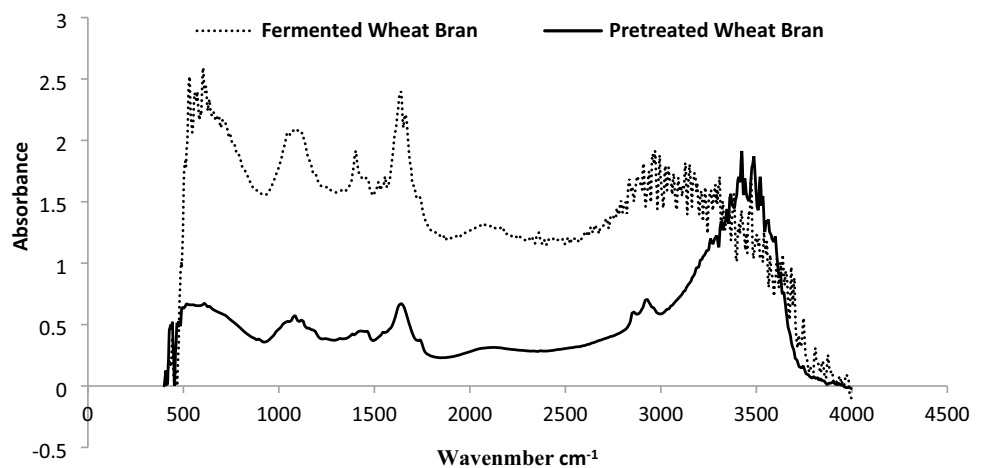


Fig. 4 For optimal FPase production: Response surface graphs illustrating the interactions between factors in the cellulose conversion to reducing sugars. Interaction between (A) inoculum size & incubation

period (B) agitation speed & incubation period (C) wheat bran (%) & incubation period (D) agitation speed & inoculum size (E) wheat bran (%) & inoculum size (F) wheat bran (%) & agitation speed

Fig.5 FTIR spectra for pre-treated/unfermented and fermented wheat bran using *Aspergillus stellatus* NFCCI 5299



531.31, 487.97, 460.76, 442.41 cm^{-1} is the characteristic of β -glycosidic linkage between glucose units.

SEM analysis

The structure and surface morphology of alkaline pre-treated/unfermented and fermented wheat bran were studied using SEM analysis. Extensive mycelial proliferation on fermented wheat bran and mycelial invasion in bran pores was evident in the SEM image. However, the control image of chemically pre-treated/unfermented wheat bran revealed the thick textures and intact surfaces. The breakdown and alteration of the fibre structure as well as an increase in pores and cavities were caused by the fungal proliferation on fermented wheat bran (Fig. 6). In addition, the exposed surfaces of the fermented wheat bran were greater than those of the pre-treated/unfermented wheat bran Table 4.

Discussions

Utilizing cellulolytic microbes in place of chemical and mechanical processing of cellulose has been recognized as being more eco-sustainable approach. Numerous cellulolytic microbes have been discovered in a variety of habitats, including soil, organic waste, guts, animal waste, marine sediments, and seaweed. However, the available enzymatic repertoire is currently insufficient to fulfil industrial demands, thus efforts to obtain potent isolates from uncharted habitats are continuously being made. In this investigation, a potent cellulolytic fungal strain was isolated from soil sample. The colonial and morphological characteristics were found to be comparable with *Aspergillus* sp. Further, the organism was deposited at national fungal culture collection, India and identified as *Aspergillus stellatus* NFCCI 5299. The synthesis of extracellular cellulase is significantly impacted by fluctuations in the physical factors as well as substrate concentration. Therefore, one strategy to lower the cost of producing cellulase by microorganisms is

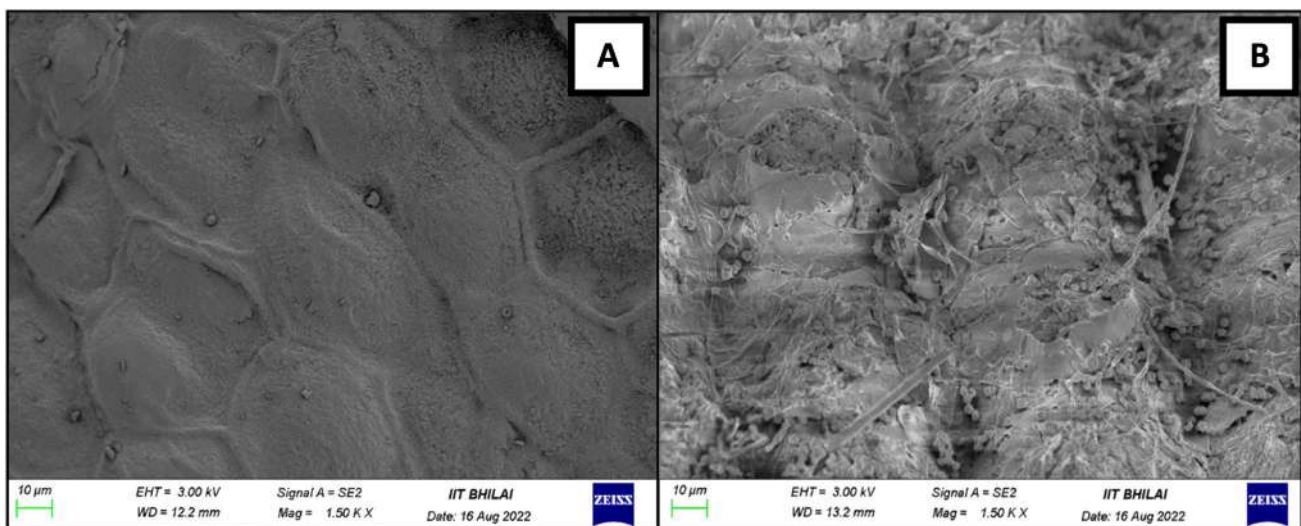


Fig. 6 SEM micrographs of wheat bran (A) pretreated/unfermented wheat bran (B) fermented wheat bran

Table 4 Validation of experimental design for cellulase production by *Aspergillus stellatus* NFCCI 5299

RSM optimized process parameters					
Incubation period (days)	Inoculum size (10 mm Mycelial disc)	Agitation rate(RPM)	Wheat bran (g/100 ml)	CMCase activity (IU/ml)	
				Predicted	Experimental
6	4	125	3.5	0.50	0.508
RSM optimized process parameters					
				Filter paper activity (FPU/ml)	
				Predicted	Experimental
6	4	125	3.5	0.63	0.623

to optimize each factor of the medium. RSM is a widely used statistical technique that uses cost efficient experimental designs and provides statistical assessments and predictions. To boost the CMCase and FPase production by *Aspergillus stellatus* NFCCI 5299, RSM was used in conjunction with CCD to optimize physical parameters including wheat bran concentration. The RSM simplified the optimization techniques in 30 trials. The model developed was found to be very effective in optimizing the chosen medium constituents which is evident from R^2 value 0.9051 for CMCase and 0.6078 for FPase. The model's ability to predict the outcome increases as R^2 approaches 1. When compared to earlier studies, the observed R^2 value was similar. The use of 3D plots, which enables the direct display of the individual and interactive interaction of variables, makes it possible to effectively optimize the synthesis of microbial enzymes. According to the 3D plots, the maximum CMCase and FPase activities took place during the moderate incubation period (6 days), inoculum size (4 disc of 10 mm diameter), agitation rate (125 rpm) and 3.5% wheat bran. Sravanan et al. (2012) reported similar results using Box-Behnken design for enzyme optimization with *Trichoderma reesei* and observed six days of incubation period for maximal cellulase activity. Similar studies were also reported with *Aspergillus niger* under solid-state fermentation. Six days was optimum incubation period after statistical optimization of cellulases (Verma et al. 2019). Researchers also investigated cellulase production with endophytic fungus *Pestalotiopsis microspora* using RSM. The outcome demonstrated that the incubation time of 5–6 days was ideal for increasing the activity of the cellulase enzyme (Goukanapalle et al. 2020). The results were also in agreement with Gad et al. (2022), who reported six days as optimal incubation time for CMCase production. The decrease in activity following the ideal incubation period may be caused by a number of factors. This includes modifications to the fungus's machinery for secreting enzymes under stress brought on by the depletion of vital nutrients (Mrudula and Murugammal 2011), an inhibitory effect of cellobiose (Azzaz et al. 2012) or glucose accumulated in the medium, the production of proteases (Nathan et al. 2014), or other physiological conditions. Production of cellulase is significantly influenced by the quantity of fungal inoculum. A number of four mycelial discs of 10 mm diameter were inoculated into the fermentation medium in the current study. However, no significant impact of inoculum size on enhancing cellulase production was observed. According to Saravanan et al. (2012) and El-Hadi et al. (2014), an imbalance between growing biomass and nutrient accessibility may lead to decrease in enzyme activity. Cell clumping can also interfere with oxygen intake and enzyme release. On the contrary, insufficient inoculum levels result in less biomass production, which leaves many nutrients

unused and reduces the synthesis of enzymes (El-Hadi et al. 2014). Similar findings were made by Agrawal (2016), who found that a 2.5% (v/w) inoculum size was the ideal one for increasing CMCase production from *Aspergillus* sp. According to Saini et al. 2017, two mycelial discs of *Trichoderma reesei* (NCIM 992) per gram of substrate resulted in the best CMCase production. Authors (Ezeilo et al. 2022), studied the solid-state fermentation using palm oil leaves *Trichoderma asperellum* and *Rhizopus oryzae* for efficient production of cellulose degrading enzymes. They observed 2.0×10^7 spores g^{-1} as optimal inoculum size for both CMCase and FPase production. Agitation speed of 125 rpm was found to be optimal for maximal CMCase and FPase production. Increased dissolved oxygen in the medium and consistent distribution of nutrients and catabolites are both influenced by the rate of agitation. However, increase in agitation rate can also lead to damages in cell structure, leading to morphological changes brought on by shear stresses. Comparable results were reported by (Deka et al. 2013), viz., 121 rpm as optimal agitation speed for CMCase production using *Bacillus subtilis*. Researchers (Tabassum et al. 2018), also reported 120 rpm as optimal agitation rate for enhanced CMCase activity. One study (Chavan et al. 2022) reported 157 rpm as optimal agitation rate for maximal cellulase production from *Penicillium funiculosum* NCIM 1228 using response surface methodology. According to the investigations mentioned above, cellulase is best produced at an agitation rate ranging from 120 to 160 rpm. Wheat bran of 3.5% was found optimal for improving enzyme production. Similar outcomes were reported by Gomathi et al. 2012, i.e., 4% wheat bran as optimal substrate concentration for improved cellulase synthesis. Another study (Kumar et al. 2018) also reported 1% wheat bran for maximal enzyme production with *Schizophyllum commune* NAIMCC-F-03379. Yousef et al. 2022 investigated in one study about how *Virgibacillus salarius* produces thermo and halostable cellulase. They claimed that 30 g/L of wheat bran was the ideal concentration for producing enzymes and for achieving the highest possible saccharification output. It is generally accepted that the form and content of the carbohydrates in wheat bran make them ideal for stimulating the production of cellulases by filamentous fungus throughout both submerged and solid-state fermentation (Deswal et al. 2011). The significance of previous work on cellulase production from *Aspergillus* species using agro-residual waste lies in its potential to alleviate environmental and industrial challenges while contributing to sustainable resource. Researchers have investigated various factors influencing cellulase production, such as substrate selection, microbial strains, fermentation parameters and inducer molecules. These findings guide the optimization of cellulase production processes for higher yields and cost-effectiveness, as well as the investigation of other

cellulase-producing strains, including various species of *Aspergillus*, *Trichoderma*, and other fungi. Sasi et al. (2012) observed the optimization, production, and purification of cellulase enzyme from marine *Aspergillus flavus*. The experimental results showed that the cellulase production was higher at pH 8 and 30 °C on seven days of incubation period. The effect of different carbon sources like rice bran, wheat bran, bagasse were used for cellulase enzyme production. Reddy et al. (2015) investigated the cellulase production by *Aspergillus niger* on different natural lignocellulosic substrates (rice bran & wheat bran). Maximum titers of FPase, CMCase and β -glucosidase obtained on this combination were 2.632, 2.478 and 2.984 U/mL in SmF and 29.81, 25.2 and 32.18 U/g DS in SSF, respectively. This work helps in identifying the most promising strains with high enzyme yields and specific cellulase activities. The current investigation suggests that *A. Stellatus* is an uncommon isolate reported up to this point for optimizing cellulase production using solid substrate, despite the fact that there are only a few reports of it having cellulolytic capability. Enzyme characterization studies have revealed the diversity of endoglucanases, exoglucanases, and β -glucosidases and their synergistic actions in cellulose degradation. Analyzing various cellulase-producing strains and evaluating the cost-effectiveness of cellulase production process by particular strain, substrate cost, enzyme yield and downstream processing expenses are crucial for determining utility in large scale industrial production and application. Comparative studies of different agro-residue waste substrate (rice straw, wheat straw, corn stover) with various fermentation conditions (temperature, pH, aeration and agitation), enzyme profiling across different strain can provide insights into variation in the types and proportion of cellulase enzyme. Cellulases have enormous potential in industries and are used in food, beverages, textile, laundry, paper, waste management, medical/pharmaceutical industry, protoplast production, genetic engineering, pollution treatment and in other area and pulp industries etc. (Gomathi et al. 2012). The field of bioprocess engineering has been benefited from earlier research by developing strategies for scaling up cellulase production from laboratory to industrial level (Khan et al. 2016). In summary, earlier work in cellulase production serves as a knowledge base for understanding the process, optimizing conditions, synergistic effects of different cellulase enzyme and identifying promising microbial strains. Based on the FTIR spectra of the unfermented and fermented wheat bran, the modifications to the functional groups of wheat bran after fermentation produced absorption bands at 3209.84 cm^{-1} and 3104.44 cm^{-1} indicating stretching vibration of the O–H that confirms the presence of cellulose. The findings concurred with the literature (Vinche et al. 2021), who also investigated the enzyme optimization using wheat bran as substrate. Absorption bands at 3091.02–2908.68 cm^{-1}

ascribed to C–H stretching vibration, 1637.15 cm^{-1} and 1661.78 cm^{-1} indicated the C=C stretching, 1401.33 cm^{-1} revealed O–H bending and 1092 cm^{-1} indicated C–O–C stretching. The results were in agreement with other work Silva et al. (2021), absorption bands in the region 500–1000 cm^{-1} was related to the carbohydrate skeletal vibrations (Wiercigroch et al. 2017; Hong et al. 2021). SEM analysis was used to examine the structure and surface morphology of pre-treated and fermented wheat bran. The chemically pre-treated/unfermented wheat bran revealed the dense and solid surfaces. The breakdown and modification of the fibre structure were caused by the mycelial growth on fermented wheat bran. Similar observations were reported by some researchers (Vinche et al. 2021; Kumari et al. 2022; Abdullah et al. 2021), on agricultural waste. The findings showed that crude enzyme produced from *Aspergillus stellatus* NFCCI 5299 was good at hydrolyzing wheat bran.

Conclusion

Cellulase output can be enhanced by *Aspergillus stellatus* NFCCI 5299 using wheat bran as substrate in submerged fermentation. To improve growth and the potential for the synthesis of enzymes, it is important to consider the physicochemical characteristics and composition of the wastes. Due to its favorable lignocellulosic characteristics for cellulose production, the wheat bran provided great support for the enzyme's synthesis. Using RSM with central composite design, the best process parameters for maximizing the production of CMCase and FPase were identified. The optimal conditions for the production of CMCase and FPase were achieved at the incubation period of 6 days, inoculum size of 4, agitation rate of 125 rpm and wheat bran concentration of 3.5%. Utilizing SEM and FTIR analysis, the morphological structure and surface of alkaline-pre-treated and fermented wheat bran were examined. The high cellulolytic activity of the enzyme can be utilized in a wide range of biotechnological and manufacturing industries. Other agro-industrial waste can further be tested to get closer to the proper valorization parameters supporting production of enzymes.

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Declarations

Conflict of interest The authors declare that there is no conflict of interest regarding publication of this paper.

Ethical approval The research does not require any ethical approval or consent because no humans or animals have been involved in the study.

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Regular article

Tannase production using green biotechnology and its applications: A review

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ABSTRACT

An enormous increase in the use of enzymes in a wide range of industrial biological conversion technologies has been made possible by the explosion of green biotechnology. Industrial enzymes' huge biocatalytic potential gives them an advantage over chemical technology in terms of security, reusability, and greater process regulation. One such enzyme with enormous potential for converting hydrolyzable tannins into gallic acid is tannase. Tannins mostly accumulate in plant components including leaves, fruits, roots as well as bark. Additionally, harmful tannery effluents from a variety of tanneries contain high concentrations of tannins in the chemical form of tannic acid. Tannase is primarily used to degrade the tannins that mostly exist in harmful tannery effluents, offering a comparatively much more affordable method for their biodegradation. This review discusses the mechanism of action of tannases, with an emphasis on substrates and production, biochemical characterization, and its applications.

1. Introduction

Tannins are naturally occurring polyphenols and are widely distributed non-volatile secondary plant metabolites with varying molecular weights. They are involved in protection against ultraviolet rays as well as invading pathogens in plants [1,2]. Based on their structure and characteristics, tannins are divided into two major classes. They consist of condensed and hydrolyzable tannins, as well as Catechin tannins in the form of an intermediate. The majority of plants contain tannins [3]. They are found in the bark, wood, leaves, fruits, roots, and seeds of plants. Tannins are regarded as anti-nutritional substances that drive enzymes involved in digestion and other proteins to proliferate. Additionally, they also provide wine, fruit juices, and tea its bitter flavor. The enzymes known as tannases are responsible for catalyzing the transformation of tannins and gallic acid esters into gallic acid and glucose. Tieghem unintentionally found tannase from fungi growing in the solution of tannins [4]. Tannase is ubiquitous enzyme that is obtained from the family of esterases and depsides [4,5]. Also known as Tannin acyl hydrolase, these enzymes hydrolyze the ester bonds present in tannic acid, gallotannin, and gallate esters producing glucose and

gallic acid [6], [7],[8]. They usually hydrolyze those substrates that have at least two phenolic hydroxyl groups in the acid component [4,9]. Tannases are produced by microbial, animal, and plant sources, however, industrial production of tannases on a large scale is primarily carried out by microbes due to their metabolic diversity, consistency in the production of enzymes, and simplicity in downstream processing. Several reports have mentioned *Aspergillus*, *Penicillium*, *Fusarium*, and *Trichoderma* as potential tannase producers. Bacterial species viz., *Bacillus*, *Clostridium*, and *Lactobacillus* along with a few yeast are also reported for their ability to synthesize tannase [10]. Solid state fermentation (SSF) is frequently used for the production of tannase from fungal sources because it lacks product feedback inhibition without any requirement of sophisticated instruments. In contrast to low-value medium sources, it has simple processing after fermentation with excellent yielding and cost-effective characteristics [6].

On the other hand, submerged fermentation (SmF), has a high water need for easy provision of nutrients for growth and culture and is frequently employed for the manufacture of bacterial tannase. For the production of highly purified tannase, downstream processing combines techniques including recovery, concentration, and purification;

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however, adding more than two stages increases the cost [11]. Tannase is used to make quick tea, wine, beer, refreshing drinks, and fruit juices, as well as it improves the nutrition of animal feed. Additionally, tannase is used for fruit ripening, colon cancer detection, and the treatment of effluents that are associated with high content of tannin [12]. Tannase is a crucial industrial enzyme, and has been known for its application in advancement of green biotechnology. However, little is known about these biocatalysts due to ignorance about solid substrates, methods of production, catalytic activity, and other characteristics. Moreover, a number of researchers have documented the use of waste with high tannin concentrations to produce tannase. For instance, cashew testa waste containing high tannin content was utilized for the production of tannase leading to reduction of harmful effects of tannin. Additionally, selecting a potentially active microbe to be used with a cheaper substrate composed of agricultural waste can help to lower the cost of synthesizing tannase [13]. The development of green biotechnology is aided by the discovery, that high titres of tannase, produced by many fungal species such as *Aspergillus* isolated from tannin waste, digest tannin present in tannery effluent, consequently lowering water pollution. Several techniques involving biosorption, bioaccumulation, bio-reduction, and immobilization of microbial cells can also potentially help in reducing tannin content leading to decreased environmental pollution. Additionally, recent advancements in recombinant tannase manufacturing and the creation of straightforward downstream procedures are crucial in lowering production costs. Tannase has numerous uses in the commercial sector, for instance in beverages, medicine, skin care products, and bioremediation [14]. Tannase is receiving attention as a result of their ability to hydrolyze and synthesize in appropriate solvent systems. The tannases' intricate catalytic ability has increased their commercial significance [15]. Although a number of review articles have been reported the challenges, microbial production, and biotransformation of tannins [16–18], no review has highlighted the biotechnological production of tannase and its applications in different fields. Therefore, the current review article is focussed on tannins and their harmful impact on the environment along with their microbial decomposition using tannase. The chemistry of tannase has also been addressed, in terms of significance in bioremediation, action mechanism, synthesis, characterization, and significant applications in numerous industries. In the biological method of pollutant degradation, the utilization of microbial tannase is a relatively new and promising topic of study. Many enzyme systems have been shown to oxidize and break down various organic pollutants into smaller intermediates, therefore efficiently degrading the pollutants. The synthesis and biochemical analysis of tannase might contribute to the comprehension of the nature of enzymes and their potential uses in industry. This would also enable to employ various immobilization techniques for the effective use of the protein and efficiently alter it via proteomics.

1.1. Tannins

The tannins are the second-most prevalent category of phenols in ecology and have a number of significant biological functions, including defense against bacterial, viral, and fungal infections in plants. They have also been known for protection against several pests and herbivores [16]. The location and distribution of tannins in different plant parts, such as flowers, needles, bark, seeds, and leaves, were documented by Belmares et al. [19]. Condensed and hydrolyzable tannins are the two main categories into which tannins have conventionally been divided. Gallotannins, ellagitannins, condensed tannins, and complex tannins make up the four groups that make up the most recent and widely accepted classification of tannins. Gallotannins are the most basic tannins and they are produced when the units of galloyl or di-galloyl esterify to a core of glucose or another polyhydroxy alcohol. Ellagitannins are hexahydrodiphenic acid (HHDP) esters, polymeric proanthocyanidins are condensed tannins. Gallic or ellagic acids can interact with catechins and glucosides to produce complex tannins. The chemical

structure of different tannins is shown in Fig. 1. [20]. Tannins have a variety of impacts on different organisms, ranging from poisonous consequences on animals to microbe growth inhibition. Yet, certain microorganisms have evolved other mechanisms and pathways for tannin breakdown in their native habitats, making them resistant to tannins. Condensed tannins' microbial breakdown occurs in both aerobic and anaerobic settings, however, has received less research than that of gallotannins. Environmental contamination is greatly exacerbated by tannins' capacity to bind with proteins and other substances. This implies the need for environmentally friendly methods of tannin degradation [1].

1.2. Tannase and their mechanism of action

Tannin acyl hydrolase (TAH), commonly known as tannase, is a widely distributed enzyme [4]. It is a member of the esterase family that hydrolyses the ester bonds in tannic acid, gallotannin, and gallate esters to produce glucose and gallic acid [7],[8]. Typically, they only hydrolyze the substance's acid components that have two or more phenolic hydroxyl groups. Tannic acid is completely hydrolyzed by TAH to gallic acid and glucose. The 1,2,3,4,6-pentagalloylglucose, 2,3,4,6-tetra-galloylglucose, and two varieties of mono-galloyl glucose are the reaction's intermediates [16]. The tannase-catalyzed hydrolysis reaction is shown in Fig. 2.

2. Microbial sources of tannase

Tannases are produced by plants, animals, as well as microorganisms. Microbial tannase is not only employed in bioremediation, but also utilized in industry. Various microbiological sources of tannase, have been described:

2.1. Bacterial tannase

Microorganisms are the major sources of tannase, particularly bacteria [6]. There are few reports on bacterial tannase in the literature before 1969 s. In 1969, Lewis and Starkey first reported that *Achromobacter* sp. can utilize gallotannin as the energy source for their growth. Deschamps et al. isolated several bacterial strains that can utilize tannic acid as the sole carbon source [21]. Over the past years, culturable, tannase-producing bacteria have been isolated from copious sources such as soil, wastewater, decaying bark, pickles, animal feces, beverages, etc. In general, the optimal pH (4.5–7) and temperature (30–40 °C) were reported for most active tannase-producing bacteria [6]. The molecular weight of monomeric bacterial tannase exists in the range of 46.5–90 kDa [6,22]. Maximum productivity of tannase was reported in the stationary phase of growth in bacteria [23]. There is no substrate specificity for bacterial tannase due to the variety in the quality of the substrate [6]. In order to defend themselves from tannin, microbes synthesize the enzyme tannase [24]. The bacterial, yeast, and fungal tannases have divergent amino acid sequences but share a common pentapeptide active site motif of Gly-X-Ser-X-Gly, a typical feature for serine hydrolases [25]. Cloning of fungal tannase genes has proven to be difficult due to the complexity of fungal enzymes. However, bacterial tannase is made up of a single subunit of the polypeptide chain, which makes cloning, overexpression, and purification accessible compared with fungal tannase [26].

Bacterial tannase is classified into two subtypes based on the presence or absence of aspartate residues in the catalytic triad, the presence or absence of single peptides, and the protein length. Subtype A is around 600 residues, and subtype B is smaller than type A with 470–570 residues [25]. However, other than a few type B tannases that have been shown to selectively cleave gallate esters with longer alkyl chains, there haven't been any obvious changes in the biochemical features between the two proposed classes [27]. The first three-dimensional structure of tannase from *Lactobacillus plantarum* was reported by Ren et al. [24], as

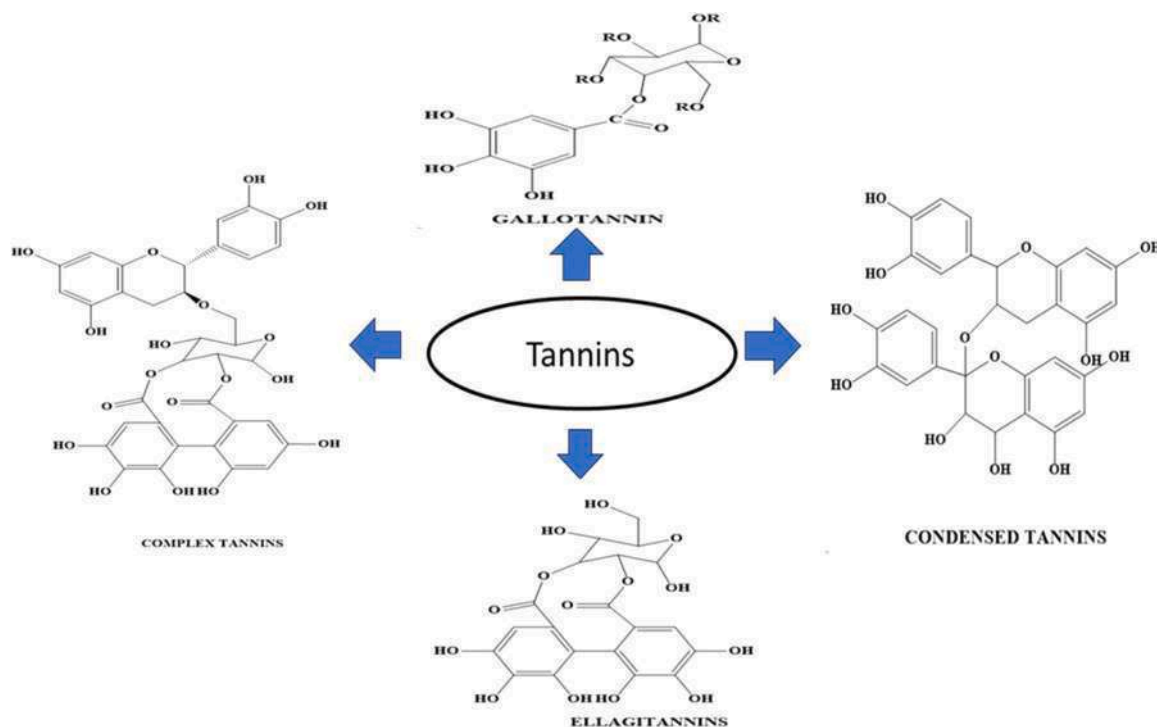


Fig. 1. Classification of tannins (Source: Aguilar and Gutiérrez-Sánchez 2001) [19], Adopted with permission.

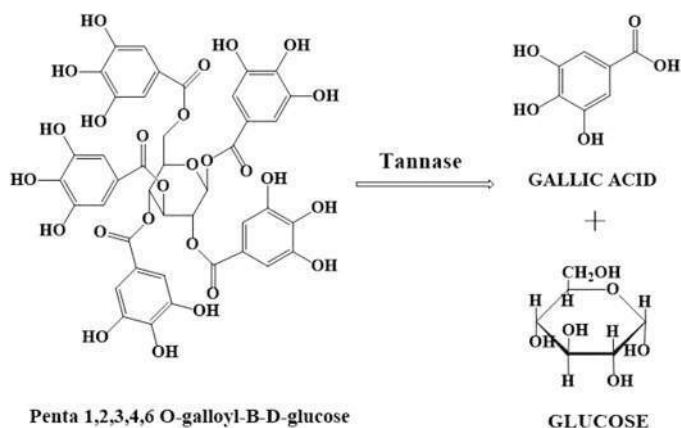


Fig. 2. Tannase catalyzed hydrolysis of 1,2,3,4,6-pentagalloylglucose (Source: Aguilar and Gutiérrez-Sánchez 2001) [20], Adopted with permission.

shown in Fig. 3a. The enzyme has a huge cap domain inserted into a classical serine hydrolase fold, giving it α/β structure with 18 α helices and 13 β strands. The structure was found to have a catalytic triad made up of Ser163, His451, and Asp419. The catalytic triad of the enzyme forms hydrogen-bonding interactions with the carboxyl group of the gallic acid molecule, and the three hydroxyl groups make contact with Asp421, Lys343, and Glu357 to create another hydrogen-bonding network. A left-handed twisted sheet made up of nine β -strands (β 1 to β 7, β 12, and β 13), in which β 1 and β 3 run antiparallel to each other. On the concave side of the major β -sheets, the helices α 3 and α 18 are linked, whereas the other side has the majority of helices. On the C-terminal side of the β -sheet, the α 10 helix runs roughly perpendicular across β 13 and joins together with α 11, α 12, and a two-stranded antiparallel β -sheet composed of β 10 and β 11. One of the structure's distinguishing features is the flap hung above the major β -sheet. Two long strands, β 8, and β 9, that are twisted together to form an antiparallel sheet make up the flap.

On the protein surface, a tunnel is created when the loop between positions β 8 and β 9 makes contact with positions β 4 and α 3. The interactions are mediated by Val89, Thr90, Trp91, Asn238 and Arg240. A hydrogen bond is formed between the backbone nitrogen of Trp91 and oxygen of Asn238. Tannase is found in the crystal as a dimer in the asymmetric unit. Most of the residues in helix α 9 and the loop between helices α 9 and α 10 are involved in the inter-subunit interactions. At the dimer interface, the two helices of α 9 are parallel to one another, forming hydrophobic interactions and many hydrogen bonds between them as well as between α 9 in one subunit and the loop connecting α 9 and α 10 in the other subunit as depicted in Fig. 3a [26].

Researchers have isolated a variety of bacterial species that produce tannase and are capable of degrading tannin from the environment. A significant role is performed by lactic acid bacteria (LAB) in the breakdown of dietary tannins. LAB can hydrolyze tannins and reduce the amount that they are absorbed by intestinal cells [28]. In environmental biotechnology, tannase has also been used to remediate tannery effluent [29]. Tannase produced from *Enterobacter* species can be used in bioremediation as well as in biocatalysis and biotransformation to create molecules like gallic acid, trimethoprim, and other pharmaceutically relevant chemicals [30]. Cellulase's catalytic activity can be increased by using tannase to break down the phenolic substances [31]. A tannase and a gallate decarboxylase functioned together to decarboxylate the gallic acid synthesized by tannase action in the metabolic route used by *L. plantarum* to break down tannins [27]. The rumen bacteria that synthesize tannase and catalyze the degradation of HTs (hydrolysable tannins) and euptox A, have applications as microbial feed additions to promote the utilization of plant biomass containing anti-nutritional phytometabolites [30]. Amanda et. al., described biochemically and structurally three tannase enzymes from a single organism, the soil and gut-dwelling anaerobic bacterium *Clostridium butyricum* [10]. Tannase encoded by *C. butyricum* may indicate the ability to either metabolize or detoxify tannins to sustain growth in a wide range of environments. Different bacterial sources along with their tannase activity are listed in Table 1.

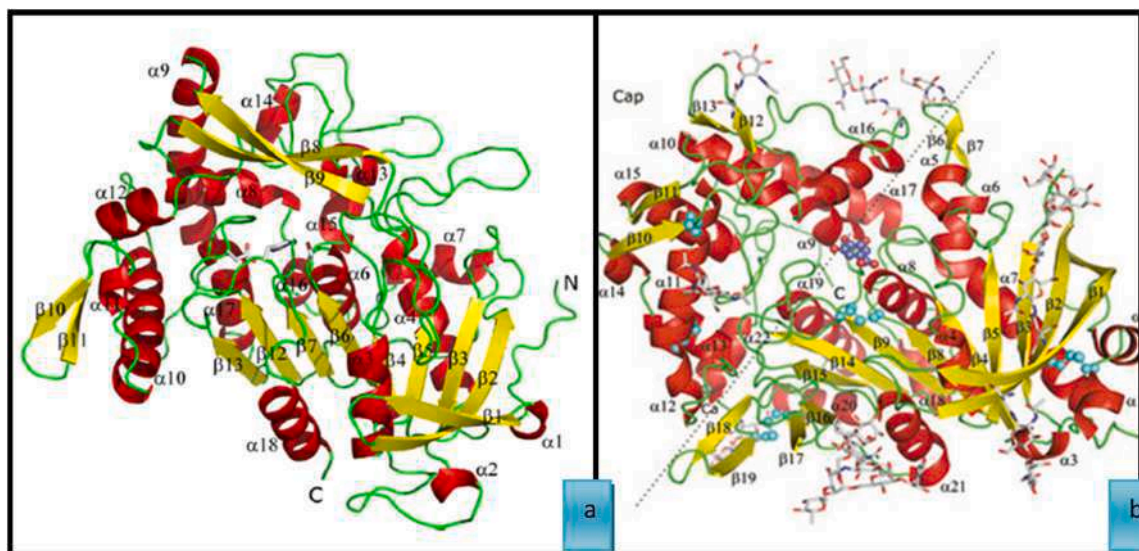


Fig. 3. The structure of *L. plantarum* tannase. A monomer. Stick depiction is used to show the side chains of the catalytic triad's residues (Ren et al.2013) [26]. (a) Crystal structure of *Aspergillus niger* tannase (b) (Dong et al. (2021) [32], adopted with permission.

2.2. Fungal tannase

Tannase producers do not belong to a large variety of fungal species, even though fungi are the prominent tannase producers among all microorganisms. *Aspergillus* and *Penicillium* species are the most frequent tannase makers, according to the majority of studies' outputs. The list of other mould species that have been reported to generate tannase is not very large but includes *Fusarium* sp., *Mucor* sp., *Paecilomyces* sp., and *Hyalopus* sp. Only a few yeast species that produce tannase have been identified [46]. Kita discovered fungal tannase from *Aspergillus oryzae* [47]. Yamada et al., discovered fungal tannase from the mycelium of *Aspergillus flavus* [8]. Several yeast strains were also found to produce tannase. Four different species of tannin-tolerant yeast, including *Cyberlindnera rhodanensis*, *Debaryomyces hansenii*, *Candida* sp., and *Sporidiobolus ruineniae*, were isolated from the city of Miang by Kaniengjai et al. [43]. The tannase produced by them translocated in their cell wall, hence they were called as cell-associated tannases (CATs). Thirty *Aspergillus niger* strains were reported by Pinto et. al., for their potential to make tannase [48], *A. niger* 11T25A was reported as the best producer. Enemuor [49] isolated the tannic acid-degrading fungus *Aspergillus tamari* from the soil contaminated by tannery effluent. Feces of koalas were also reported to contain tannin-degrading microorganisms [50].

Commonly, fungal tannase production is done by solid-state fermentation (SSF), however, bacterial tannase production occurs via submerged fermentation [6]. SSF is more significant when compared with SmF since it requires less water and energy to operate. Because of the extracellular nature of tannase, SSF is more feasible and the enzyme is easy to recover, whereas in SmF it is largely preferred for intracellular enzymes [16,5]. The favorable pH for fungal tannase is 4.0–6.0. Tannase produced by yeasts can tolerate high temperatures compared with bacterial tannases [18]. The majority of commercialized tannase is manufactured by the fungus as in Biocon (India), Kikko-man (Japan), and JFC GmbH (Germany) [46]. Fungal tannase has a comparatively higher molecular weight (45–310 kDa) than bacterial tannase (31–90 kDa) [51]. Tannase produced by *Penicillium montanense* URM 6486 is stable over the entire range of pH, because of this property the cost of pH control during the manufacturing process is reduced [52]. *Aspergillus* sp. tannase has a higher isoelectric point than other fungal species, confirming its thermal stability [53]. The catalytic site of tannase containing tryptophan is sensitive to salts and thus affects the enzyme activity [26]. High concentrations of urea (6–8 M) are also

known to cause conformational changes in the enzyme [54]. The crystal structure of fungal tannase depicted in Fig. 3b was first reported by Dong et. al., [32]. They reported that the enzyme has a large inserted cap domain along with a typical α/β -hydrolase-fold domain that forms a bowl-shaped hemispherical structure with a surface concavity surrounded by N-linked glycans. In between the two domains, gallic acid is present by forming two hydrogen-bonding networks with adjacent residues. One bond is formed around the carboxyl group of gallic acid involving residues from the hydrolase fold domain, together with the residues of a catalytic triad consisting of Ser206, His485, and Asp439. The second one is around the three hydroxyl groups of the compound involving the residues of the cap domain namely Gln238, Gln239, His242, and Ser441. By forming a hydrophobic contact with Ile442, gallic acid is sandwiched together. All of these residues are highly conserved in both fungal and yeast tannase. Fungal tannase has been used for the bioremediation of waste from industries [55]. Tannery effluents are highly polluted and contain a huge amounts of tannin. It's highly soluble and also inhibits the growth of microorganisms [56]. It was also applicable in the biodegradation and decolorization of wastewater from olive-mill and was found to remove 58% of the color [57]. Other than this tannase finds application in the food industry as well as it is used to reduce the bitterness and dark color during the preparation of fruit juices [16]. It is also used in the production of instant tea and gallic acid [18]. Although it is a useful enzyme, due to the high production cost its applications are limited [41]. Recently genetic engineering (Genetic Modified Organisms: GMO) and recombinant DNA technology are being used to increase the production of tannase [18,58]. Liu et. al., also conducted research by transferring the tannase gene in *A. niger* to increase its yield [59]. Some important fungal tannase along with their source and activity are listed in Table 2.

2.3. Affecting parameters in tannase production

Microbial tannases are extracellular enzymes and their production is highly regulated by physical and nutritional parameters such as pH, temperature, nitrogen and carbon sources, inorganic salts, agitation, and moisture content. The control of tannase gene activity by the manipulation of various physicochemical circumstances has been the subject of several reports. The tannase gene may be induced by all of these imposed microenvironments, which would then cause this enzyme to be expressed. Since the majority of tannases are inducible enzymes and are typically synthesized in the presence of inducers, such as tannic acid,

Table 1
Bacterial tannase from various sources and their tannase activity.

S. No	Sources	Bacterial Isolates	Tannase activity	References
1	Forest litter and decaying bark of oak and pine tree	<i>Bacillus polymyxa</i> , <i>Bacillus pumilus</i> <i>Corynebacterium</i> sp. <i>Klebsiella planticola</i> <i>Klebsiella pneumonia</i> <i>Paenibacillus polymyxa</i> <i>Pseudomonas solanacearum</i>	0.5 U/mL	[21]
2	Domestic livestock	<i>Selenomonus ruminantium</i>	4.5 mg/ mL	[22]
3	Tannery effluent	<i>Citrobacter freundii</i>	1.87 U/ mL	[30]
4	Sal forest soil	<i>Bacillus licheniformis</i> <i>Bacillus cereus</i>	5.44 U/ mL	[23] [23]
5	Olive wastes	<i>Lactobacillus plantarum</i>	6 U/mL	[28]
6	Compost tannery soil	<i>Pseudomonas citronellolis</i> <i>Pseudomonas plecoglossicida</i>	0.25 g/ mL	[33]
7	Human feces	<i>Lactobacillus plantarum</i>	11.4 U/ mL	[34]
8	Feces of Japanese large wood mouse	<i>Lactobacillus animalis</i> <i>Lactobacillus murinus</i>	10.1 U/ mL	[35]
9	Sheep excreta	<i>Lactobacillus</i> sp.	9.7 U/mL 0.85 U/ mL	[36]
10	Mouse feces	<i>Lactobacillus apodemi</i>		[37]
11	Tannery effluent	<i>Citrobacter</i> sp.	0.5 U/mL	[38]
12	Compost tannery soil	<i>Enterobacter cloacae</i> <i>Pseudomonas aeruginosa</i>	0.55 U/ mL	[39]
13	Olive wastes	<i>Pantoea</i> sp. <i>Serratia</i> sp.	13.65 U/ mL	
14	Tea processing factory	<i>Microbacterium terregens</i> <i>Bacillus massiliensis</i> , <i>Serratia ficaria</i> , <i>Serratia marcescens</i> <i>Providencia rettgeri</i>	1.005 U/ mL 0.902 U/ mL 0.026 U/ L 9.65 U/L 0.29 U/L 0.017 U/ L 0.15 U/L	[40] [41]
15	Tannery effluent	<i>Klebsiella pneumonia</i>	22.7 U/ mL	[42]
16	Compost tannery soil	<i>Bacillus subtilis</i>	10.69 U/ mL	[6]
17	Rhizospheric soil	<i>Klebsiella pneumonia</i> KP715242	0.065 U/ mL	[30]
18	Miang (A traditional fermented tea leaf found in northern Thailand)	<i>Lactobacillus pentosus</i> BA-7 <i>Lactobacillus pentosus</i> QA1-5	40 KU/L 39KU/L	[43]
19	Pomegranate	<i>Bacillus velezensis</i> TA3	32 U/g	[44]
20	Forest soil	<i>Paraburkholderia tropica</i> PK17 <i>Kosakonia arachidis</i>	0.75 U/ mL 1.49 U/ mL	[45]

carbon has traditionally been the primary determinant for the expression of tannase activity [49]. However, additional carbon sources such as arabinose, glucose, maltose, mannose, sucrose, and xylose have a big impact on their synthesis as well. In one experiment, tannase from *Paecilomyces variotii* was stimulated by the presence of glucose, whereas the presence of arabinose, raf-finose, sorbose, and starch suppresses it [65]. Lagemaat and Pyle, also reported that depletion of glucose supply in media could result in the partial stimulation of tannase [74]. Additionally, Banerjee and Pati observed that glucose had a favorable impact on the tannase synthesis of *Aureobasidium pullulans* [46]. According to Seiji et. al., an organism's tannase activity can only be seen during

Table 2
Fungal tannase from various sources and their tannase activity.

S. No	Sources	Fungal Isolates	Tannase activity	References
1	Soil	<i>Rhizopus oryzae</i>	32.76 U/mL	[46]
2	Soil of IIT KGP	<i>Aspergillus foetidus</i>	25–30 U/ mL	[60]
3	Soil of IIT campus	<i>A. awamori</i> <i>nakazawa</i> .	2–3 U/ mL	[54]
4	Tunisian soil	<i>A. flavus</i>	8000 UI/L	[57]
5	Soil sample and damaged tissue of tannin-rich plants of Mexican desert	<i>Penicillium commune</i> , <i>A. niger</i> , <i>A. rugulosa</i> , <i>A. terricola</i> , <i>A. ornatus</i> and <i>A. fumigatus</i>	500 U/L	[61]
6	Garbages, forests and orchards,	<i>A. rubber</i>	69 U/g	[62]
7	Tannery effluent	<i>A. niger</i>	16.77 U/ mL	[63]
8	Tannery effluent	<i>A. fumigates</i>	174.32 U/g	[64]
9	<i>Ocimum sanctum</i>	<i>Hyalopus</i> sp.	7.6 U/ mL	[54]
10	Tannery wastewater	<i>Paecilomyces variotii</i>	98 U/ mL	[65]
11	Tannery soil	<i>A. tamari</i>	0.8–1 U/ mL	[49]
12	Seawater	<i>A. awamori</i>	2761.89 IU/ mg	[66]
13	Tannery effluent	<i>Penicillium atramentosum</i> KM	170.75 U/g	[67]
14	Bark of <i>Acacia nilotica</i> trees	<i>A. niger</i>	101.428 U/ mL	[68]
15	Air from the Brazilian Caves	<i>A. japonicus</i> 246 A A. <i>tamarii</i> 3	16.45 U/mg and 12.95 U/ mg	[69]
16	Moldy tea leave	<i>Penicillium</i> EZ-ZH190	4.33 U/ mL	[70]
17	Barks of angico	<i>A. niger</i> <i>A. fumigatus</i>	10.05 U/ mL 10.14 U/ mL	[71]
18	Marine sediment	<i>A. nomius</i>	291 U/mg protein	[72]
19	Tea industry waste	<i>Rhizopus stolonifer</i>	1.052 U/mg	[2]
20	Soil of Gururipal sal forest	<i>Penicillium Purpurogenum</i>	5.784 U/g	[6]
21	<i>Odontotermes obesus</i> .	<i>Mucor ellipsoideus</i> strain CBS 126271	0.690 IU/ mL	[73]

glucose-rich growth conditions [75]. Selwal et. al., reported the presence of maltose as a significant carbon source for improving tannase production up to 31.1 U/mL from *Penicillium atramentosum* [67]. Mannose (0.1%) and sucrose (0.05%) were also observed to enhance tannase activity in bacterial species viz., *Bacillus subtilis* [6] and *Klebsiella pneumonia* [30]. Under solid-state fermentation, the use of coffee husk enhanced enzyme production employing *Lactobacillus* sp. [28], coffee husk combined with wheat bran and tea stalk powder in combination with glucose significantly improved the production of fungal tannase [5,76].

The diverse nitrogen sources in the medium, in addition to the carbon sources, have an impact on the tannase titers in the production broth. The presence of various nitrogen sources, including yeast extract, sodium nitrate, ammonium nitrate, ammonium sulphate, and ammonium chloride, was investigated by a number of researchers. The presence of ammonium nitrate in the medium along with tamarind seed powder increased the tannase production [36]. Raman et. al., reported 0.2% sodium nitrate as an optimal nitrogen source for enhanced tannase production utilizing *Paecilomyces variotii* under solid-state fermentation [65]. Similar studies were also reported using *Aspergillus flavus* under submerged fermentation with sodium nitrate as the optimal nitrogen source. The highest tannase production was reported by Banerjee and Pati by utilizing di-ammonium hydrogen phosphate [77]. A few studies reported the inhibiting effects of nitrogen. According to Kumar et al. [30] adding ammonium sulphate to the medium decreased the production of tannase. Similar findings were also reported by Selwal et. al. [67] who revealed that decline in tannase production decreased in the medium containing sodium nitrate, ammonium chloride, urea, and ammonium sulphate, but increased in the presence of ammonium nitrate

[67]. Apart from the diverse chemical components of the fermentation medium, physiological factors like pH, fermentation time, agitation, and temperature also have a significant impact on enzyme production. Mostly, microbes prefer a pH range of 4.5–6.0 to produce tannase such as *Bacillus haynesii* [18], *B. licheniformis*, *Aspergillus niger* [51], and *Rhizopus oryzae* [78]. However, *Rautella orythinolytica* showed maximal tannase yield at pH 7 [79]. The synthesis of the enzyme and biomass are both significantly influenced by temperature, a key process variable. By changing the characteristics of the cell membrane, it is also known to play a significant part in the release of the extracellular enzyme. Largely fungal tannase production ranged from 25 to 37 °C such as *Aureobasidium pullulans* [46]; *Paecilomyces variotii* [65]; *A. niger* and *A. fumigatus* [71]. However, bacterial tannase showed optimal production under the temperature ranging from 30 to 40 °C. Several bacterial species reported in this temperature include *Enterobacter cloacae* [39]; *Klebsiella pneumonia* [30] and *Bacillus amyloliquefaciens* [79]. However, Shakir et. al., reported 45 °C as the optimal temperature to enhance tannase production by *Rautella ornitholytica* [79]. It has been established that incubation intervals ranging from a few hours to several days are ideal for maximizing tannase production. *Pseudomonas aeruginosa* produced tannase best during an incubation duration of 24 h [67]. Although *Aspergillus ruber*, *Penicillium atramentosum*, and *Aspergillus niger* produced the most tannase after 96 h of incubation [80]. Metal ions are necessary for tannase to display its full enzymatic activity. Selwal et. al., found that the presence of Mg^{2+} in the case of amla (*Emblca officinalis* Gaertn) and Hg^{2+} in the case of keekar leaves stimulated the synthesis of tannase from *Pseudomonas aeruginosa* [67]. The generation of tannase by *Aspergillus niger* is stimulated by traces of Fe^{2+} , Zn^{2+} , and Cu^{2+} . Likewise, *Verticillium* sp. showed that Mg^{2+} has a stimulatory effect on tannase synthesis. However, *Aspergillus japonicus* tannase synthesis was found to be inhibited by divalent cations. Briefly,

we can say that tannic acid is the most common inducer followed by other carbon sources and waste residues, which may both suppress or increase the tannase activity. The second major chemical component in the medium was the nitrogen sources which significantly helped to increase tannase activity and also add up to its moisture content. With the above conditions, all the organisms optimally produced tannase between 25 and 45 °C, except some produced at lower temperatures, and the pH widely varied from 3 to 8. However, there is a need to explore more tannase-producing microbes capable of thriving in extreme environments which can be proven as more cost-effective, sustainable, and environmentally friendly than traditional. They create extremozymes, and extremolytes, in response to these settings through biochemical and physiological changes. These products find application in a variety of industries, including bioremediation. It is possible to increase the synthesis of enzymes under both SmF and SSF settings. In contrast to SSF, SmF had a shorter incubation period and may facilitate simpler product purification. Fermentation can be controlled more easily in liquid culture, which allows for much shorter fermentation durations. A few divalent metals also played an important role in the higher production along with this. Different bioprocess parameters utilized with various microorganisms are listed in Table 4.

3. Purification and biochemical characterization of tannase

The complex process of enzyme purification necessitates the sequential use of various techniques in order to reach acceptable high purity levels. Researchers are constantly looking for less expensive, simpler processes that yet produce significant amounts of product early in the purifying process. Any effective method for enzyme purification should meet the following criteria: (1) increased ultimate level of purity; (2) increased overall recovery of biocatalyst; and (3) ability to be easily

Table 4
Overview of bioprocess parameters for tannase production.

S. No	Organism	Fermentation	Incubation period	pH	Temperature (°C)	Substrate	Tannase activity	References
1	<i>Lactobacillus Plantarum</i>	SmF	24 h	6	37	Tannic acid	6 U/mL	[28]
2	<i>Lactobacillus</i> sp.	SSF	72 h	5.0	33	Coffee husk and tannic acid	0.85 U/gds	[36]
3	<i>B. licheniformis</i>	SmF	30 min	5.0	40	Tannic acid	0.356 U/ mL	[81]
4	<i>L. plantarum</i>	SmF	8 h	6.0	30	Tannic acid	9.29 U/ mL	[82]
5	<i>S. ficaria</i>	SmF	25 h	5.5	30	Tannic acid	0.56 U/L	[41]
6	<i>L. plantarum</i>	SmF	SmF- 30 h	5.0	30	Tannic acid	SmF-9.13 U/ mL	[82]
		SSF	SSF- 48 h			Coffee husk	SSF-Coffee husk -	
						Tamarind seed	5.319 U/gds	
						wheat bran	Tamarind seed- 4.115 U/gds	
7	<i>Aspergillus flavus</i>	SmF	96 h	5.5.	35	Tannic acid	wheat bran-2.877 U/gds	[83]
						Redgram Husk	Redgram Husk-76.43(U/ mL)	
						Tamarind seed powder	Tamarind seed powder-67.58(U/ mL)	
8	<i>Aspergillus niger</i> Van Tieghem	SmF	4 days	4	30	Tannic acid	580 U/50 mL	[84]
9	<i>Aspergillus niger</i> AVM-1	SmF	96 h	5.5	30	Tannic acid	7.5 U/ mL	[85]
10	<i>A. tubingensis</i> CICC 2651	SSF	118 h	6.0	4	Tea stalk powder	84.24 U/gds	[86]
11	<i>Klebsiella pneumonia</i> KP715242	SmF	91.34 h	5.2	34.97	Tannic acid	0.065 U/ mL	[87]
12	<i>Aspergillus</i> sp. GM4	SSF	2 days	4.0	25	Jamun leaves, Mango leaves	Jamun leaves: 1.44 U/mg Mango leaves: 0.99 U/mg	[88]
13	<i>Penicillium</i> sp. EZ-ZH390	SmF	84 h	5.5	30	Tannic acid	21.73 U/ mL	[89]
14	<i>Bacillus gotheitii</i>	SSF	26.45 h	4.74	32	Tannic acid	49.32 U/ mL	[90]
15	<i>Aspergillus niger</i> CEPIC 11	SSF	48–120 h	3–8	32–35	Cashew testa	301.70 U/g DS,	[91]
16	<i>Mucor circinelloides</i> isolate F6–3–12	SSF	72 h	4.26–7.83	30	Modified dox medium	Plackett-Burman design- 5.83 U/gds Box-Behken design- 12.24 U/gds	[92]
17	<i>B. amyloliquefaciens</i>	SmF	24 h	5	37	Tannic acid	1.27 IU/ mL	[93]
18	<i>B. velezensis</i> TA3	SSF	57 h	7	37	Tannic acid	32 U/g	[44]
19	<i>Aspergillus aculeatus</i>	SmF	96 h	6.0	30	Tannic acid	388 U/ mL	[94]
20	<i>Bacillus subtilis</i>	SSF	24 h	5	45	Tannic acid	211.97 U/ mL	[79]

reproducible. The enzyme is then excavated in pure fractions with a marked increase in its particular activity using chromatographic methods such as ion exchange, gel filtration, and affinity chromatography. It is also possible to estimate the molecular weight of the enzyme. Tannin acyl hydrolase is said to include two or more subunits. According to Hatamoto et. al., *Aspergillus oryzae* native tannase is made up of four pairs of two different subunit sizes (30 and 34 kDa, respectively), which are joined by disulfide bonds to form a 300 kDa hetero-octamer [93].

Tannases were found to have a molecular weight that varied between 50 and 320 kDa [95]. Mondal et. al., studied the purification and characterization of tannase from *Bacillus cereus* [23]. At pH 4.5 and 40 °C, partially purified tannase demonstrated maximum activity. However, it was found stable at a pH range of 4.5–5.0, at 30 °C. It was also observed that the enzyme sustained up to 2 M of NaCl and retained 82% of its initial activity in 3 M which was found to be salt tolerant. Bharadwaj et al., purified and characterized the enzyme [96]. With a yield of 20%, the two-step purification procedure produced 51-fold pure enzyme. Esterase and depsidase activity contributed equally to the overall tannase activity. The purified tannase protein was electrophoresed using sodium dodecyl sulfate–polyacrylamide gel and revealed to be composed of two polypeptides with molecular weights of 102 and 83 kDa. Tannic acid was found the best substrate, having a Michaelis-Menten constant (K_m) of 2.8×10^4 M, followed by methyl gallate as well as propyl gallate as the three substrates. CaCl_2 showed the greatest suppression (58%) while EDTA had no influence on tannase activity. CaCl_2 inhibitor binding constant (KI) was 5.9×10^4 M, and it was a noncompetitive kind of inhibition. Zhong et. al., isolated tannase enzyme from the fungus *Aspergillus oryzae*, which was then successfully cloned and expressed in *Pichia pastoris* [97]. The recombinant enzyme's catalytic activity was evaluated. With the help of *Saccharomyces cerevisiae*, the enzyme was converted into a secretory form and was purified using an uncomplicated method. By using fed-batch culture, the yield of released tannase was 7000 IU/L. The 90 kDa recombinant tannase was made up of two different subunits connected by one or more disulfide bonds. The research was the first documentation of heterologous expression of tannase, indicating that the *P. pastoris* system offers a propitious technique for synthesizing significant amounts of tannase for industrial applications. Mahendran et.al., purified tannin acyl hydrolase from *Paecilomyces variotti* using gel filtration and column chromatography techniques [96]. Using native polyacrylamide gel electrophoresis (PAGE), the molecular weight of tannase was found to be 149.8 kDa. The purified enzyme was discovered to be monomeric with an average molecular weight of 45 kDa using sodium dodecyl sulphate-PAGE. The ideal conditions for tannase function and stability were between 30 and 50 °C and 5.0 and 7.0, respectively. Even after repeated application, tannase immobilized on beads made of alginate could break down tannic acid and maintain around 85% of its initial activity. Similar investigations were also reported employing a two-step purification process for isolating tannase from *Penicillium variable* IARI 2031. A100 kDa molecular weight cutoff was used to obtain the enzyme. The optimal temperature and pH of the enzyme were found to be 50 °C and 5 °C, respectively. The operational range of pH was 3.0–8.0, while the physiological temperature ranged from 25° to 80°C [39]. Goel et al. [98] purified tannase from *Enterococcus faecalis*. With a recovery of 41.7%, tannase from *E. faecalis* was purified up to 18.7 times using ammonium sulfate precipitation, DEAE-cellulose, and Sephadex G-150. The 45 kDa protein was highly active at 40 °C, pH 6.0, with 0.25 mM methyl gallate as the substrate. Reports suggest that *Emericella nidulans*' native tannase was made up of three pairs of two different subunits (45.8 and 52 kDa), which combine to produce a 302 kDa hetero-hexamer [16]. Costa et al. [97] characterized the tannase from *Aspergillus tamarii*. The homodimeric enzyme had a molecular weight of 180 kDa and 40.5% of its weight was made up of carbohydrates. TAH I was stable over a wide pH range (3.0–9.0) at 40 °C, with its activity peak at 30 °C and pH 5.5. The enzyme displayed a K_m of 0.77 mM and a V_{max} of 682.8 U/mg proteins with methyl gallate as the substrate. Metal ions hindered the enzyme,

although organic solvents and surfactants seemed to have little effect on it. Similar studies were also reported from the tannase of *Klebsiella pneumoniae*, KP715242, which was purified and examined for its favorable characteristics. An overall purification of 8.55-fold along with 9.5% yield was achieved after the purification. The molecular mass was observed to be 38.20 kDa. It was discovered that tannase activity was best at 50 °C and pH 5.5, respectively. This enzyme belongs to the thermostable category of all bacterial tannases that have been discovered so far, with an optimal temperature of 50 °C [87]. Using olive pomace as a solid substrate, *Kluyveromyces marxianus* was used to produce tannase, which was then purified. This enzyme had a 64.6% enzyme yield, 1026.12 U/mg specific activity, and a 24.21 purification fold. The molecular weight of pure tannase was 65 kDa and 66.62 kDa, respectively. With two separate pH maxima—one acidic (4.5) and the other alkaline (8.5), it displayed its peak activity at 35 °C. The enzyme was thermostable between 30 and 70 °C and found to be stable in the acidic pH range of 4.0–5.5 for 30 min. The enzyme's K_m value with tannic acid was 0.77 mM, and its V_{max} was 263.20 mol min⁻¹ mL⁻¹. On enzymatic activity, the impact of various metal ions was examined. Data from the HPLC study showed that the purified enzyme could convert tannic acid by 24.65% with a 5.25-fold higher gallic acid concentration in 30 min [99]. Ong et al. [100] purified and characterized *Rhodotorula glutinis* tannase. With a recovery rate of 1.3% and an overall 302-fold purification with specific activity, 3.33 U/mg. Based on SDS-PAGE, the tannase appeared to be homogenous with molecular weight of roughly 73 kDa. The ideal pH and temperature for tannase were 6.0 and 40 °C, respectively. The enzyme remained persistent up to 40 °C at a pH of 7.0. Fe^{3+} , Sr^{2+} , Na^+ , and Pb^{2+} were discovered to boost enzyme function at 1.0 m mol/L, whereas Ca^{2+} , Mg^{2+} , Zn^{2+} , Ag^+ , Co^{2+} , Fe^{2+} , Mn^{2+} , Cu^{2+} , Cd^{2+} , K^+ , and Li^+ suppressed tannase efficiency. As per reports, tannase activity was found to be optimal at an average temperature of 20–70 °C and a pH range of 3–9. Each of the enzymes that had been purified had a molecular weight of roughly 43–186 kDa. Regarding their stability and activity in harsh environments, the enzymes don't exhibit any notable traits. However, more research is required in regards to increasing enzyme stability like immobilization, protein engineering, and chemical modification. An enzyme that has been immobilized is more resistant to extremes in pH or temperature. Additionally, it keeps the enzyme in position during the reaction, making it simple to separate from the result and return to the reaction. This is a popular and effective procedure in enzyme-catalyzed reactions. In the case of protein engineering, changing the catalytic reaction rate of isolated enzymes or an enzyme's structure and consequently, its function is accomplished, however, chemical modifications involve changes in amino acid residues in order to improve enzyme stability. Currently, it is necessary to use methods that can boost yield at a lower cost, enhancing its biotechnological potential. Biochemical characterization of different microbial tannase are listed in Table 5.

4. Application of tannase

There are several intriguing uses for tannase in the food, feed, leather, and pharmaceutical industries. Additionally, the tannase was primarily used to produce gallic acid from high-tannin plant sources, instant tea, and corn liquor. The negative effects of tannins in beverages are lessened with tannase. When the beverage is cooled down at lower than 4 °C during vinification, soluble grape proteins are precipitated in the presence of tannins. Additionally, a significant number of aromatic compounds can be eliminated if these precipitates are removed chemically removed from the wine while it is aging. Tannase can hydrolyze these polyphenols' ester linkages, preventing their polymerization and producing wine with a high quantity of aromatic compounds and the right color, improving its quality. The formation of gallic acid, a crucial intermediate chemical in the synthesis of thrimethoprim in the pharmaceutical sector, is another significant use of tannase [80]. Gallic acid is traditionally made by acid hydrolyzing tannins; however, this process

Table 5
Purification and biochemical characterization of different microbial tannases.

S. No	Microbial Isolate	Method employed	Molecular weight	Km and V _{max}	Optimum temperature (°C)	Optimum pH	Additives and Metal ions	References
1.	<i>Aspergillus niger</i> LCF 8	Ultrafiltration and high-pressure size exclusion chromatography	186 kDa	-	35	6.0	-	[101]
2.	<i>A.niger</i>	Column chromatography	-	0.20 mM and 5.0 µmol/min/mg protein	60	6.0	-	[95]
3.	<i>A.niger</i> ATTC 16620	DEAE-Sephadex A-50 chromatography	168 kDa	1.03 mM and 4.25 mmol/min	40	6.0	Zn ²⁺ , Mn ²⁺ , Cu ²⁺ , Mg ²⁺ (inhibitor) K ⁺ (activator)	[36]
4.	<i>A. awamori</i>	Gel filtration chromatography	-	-	35	5.0	Urea, Sodium lauryl sulfate, EDTA (inhibitor)	[54]
5.	<i>Verticillium</i> sp. P9	Column chromatography	155 kDa (TAH I and TAH II)	-	25–20	5.5	Mg ²⁺ and Br ⁻ (activator)	[102]
6.	<i>Paecilomyces variotti</i>	DEAE-Sepharose ion exchange chromatography	87.3kDa	0.61 µmol and 0.55 U/mL	40–65	4.5–6.5	-	[76]
7.	<i>Streptomyces psammoticus</i>	Anion exchange and Gel filtration	43 kDa	0.25 mM	50	6.5–9.5	Fe, Zn, Cu, Na and Mg (activator)	[103]
8.	<i>A.heteromorphus</i> MTCC 8818	DEAE-Cellulose column chromatography	-	-	50	5.5	Ca ²⁺ , Fe ²⁺ , Cu ⁺ , Cu ²⁺ (activator) Hg ²⁺ , Zn ²⁺ , Tween 20, EDTA (Inhibitor)	[104]
9.	<i>Rhodococcus</i> NCIM 2891	DEAE Cellulose Ion exchange chromatography	Dimeric Tannase I (60 kDa) Tannase II (62kDa)	0.034 mM and 40 U/mL (Tannase I); 0.040 mM and 45 U/mL (Tannase II)	30	6.0	Hg ²⁺	[105]
10.	<i>Penicillium notatum</i> NCIM 923	DEAE-Cellulose column chromatography	Dimeric Major band (97 kDa) Minor band (43 kDa)	0.33 × 10 ⁻² and 40 U/mg	35–40	5.0	-	[106]
11.	<i>A. nomius</i> GWAS	Sephadex G-100 and Ion exchange chromatography	30 kDa	-	50	6.0	Mg ²⁺ + (activator) EDTA, Cd ²⁺ , Pb ²⁺ and Mg ²⁺	[72]
12.	<i>Fomitella fraxinea</i>	DEAE- Cellulose and Seohadex G-100 gel chromatography	44.9 kDa	-	50–70	5.5	5 mM Fe ²⁺ and Cu ²⁺ (inhibitor)	[107]
13.	<i>A. niger</i>	Superdex 200 column gel filtration chromatography	95.49 kDa	-	20–50	3–6	1–5 mM Cu ²⁺ , Fe ²⁺ , Hg ²⁺ (inhibitor)	[108]
14.	<i>Enterobacter cloacae</i>	Ion exchange and size exclusion chromatography	45 kDa	3.0 × 10 ⁻³ M and 4.401 U/mL	50	6.0	Mg ²⁺ , K ⁺ (activator)	[109]
15.	<i>Geotrichum cucujoidarum</i>	Fast protein liquid chromatography	63 kDa	2.9 mM	30	5.0	-	[110]

produces a significant amount of toxic effluent that poses environmental risks. Curielet et. al. described an enzymatic method for producing gallic acid [111]. They used the immobilized enzyme to hydrolyze commercial tannic acid after they had immobilized a recombinant tannase from *Lactobacillus plantarum* produced in *E. coli*. Tannic acid was converted into gallic acid, yielding an almost pure molecule. To lower the tannin content of *Phyllanthus emblica* juice, sodium alginate-entrapped *Aspergillus niger* tannase was found to be more effective than soluble enzyme preparations.

The use of tannase in the manufacturing of instant tea was documented by Boadi and Neufeld [112]. The traditional method of making instant tea mostly entails treating hot water extract of tea at low temperatures, stirring continuously, and centrifuging the resulting tea cream. Tea cream has been tannase-solubilized by Tenco Brooke Bond Ltd. [117]. Although an unprocessed sample at low temperature was optically opaque and had a 7.5% undissolved solid content, the finished item generated at 5 °C was cloudy and had a 13.5% undissolved solid content. The method of removing tea cream and dissolving the components of a hot water extract of tea that are insoluble in cold water was disclosed in British Patents GB-B-1, 413,351 and GB-B-1, 380,135. This process involved treating the tea with free or immobilized tannase [18].

Phytase and tannase from *Paecilomyces variotti* were used to detoxify castor bean and sorghum residues [113]. By eliminating the tannin from guava juice, Sharma et. al., were able to enhance the bioavailability of vitamin C and minerals [51]. Tannase is essential for enhancing the nutritional value of cow feed [11]. Proanthocyanidins, which have been demonstrated to be highly beneficial in reducing cardiovascular risk, are extracted from grape seeds and skins with the aid of tannase and other enzymes [114]. Queirós et. al., employed tannase for the first time to boost the antioxidant activity and isoflavone content of soymilk [113]. In another study, Roberto et. al., employed immobilized tannase to boost tea's anti-obesity and hypoglycemic properties [113]. According to Hwang et al. [107], tannase treatment of green tea extract increased its therapeutic role in the treatment of atopic dermatitis. For increasing the effectiveness of the enzyme, immobilized tannase has also been involved in various applications [115]. Enzyme immobilization has also been used for a very long time in industries. It enhances the thermal and pH stability and helps in the separation of products. Like the one from *A. oryzae* has better thermal stability and was also stable at lower pH. Sharma et. al., concluded that immobilized tannase from *P. variable* IARI 2031 was able to retain its 85% activity even after being used continuously 9 times [115]. *Paecilomyces variotti* tannase's ability to function

under acidic circumstances was also enhanced by sodium alginate entrapment [116]. Taskin [117] employed *Rhodotorula glutinis* MP-10 immobilized cells for the first time to co-produce tannase and pectinase. In order to increase the catalytic effectiveness of tannase, Wu et al., immobilized it on carboxyl-functionalized Fe_3O_4 nanoparticles (CMNPs) [24]. The study also recommended using enzyme technology coupled with nanotechnology for tannase industrial uses.

One of the main types of waste produced in the Mediterranean region is olive mill wastewater (OMWW). It has a lot of hydrolyzable tannins, which tannases are capable of breaking down [34]. Aissam et al., studied the production of tannase using tannic acid and olive mill wastewater as substrate employing *Aspergillus niger* HA37 [27]. They observed that the fungal strain enhanced enzyme production by degrading complex wastewater. The degradation was preceded by a latency period (24 h) corresponding to the time required for spore germination. After which the content of phenolic compounds decreased from 0.9 ± 0.07 – 0.26 ± 0.03 g/L after 72 h of culture and remained constant until at least 96 h of culture. The COD reduction during this period was $71 \pm 2\%$ was associated with a biomass production of 5.3 ± 0.05 g/L dry weight. Tannase production in OMWW started in the first hour of culture and peaked at approximately 0.55–0.65 EU/mL during 8–28 h of culture. Although the enzyme levels decreased and became undetectable after 54 h of incubation, phenolic compound content continued to decrease over an additional 18 h. It can be due to the involvement of other complementary enzymes in the degradation process. After the treatment, the result indicated the depolymerization of high-molecular-weight aromatics, including gallotannins, followed by the assimilation of low-molecular-weight aromatics that were not completely consumed at the end of the growth cycle. Presumably, tannases are involved in the initial hydrolysis step of tannins, releasing monomeric components that proceed further into the fungal metabolic network. Thus, tannase has the potential to control environmental pollution remediation. Among all industrial wastes, tannery effluents have also been identified as heavy pollutants. The global community, particularly in emerging nations, is more aware of environmental challenges than ever before. Murugan and Al-Sohaibani Saleh used biomass and an enzyme from *A. candidus* MTCC 9628 to demonstrate the removal of tannin from tannery effluents [116]. In particular, White Rot Fungi (WRF) produce a number of extracellular enzymes that can break down tannins, such as laccases, lignin peroxidases, and manganese peroxidases. Due to their capacity to produce the enzyme tannase, some

Ascomycetes, especially *Aspergillus* sp. and *Penicillium* sp., are particularly effective in decomposing tannins among them. Several resistant substances might be depolymerized by fungi into substances that bacteria could break down [18]. Therefore, it was proposed that certain contaminants could be degraded more effectively by fungi and bacteria working together. It has been shown that the beneficial effect of their synergistic activity is typically challenging to maintain in non-sterile environments. There is competition between bacteria and fungi for the available organic substrates, which severely affects fungal metabolism. For instance, Spennati et al., recently treated Tara natural tannin in bioreactors using the fungus *Aspergillus tubingensis* MUT 990 embedded in Polyurethane Foam (PUF) cubes [118]. After twenty days of operation, a 90% reduction of soluble chemical oxygen demand (SCOD) was attained. However, this outcome was linked to bacterial biomass out-competing fungal biomass. Sigona et al. evaluated the possible synergistic effect of fungi and bacterivorous grazers in the degradation of resistant chemicals by evaluating the impact of bacterivorous grazers (ciliates and/or rotifers) in batch scale experiments employing fungi to remove Tara tannin [113]. It was noted that the bacterial load was substantially lower and the system was able to remove more SCOD faster in all experimental settings where grazers were present. Their findings offered practical guidance for maintaining fungal-based systems under non-sterile circumstances [45]. Various industrial and environmental applications of tannases are shown in Fig. 4.

5. Future prospective and recommendations

Numerous tannase-producing microorganisms have been discovered, out of which filamentous fungi have been found to exhibit very high potential for tannin hydrolysis. Given its potential use in the beverage, agricultural, chemical-based, and pharmaceutical industries, tannase is one of the many hydrolases that is gaining economic importance. The bioremediation of toxic tannery effluent is also more successful and cost-effective when tannase-based treatment is used. Researchers constantly have the chance to look for novel tannases with increased activity and longevity since there are so many harmful tannery and agricultural wastes that are rich in tannin. Understanding tannase structure, induction, synthesis, regulation, and underlying mechanism of action has become simpler because of advancements in molecular tools and methodologies. Researchers are using a metagenomic approach to find and use tannase genes from uncultivable microorganisms. However, in

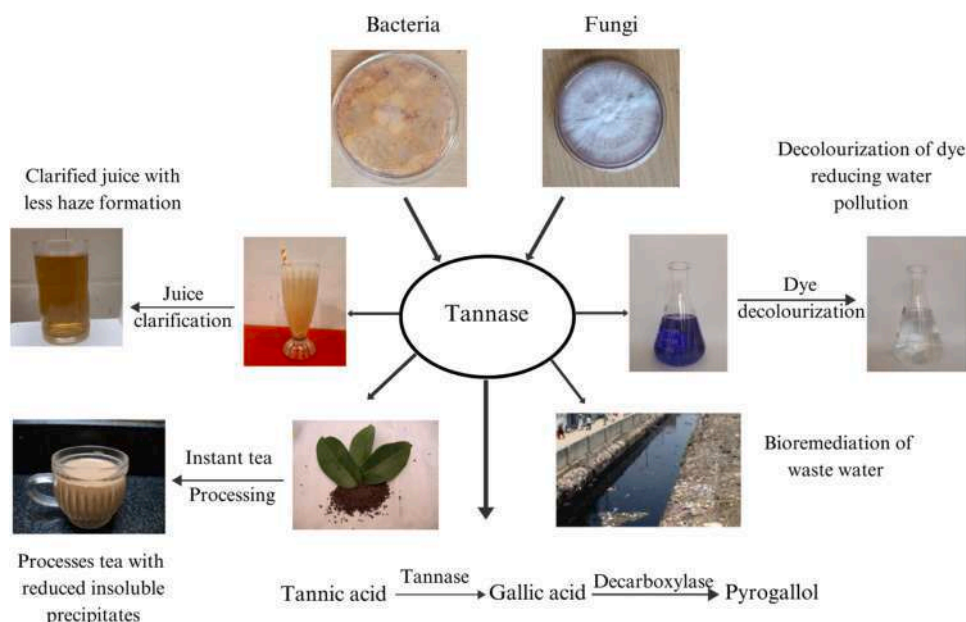


Fig. 4. Microbial tannases and their potential applications.

order to fully understand tannin breakdown by tannase, the following study and inventive solutions are needed. More study is required on the fundamental and practical properties of tannase, such as its regulation, new expression systems, design of novel bioprocesses utilizing large-scale cultivation technologies, effective and reasonably priced downstream processing, and creation of novel tannase applications. Optimizing the production procedure requires a thorough understanding of the kinetics of tannase synthesis, including the enzyme's stability, specificity, and activity. Many times, there is insufficient information on these factors for various tannase-producing microbes. Although tannase-producing microbes have some genetic material available, much more research needs to be done. Expanded genomic information may be useful in genetic engineering and strain modification to increase tannase output. It is important to choose the right microbe for producing tannase. Regarding which strains synthesize tannase most effectively and economically, there are gaps in the available data. It is critical to recognize and describe these strains.

To uncover novel tannase, researchers need to develop fresh strategies for protein engineering and metagenomics. This could result in the identification of a tannase enzyme with distinct properties that have a variety of industrial uses. Uncertainty exists in the field of research on ellagitannin biodegradation. Additionally, to produce more affordable procedures, tannase immobilization needs to be improved. To do so, it is necessary to create enzyme preparations with better catalytic properties and test new reaction conditions. The production of tannase under novel culture conditions can be improved and optimized with additional effort, even though expression studies have been conducted. Future expression in a reliable microbial expression host will be necessary to completely understand the kinetics of the recombinantly expressed tannase. The processes involved in tannase purification can be costly and time-consuming. To create effective and affordable purification methods, effective research is required. Furthermore, there is a dearth of information on large-scale downstream processing. There is frequently a lack of information available about the regulatory aspects of tannase production, such as quality control, safety, and adherence to food safety regulations. Additionally, lack of information on tannase immobilization for continuous and reusable applications. Enzyme stability and reusability can be improved by immobilization, which is important for industrial applications. Although tannase enzyme engineering for better features has been studied, information on the precise changes and the effect of the functionality of the enzyme is not always clear.

6. Conclusions

Tannin molecules have a wide range of complicated structures. Therefore, it is evident that the term "tannase" refers to a variety of enzymes from various organisms that are all capable of hydrolyzing tannins. Different microbiological sources of tannase may offer advantages for various industries, including those in the food, beverage, cosmetic, and pharmaceutical sectors as well as environmental pollution. On some substrates, a tannase may be effective but ineffective on others. More work must be put into creating particular tannases to meet these needs. In this regard, solid-state fermentation is superior to submerged culture in terms of advantages. New bioreactors, however, offer the opportunity to raise tannase output in both production systems. Additionally, improvements in molecular tools and methods have made it easier to comprehend tannase structure, induction, synthesis, regulation, and underlying mechanisms of action. There is always a chance for researchers to look for novel tannases with better activity and longevity because of the abundance of tannin-rich agro-industrial wastes and noxious tannery effluent waste available. The potential for tannin hydrolysis by filamentous fungi's tannase is very high. Additionally, the bioremediation of harmful tannery effluent using tannase-based treatment is more affordable and effective. In a nutshell, tannase is a crucial enzyme for industry and has enormous potential for use in numerous bioprocessing scenarios. The commercial use of tannase in a variety of

industrial applications has increased significantly over time. Thus, further research related to increasing the tannin hydrolysis rate, and tannin tolerance as well as to assure better process control for increased tannase production would be envisaged.

CRedit authorship contribution statement

Priya Sutaoney: Conceptualization, Writing – original draft. **Avantika Akhand:** Conceptualization, Writing – original draft. **Meenal Meshram:** Data curation, Writing – original draft. **Sakshi Sinha:** Data curation, Writing – original draft. **Veenu Joshi:** Data curation, Formal analysis, Writing – original draft. **Mohammad Shahadat:** Conceptualization, Supervision, Writing – review & editing. All authors contributed to the studies based on fundamental proof of concept. Priya Sutaoney¹, Avantika Akhand², Meenal Meshram², Sakshi Sinha¹, Veenu Joshi², data collection and drafting of the review article. The topic, Table of content and the final drafting were done by Mohammad Shahadat with the help of supporting references. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data have been mentioned in the forms of Tables and Figures.

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REVIEW ARTICLE

Concept and Evolution in 3-D Printing for Excellence in Healthcare

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Abstract: Three-dimensional printing (3DP) has gained popularity among scientists and researchers in every field due to its potential to drastically reduce energy costs for the production of **customised** products by **utilising** less energy-intensive machines as well as **minimising** material waste. The 3D printing technology is an additive manufacturing approach that uses material layer-by-layer fabrication to produce the digitally specified 3D model. The use of 3D printing technology in the pharmaceutical sector has the potential to **revolutionise** research and development by providing a quick and easy means to manufacture **personalised** one-off batches, each with unique dosages, distinct substances, shapes, and sizes, as well as variable release rates. This overview addresses the concept of 3D printing, its evolution, and its operation, as well as the most popular types of 3D printing processes **utilised** in the health care industry. It also discusses the application of these cutting-edge technologies to the pharmaceutical industry, advancements in various medical fields and medical equipment, 3D bioprinting, the most recent initiatives to combat COVID-19, regulatory frameworks, and the major challenges that this technology currently faces. In addition, we attempt to provide some futuristic approaches to 3DP applications.

Keywords: 3D printing techniques, vat photopolymerization, SLS, EMP, inkjet, DOP, EHD, personalized medicines, drug delivery system, COVID-19 treatment, 3D printed equipment, 3D bioprinting.

1. INTRODUCTION

3D printing, also known as additive manufacturing, involves creating a three-dimensional object by depositing successive layers of material in a controlled manner [1]. This process utilises Computer-Aided Design (CAD) software to transmit instructions to a 3D printer. The printer translates the digital model into two-dimensional sections and uses them as a basis to construct the object in layers. Alternative terms for this technology include freedom fabrication manufacturing and additive layer manufacturing [2].

As the name suggests, additive manufacturing (3D printing) adheres to the opposite principles of fabrication from subtractive manufacturing, which involves the creation of three-dimensional objects through the use of material removal techniques like drilling, milling, sawing, broaching, etc [3]. Both additive and subtractive manufacturing methods can be used for quick prototyping. The decision is dependent on taking into account a variety of elements, including the intricacy of the products to be manufactured, the material used, the required number of copies, and the cost. It is important to note that additive manufacturing has the potential to significantly reduce energy costs for the production of **personalised** products by employing less energy-intensive machines, as well as material waste.

3D printing was discovered back in the late 1980s

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when Charles Hull first introduced it in a patent for a technique of successively layering with liquid photopolymer solutions to print objects in three dimensions. This concept was the earliest 3D printing technology, today known as Stereolithography (SLA) [4]. Hull later used this technology to create the SLA-250, the first 3D printer available to the general public [5].

After the discovery of SLA, researchers became very interested in creating 3D printing technology to print products using alternative materials like metal, ceramics, *etc.* Some of the developed alternative print technologies are material jetting, Digital Laser Printing (DLP), Selective Laser Sintering (SLS), Selective Laser Melting (SLM), and Laminated Object Manufacturing (LOM).

The industries of aerospace, mechanical manufacturing, construction, and biomedical engineering have all benefited significantly from the rapid development and wide-ranging uses of 3D printing technologies [6]. However, the pharmaceutical industry started using it very recently. The U.S. Food and Drug Administration (FDA) **authorised** a levetiracetam pill (Spritam®) developed using 3D printing technology in July 2015, indicating the industry's acceptance of this technology [7]. In the pharmaceutical industry, it has been used to create a variety of pharmaceutical products, including microneedles, transdermal patches, orodispersible films, gastro-floating tablets, controlled-release tablets, and polypills [8]. 3D printing techniques were also helpful in the battle against COVID-19 through the development of equipment like face masks, face shields, safety goggles, nasopharyngeal swabs, ventilation devices, and respiratory devices [9-12].

Despite the benefits of 3DP, there are still several barriers that impede the advancement of 3DP technologies. High temperatures are used due to the stability of these products, which is challenging. Low mechanical resistance, low printing resolution and limited material choices are some other aspects confined to the limitations of this technology [13].

This review **summarises** the 3DP concept, its evolution and workings, outlining the most prevalent types of 3D printing technologies and their application in the pharmaceutical field. The relevance of this technology to the various medical fields, including manufacturing of medical equipment, 3D bio-printing and the most recent approach to combating COVID-19, have been discussed in this report. It also covers the regulatory guidelines, the major challenges currently associated with 3-DP technology, and the future outlook toward the advancement of human healthcare (Fig. 1).

2. EVOLUTION FROM CONVENTIONAL TO 3D PRINTING TECHNOLOGIES

The conventional methods of medical treatment were based on the formula “one size fits all”, which means that the same doses of the same drugs were given to every patient for a specific illness [14]. The drugs were made with fixed parameters, which include shape, size, and release type, without considering the patient's needs, such as gender, age, genetic features, and level of the disease. Moreover, drug dosage is generally adult-based in traditional methods, which demands the production of age-specific doses for children and elderly patients [15, 16]. Moreover, conventional methods are heavily based on trial-and-error methods, which leads to uncertainty in the development procedures [17]. In addition to the oral delivery of drugs, other specific dosage forms are also needed depending on the patients, such as a transdermal delivery system [18]. Also, the establishment of new methodologies is desirable for the production of hydrophobic drugs to achieve the time-specific release [19, 20]. Currently, researchers have found that 60% of drugs in research and 40% of commercial drugs are hydrophobic in nature, which causes problems in the formulation of oral drug delivery systems [19, 21, 22]. The conventional method procedures have some drawbacks, such as time consumption for large-scale production, rigid labour work as well as doses that cannot be changed according to the requirements of the patients. As a consequence, of all these aspects, pharmacists need to develop new methods and compounds that have controlled release properties and patient-specific needs [22, 23].

Therefore, the concept of **personalised** medicine has begun, where medicines are fabricated for a patient according to their physiology and genetic features [12]. **Personalised** medicines are more precise, productive, safer, and cost-efficient [24]. Hence, 3D printing is an appealing route for the fabrication of personalized medicine because it is a method that manufactures substances in a solid form by settling the material layer by layer. In pharmaceuticals, 3D printing plays a huge role in the construction of personalized medicine and drug delivery. During the late 1970s, several patents were granted for computer-aided techniques that attempt several platforms of 3-DP [25]. Charles Hull invented the technique that is currently used in 3D printing, *i.e.*, stereolithography (SLA), which involves the process of polymerization of resins by using UV light to get the desired material and his work soon got patented during the mid-1980s [26-28]. This technology was used in non-clinical areas, such as automobiles and consumer products [29]. A student of Texas State

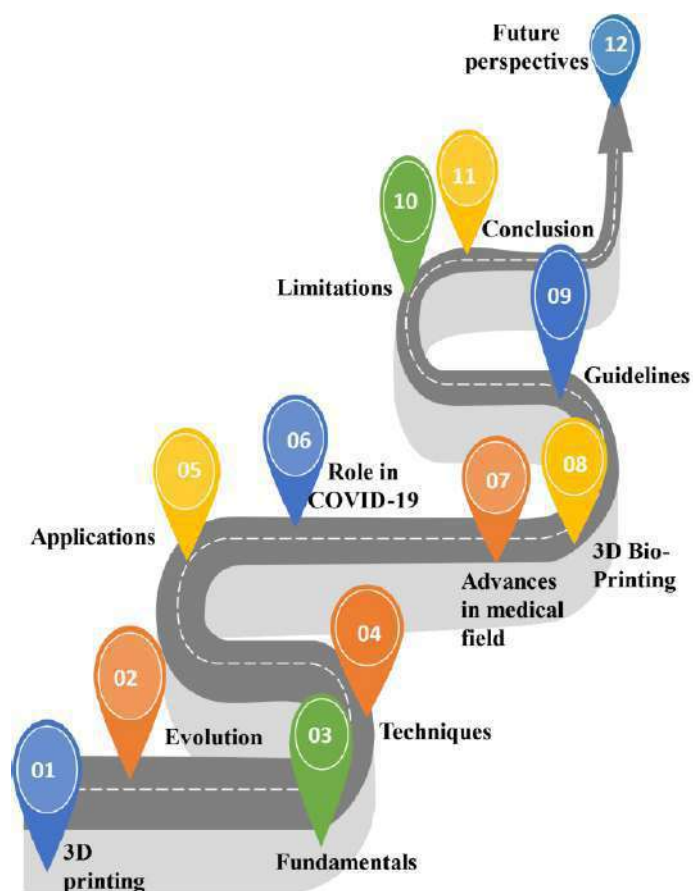


Fig. (1). Roadmap of the review. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

University named Carl Deckard invented another method called Selective laser sintering by fusing the powder through laser operations in 1986. By following this method, in 1989 by Scott and Lisa Crump at Stratasys company, a fused deposition modelling was proposed, involving metal and plastic extrusion by heating. Furthermore, Emanuel Sachs and his team at MIT (Massachusetts Institute of Technology, Cambridge, USA) invented an inkjet printer or binder jetting method based on 3D printing in the early 1990s, which involved binding solutions from the powder surface. This innovation led to the beginning of 3D printing in the drug industry [13]. Hans Langer developed metal laser sintering, which used lasers to generate 3D materials through computer operations [26-30]. Andrew Bowyer from the University of Bath focused on the 3D printers that generate their own materials, and later, they reported their application in various fields [25]. Moreover, implants with active pharmaceutical additives can have the potential for **personalised** medicine [31]. This is how 3D printing technology by using a Magnetic Resonance Image (MRI) or 3D Comput-

er-Aided Design (CAD) has entered the sector of pharmaceuticals for the development of programmed and personalized products [32, 33]. Thereafter, Spritam or Lev- etiracetam, which is the first 3D printed drug, was developed by Aprelia Pharmaceuticals and approved by USFDA in 2015. This drug was constructed by applying the binder jet printing technique. It has the ability for fast oral dissolution due to its highly porous nature and is used for epilepsy treatment [34]. Additionally, 3D printing has a huge application in drug delivery, diagnosis purposes, transdermal therapies, organ and tissue manufacturing, biomedical apparatus, and Additive Manufacturing (AM), such as biorobotics, implants and bioprinted substances for wound healing, *etc.* There are several advantages of 3D printing compared to traditional methods, like rapid and easy, highly accurate solid dosage forms, personalized formulation with adjustable dosage, being more **computerised**, and cost-efficient [35-39]. This innovation can decrease the chances of failure in new pharmaceutical procedures (Fig. 2) [29].

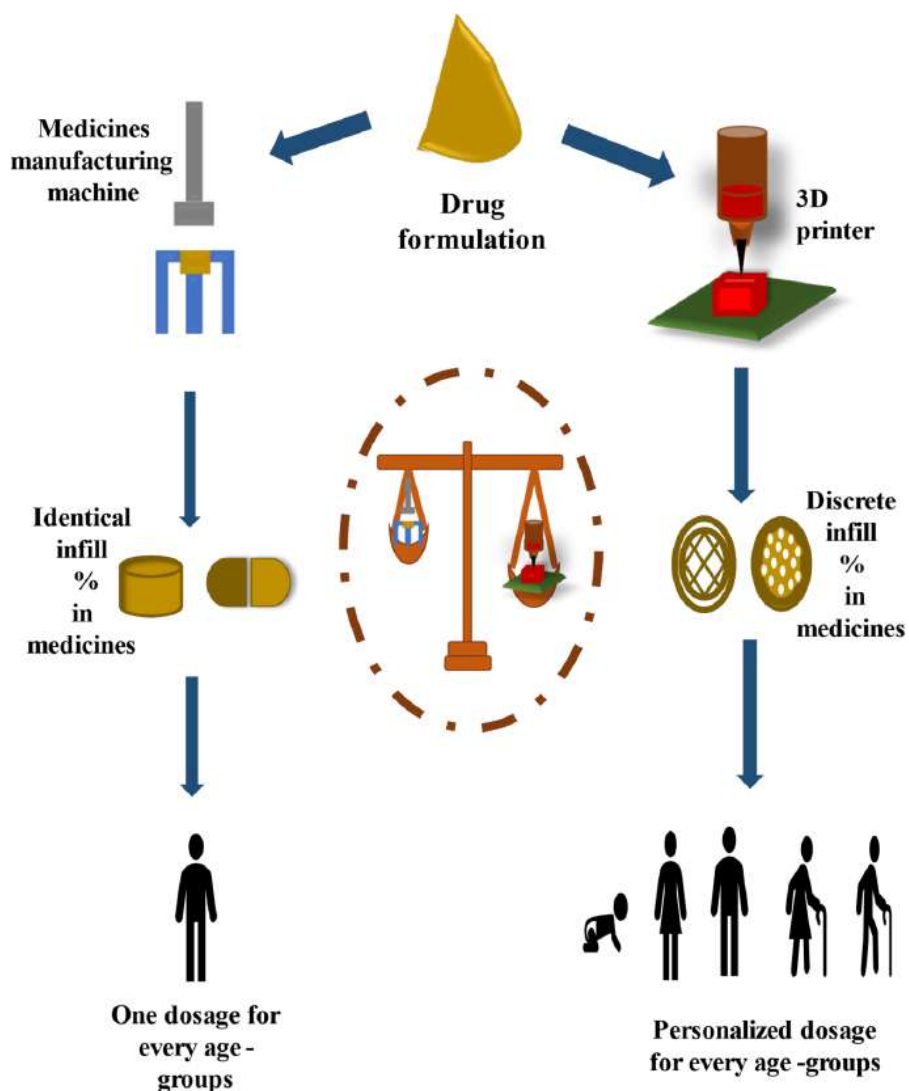


Fig. (2). Comparison of conventional and 3D printing methods. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

3. FUNDAMENTALS OF 3D PRINTING

A cutting-edge technology called 3D printing is assisting designers in rethinking the design of things like **personalised** formulations and leadership development. This is achieved by reducing the design cycle of making decisions through the creation of fresh concepts and ideas, useful feedback, and improved design [40].

Digitally exquisite software, such as Solid Works, Onshape, Creo Parametric, Autocad, Autodesk Tinker Cad, BRL-CAD, Free CAD, Open SCAD, 3D Slash, Wings3D, Sketch UP, Fusion 360, etc., are used to create virtual 3D designs of objects [41]. The 3D model must be converted to the Standard Tessellation Language (STL) file format (from Stereolithography), which records the information about the model's sur-

faces as a table of triangulated section coordinates after it has been constructed [42].

Slicing is the process of converting a three-dimensional model into a stack of flat layers. Software for slicing, such as Matter Control, Ultimaker Cura, Slic3r, Octo Print, Concept Maker, etc., are used to slice objects [43]. These layers appear in slicing software as direct derivatives of the laser or other extruder fixing mechanisms used in 3D printing. The Standard Tessellation Language (STL) file is converted into a G file by slicing the design into a series of 2D horizontal cross-sections with the aid of specialized slicer software installed in the 3D printer. The next step is to select a material that will work well for 3D printing. A vast range of materials, including plastics, ceramics,

resins, metals, sand, fabrics, biomaterials, glass, food, and lunar dust, among others, may be used in 3D printing. The computer sends instructions to the 3D printer for layer-by-layer material deposition as soon as the model is loaded. A 3D printer operates by extruding molten plastic through a tiny nozzle. It moves precisely in accordance with computer instructions. After

printing one layer, the printer waits for it to dry before printing the next layer on top. This process continues until the final product is obtained (Fig. 3) [44].

All types of 3D printing follow a basic work cycle and flow, often referred to as the “three D’s of 3D printing,” even if each has unique features and benefits to offer (Fig. 4) [29].

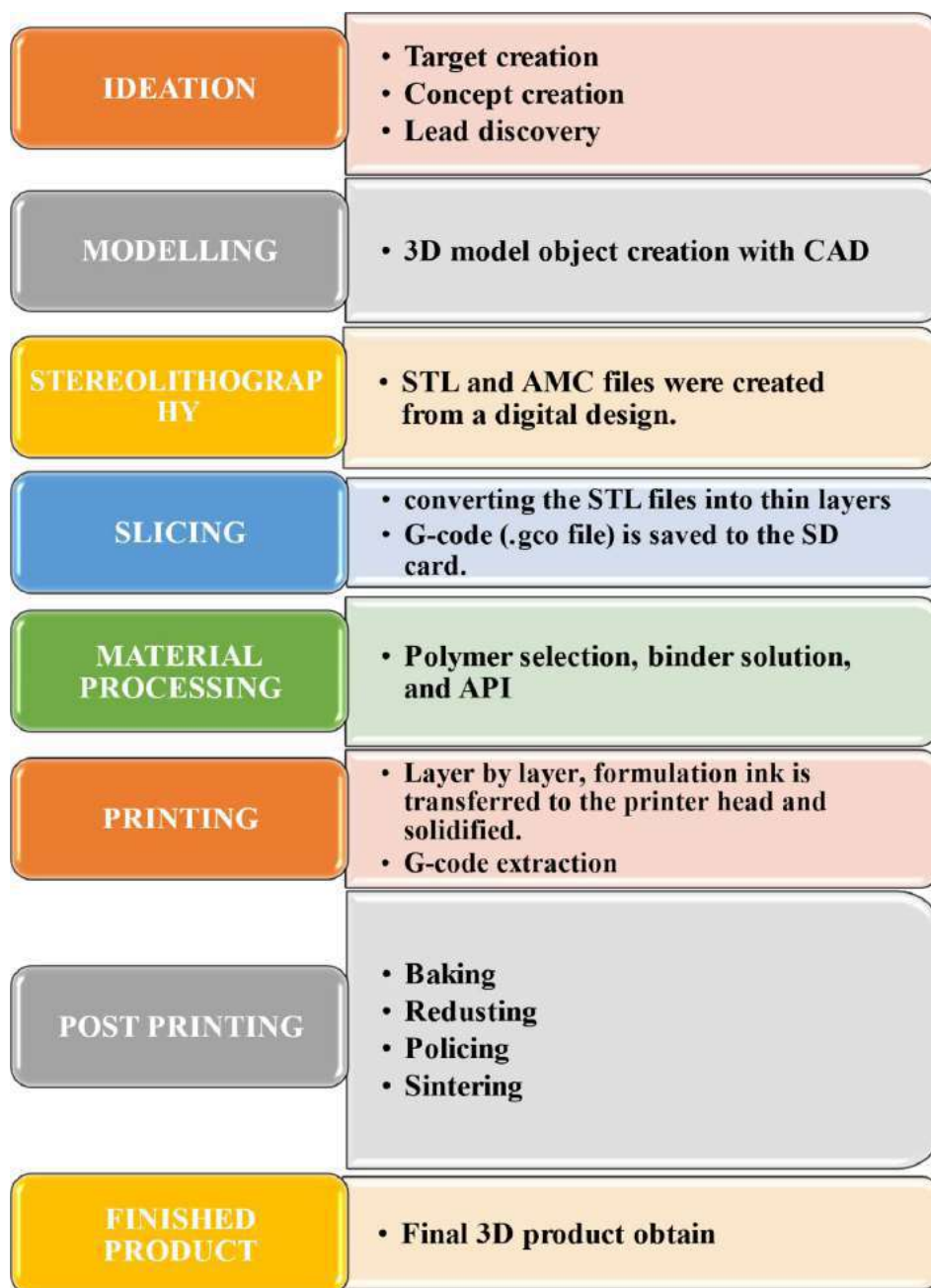


Fig. (3). Step-by-step procedure for 3D printing. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

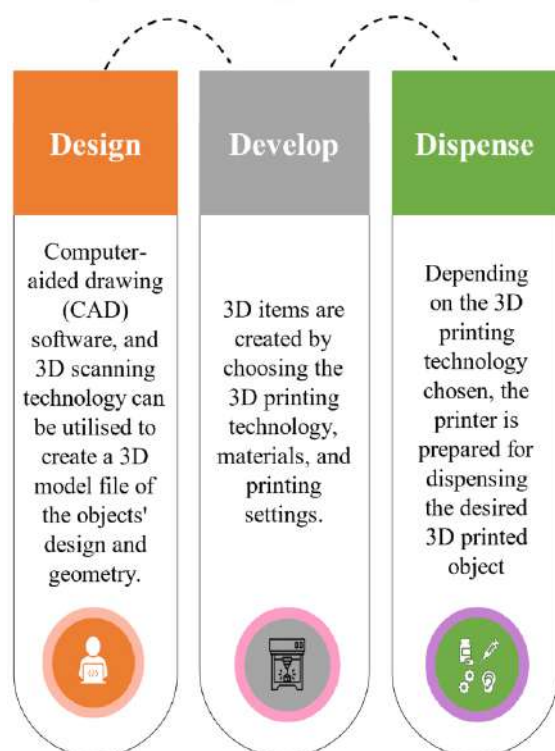


Fig. (4). Three D's of 3D printing. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

The fact that production is carried out layer by layer, as is typical of an additive process, as opposed to more conventional production techniques that employ subtractive procedures or casting processes, is what unites all these 3D processes and technologies [45].

4. TECHNIQUES OF 3D PRINTING

Various 3DPs have been designed, which have the ability to print, extrude, and shape the important dimen-

sions of 3D printing. There are six types of printing methods (Fig. 5) used in the pharmaceutical field based on the energy source, materials, mechanical properties and layer formation, as shown in Table 1. These are Vat photopolymerization, Selective Laser Sintering (SLS), Extrusion Molding Printing (EMP), ink-jet-based printing, Drop On Powder (DOP), and Electrohydrodynamic (EHD) printing techniques.

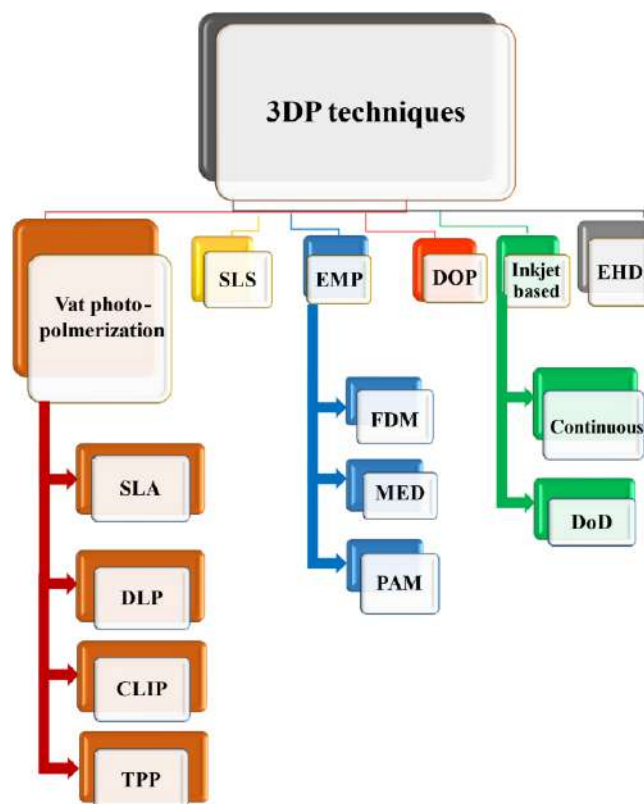


Fig. (5). Various techniques of 3D printing. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

Table 1. Summary of various 3D printing techniques.

3D Printing Techniques	Excipients Used	Advantages	Disadvantages	Configure	References
Vat photo-polymerization	SLA • PEG • pHEMA • PEGDA • GelMA • PEG-DMA • PPF/DEF, etc	• Excellent resolution • Less thermal stress is involved • Less demand for properties and chemical structure of drugs/excipients • Patterning precise structures	• Limited formulation • Toxic material • Costly • Fewer resins present	• Transdermal micro-needle • Modified release tablets • Multi-layer polypills • Drug loaded hydrogels • Bladder devices • Anti-acne patch	[28, 87]

(Table 1) contd....

3D Printing Techniques		Excipients Used	Advantages	Disadvantages	Configure	References
	DLP	<ul style="list-style-type: none"> • PEGDA • PEGDMA • PPF • DEF • PEGMA, <i>etc.</i>	<ul style="list-style-type: none"> • Fast process • Less usage of resins • Instantly solidify the complete layer 	<ul style="list-style-type: none"> • Possibility of degradation of materials • Unexpected drug-polymer interactions • Time-consuming 	<ul style="list-style-type: none"> • Drug delivery implants • Solid oral dosage forms • Micro-needle arrays 	[47]
	CLIP	<ul style="list-style-type: none"> • PEGDMA • PCL-tMa • PCLDMA • PMA, <i>etc.</i> 	<ul style="list-style-type: none"> • Predictable mechanical features • Consistent molecular structure of 3D object 	<ul style="list-style-type: none"> • Degradation of materials • Accidental drug-polymer reactions 	<ul style="list-style-type: none"> • Transdermal drug delivery devices • Microneedle • Mask devices 	[47]
	TPP	<ul style="list-style-type: none"> • PEGDA • PEGDMA • PLA, <i>etc.</i> 	<ul style="list-style-type: none"> • Control drug release profile • Act as a drug carrier with variable size and shape • Adjustable drug release kinetics 	<ul style="list-style-type: none"> • Unexpected drug-polymer interactions • Degradation of materials 	<ul style="list-style-type: none"> • Microneedle • Drug delivery devices 	[47]
SLS	-	<ul style="list-style-type: none"> • PE • PVA-PEG • PCL, <i>etc</i> 	<ul style="list-style-type: none"> • Solvent-free • High resolution • Single-step method for drug delivery • Less time consuming • Absent of liquid binders 	<ul style="list-style-type: none"> • Degradation of materials due to highly energetic light source • Finite speed of sintering 	<ul style="list-style-type: none"> • Oral dispersible tablets • Cubic porous structure • Pellets loaded with drugs 	[28, 87, 289]
EMP	FDM	<ul style="list-style-type: none"> • PVA • TCP • PLA • HPMCAS • PCL • HPC • PLGA • Eudragit, <i>etc</i>	<ul style="list-style-type: none"> • Low-cost • Easy operating process • Accurate • Promising parameter properties • Association of HME • Excellent mechanical properties • More flexible in designing complex formulations 	<ul style="list-style-type: none"> • Less drug loading capacity • Causes of thermal degradation 	<ul style="list-style-type: none"> • Immediate, Pulsatile and Enteric drug-release tablet • Vaginal ring suppositories • Microneedle patches • Rectal ring suppositories • Oral dispersible films • Delivery devices for nanocapsules • Uterus devices 	[289]
	MED	<ul style="list-style-type: none"> • PEG • HPC • Glycerol • Kollidon, <i>etc</i>	<ul style="list-style-type: none"> • Filament-free method • Accurate • Reproducible • Large-scale production • Operating multiple materials • Excellent compatibility with drugs/ excipients • Broad-range excipients can be used • No product degradation • GMP compliance 	-	<ul style="list-style-type: none"> • Multi-component tablets, such as core-shell structured tablets with a delay layer • drug delivery devices 	[17]

(Table 1) contd....

3D Printing Techniques		Excipients Used	Advantages	Disadvantages	Configure	References
	PAM	<ul style="list-style-type: none"> • PVP • HPC • HPMC • MCC, etc 	<ul style="list-style-type: none"> • Appropriate for thermally unstable drugs • A broad range of initial materials can be used 	<ul style="list-style-type: none"> • Post-processing required • Usage of heavy machinery tools, <i>i.e.</i>, hot extruder motor • Low resolution • Organic solvents are used 	<ul style="list-style-type: none"> • Double layer tablet • Suppositories • Floating drug delivery system (FDDS) • Nanocapsules • Gummy drugs 	[29, 87]
Inkjet based	-	<ul style="list-style-type: none"> • Binder fluid like glycerol, deionised water • PVP • Polysorbate, <i>etc.</i> 	<ul style="list-style-type: none"> In continuous inkjet, <ul style="list-style-type: none"> • Rapid droplet ejection • No blockage in the nozzle In DoD, <ul style="list-style-type: none"> • Cost-effective • Easy to use • High precision • Controlled droplet sizes • Less wastage of drugs 	<ul style="list-style-type: none"> In continuous inkjet, <ul style="list-style-type: none"> • Unnecessary dispersion of ink • Costly maintenance • Low resolution In TIJ, <ul style="list-style-type: none"> • Degradation of thermal-sensitive active ingredients 	<ul style="list-style-type: none"> • Implants • Oral wafers • Tablets • Inhaler 	[28, 289]
	-	-	-	-	-	-
DOP/ Binder jet	-	<ul style="list-style-type: none"> • PVP • HPMC • Starch, <i>etc.</i> 	<ul style="list-style-type: none"> • Restoration of unprocessed powder after the activity • High level of porosity • Inexpensive production • Removal of residual volatile solvent through thermal sintering • Normal temperature process • A broad range of materials can be used 	<ul style="list-style-type: none"> • High fragile • Less resolution • Post-processing required • Defects in product • Deficient mechanical features 	<ul style="list-style-type: none"> • Implants • Orally disintegrating tablets (ODTs) • Extended-release and Enteric dual pulsatory tablets 	[28, 87]
EHD	-	<ul style="list-style-type: none"> • CA • PCL • PEO • PVA, <i>etc</i> 	<ul style="list-style-type: none"> • Highly controllable resolution • Provide a suitable atmosphere for polymers/drugs • Controllable digital system for the deposition of materials • Complex geometries fabrication • Single step process • Low-cost production 	<ul style="list-style-type: none"> • Organic solvents are used • Less effective 	<ul style="list-style-type: none"> • Micro/nano-scale fibers • Wound dressings • Cylindrical capsules • Film patches • Composite films • Dual-core matrices 	[87]

4.1. Vat Photopolymerization Printing Technique

Vat photopolymerization 3D printing method is the process in which high energy light is ejected onto the

vat of liquid photopolymer to fabricate the solid objects. The polymer forms due to the reactive species generated from the photoinitiators under the radiation. Recently, researchers have developed novel

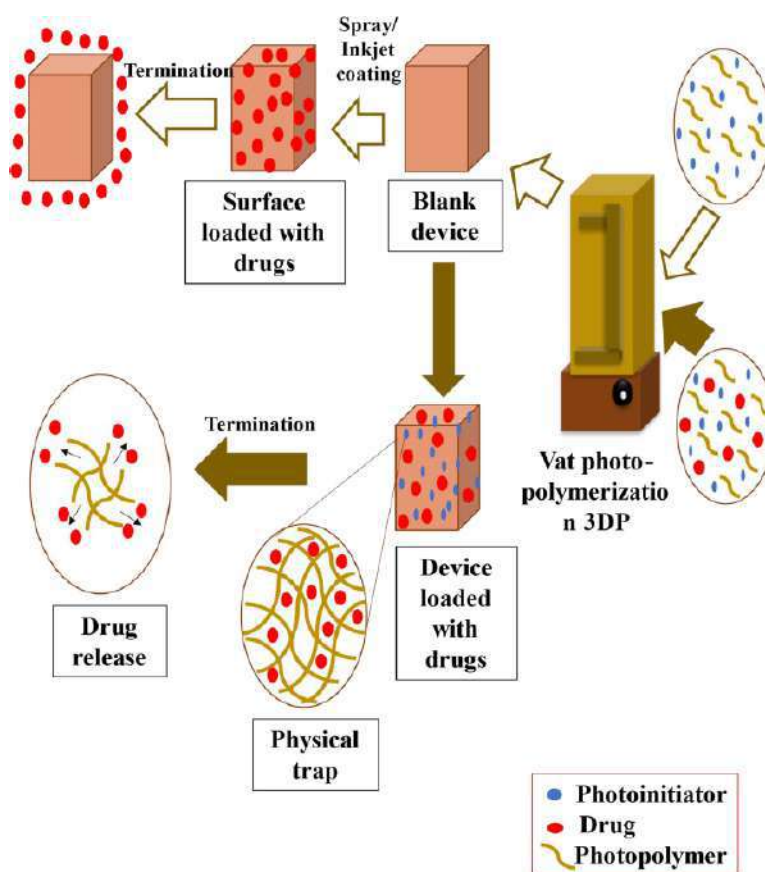


Fig. (6). A schematic illustration of VAT photopolymerization 3D printing technique for drug delivery system preparations. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

photopolymers that have shape memory properties. This can be used to tailor the smart devices by formulating the water-responsive shape rearrangement 3D structures with the hydrophilic or hydrophobic complex based on poly (propylene glycol) dimethacrylate (PPGDMA) and poly (ethylene glycol) diacrylate (PEGDA) [46]. It has numerous applications in tissue engineering, versatile drug delivery, and biomedical devices [47]. Fig. (6) shows graphically how vat photopolymerization 3D printing can be used to create devices that are loaded with drugs. This can be done in one of two ways: either by adding the drug directly to the liquid resin before printing or by adding it to a blank device after printing [48]. In the first scenario, magnetic stirring at room temperature is used to completely dissolve or uniformly disperse the medication in a resin made up of a photoinitiator and a photopolymer. The medication is then physically confined in the cross-linked polymeric network after printing. The medicine is released *via* diffusion from the swelling matrix once the device has been disseminated into a dissolving media. For blank devices, conventional drug loading meth-

ods based on adsorption, such as spray coating and dipping, can be used to integrate the medication. Alternatively, by soaking the blank device in a drug-concentrated solution, the drug can be absorbed into the polymer network. Post-loading **minimises** potential drug deterioration while pre-printing or printing, even if it adds an extra production step. Moreover, there are four main types of vat photopolymerization processes, which are as follows: Stereolithography (SLA), Continuous Light Interface Production (CLIP), Two-Photon Polymerization (TPP), and Digital Light Processing (DLP) [49].

4.1.1. Stereolithography (SLA) Printing Technique

SLA technology is the first technology that is available for commercial purposes [4]. SLA printing method uses an ultraviolet laser to photopolymerize the photosensitive liquid resins [50, 51]. The SLA printer system can either be top-down, in which the platform is below, and the UV laser is above, or bottom-up, in which the platform is above, and the UV laser is below [28]. The first step of SLA is scanning a

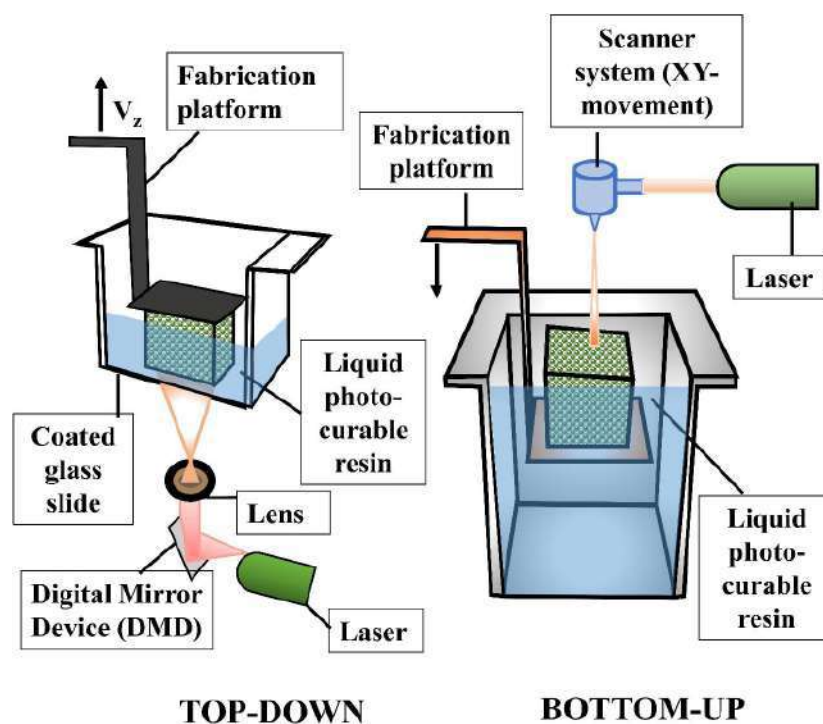


Fig. (7). A schematic illustration of top-down and bottom-up approaches of SLA 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

thin layer of liquid resin along with the drug for polymerization by using a photoinitiator. The adhesion of the next layer on the basic layer takes place due to the curing depth being a little bit larger than the thickness of a single layer, which results in the polymerization between the resins and unreacted compounds in two adjoining layers. This cycle takes place till the product is formed. After the process, unnecessary resin and photoinitiator should be rinsed with alcohol to avoid the toxicity of resin and to develop the mechanical properties of the object by using a UV oven [28, 52, 53]. Additionally, when drugs, excipients, and resins form a homogeneous mixture with each other, they can be absorbed into it due to polymerization and cross-linking [54]. Hence, it is necessary that materials used in SLA have photo-curable properties for photo-cross-linkage.

The advantages of SLA include excellent resolution (20 μm), less thermal stress involved, less demand for properties and chemical structure of drugs or excipients, and patterning precise structures [28, 55]. Therefore, SLA has applications in hydrogels, microneedle patches, and fabricating oral solid dosages [56-60]. However, it has some drawbacks, like the limited formulation for dosage formation, as SLA can barely use a particular resin formulation at a time of a single printing process, except the earlier formulation is replaced

with the latest formulation if the printing is discontinued. Although some photocrosslinkable polymers have been developed over the past few years, such as Gel-MA and PEGDA, photosensitive polymers are limited and are FDA-approved [61-63]. Hence, SLA is a potential tool for the pharmaceutical industry (Fig. 7).

4.1.2. Digital Light Processing (DLP) Printing System

In this printing system, liquid photopolymers are cured by photon exposure in a layer-by-layer form. The building platform is immersed in resin, and the polymerized resin layer is at the bottom of the vat during the printing process. This method prevents direct contact with the air, making the printing process less vulnerable to oxygen inhibition [64]. The 3D material through the DLP printing system was prepared by Yang *et al.* [65]. It was found that robustness, printability, drug loading capacity and drug release profile were highly dependent on the height of the layer, plasticizer addition, emission time, and concentration of PEGDA. When compared with SLA, the DLP printing system is a fast process, allowing less usage of resin to develop 3D objects and instantly solidify the complete layer [66]. DLP has applications in the construction of drug-delivery devices and personalized medicine (Fig. 8) [47].

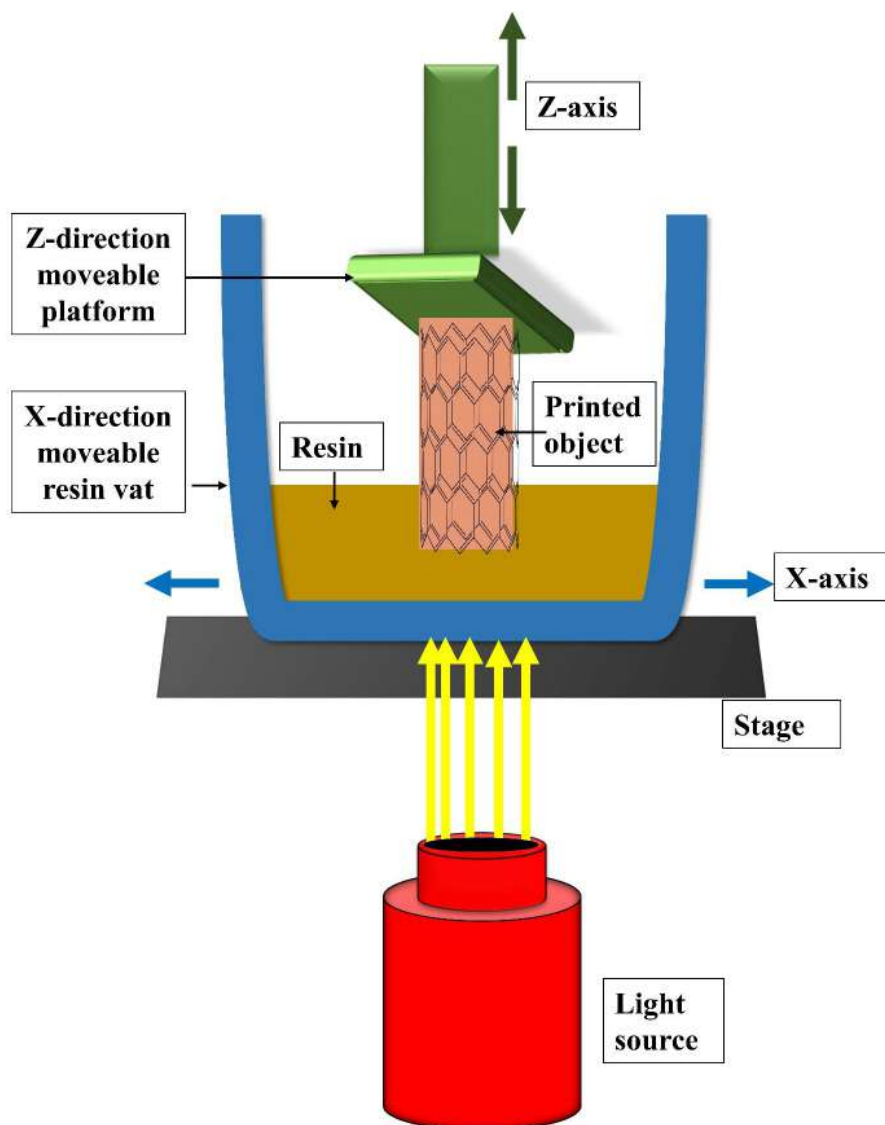


Fig. (8). A schematic illustration of the DLP 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

4.1.3. Continuous Light Interface Production (CLIP) Printing Technique

In the CLIP printing method, 3D objects are formed by a continuous fabrication process instead of a layer-by-layer manner. In 2014, Joseph DeSimone *et al.* prepared the CLIP printing system [67]. The dead zone is a thin layer of liquid interface between the liquid resin and the printed parts created by the CLIP system using an oxygen-permeable window [68]. This dead zone prevents photopolymerization at the interface, permits resin to flow freely under the window surface, and removes the need for an intermediate resin re-coating step for each layer, which is the most time-con-

suming procedure in DLP printing [69]. It has advantages over the SLA or DLP method, such as predictable mechanical features and consistent molecular structure of a 3D object. The CLIP technique includes the mask device fabrication for the microneedle coating and was developed by Caudill *et al.* [70]. In addition to this, the coated mask was applied for the regulated fast delivery of model proteins (such as bovine serum albumin, lysozyme and ovalbumin) from the microneedles into the skin and also the possibility of co-delivery of various antigens/ proteins through a single microneedle. Therefore, it has applications in the fabrication of transdermal drug delivery devices (Fig. 9).

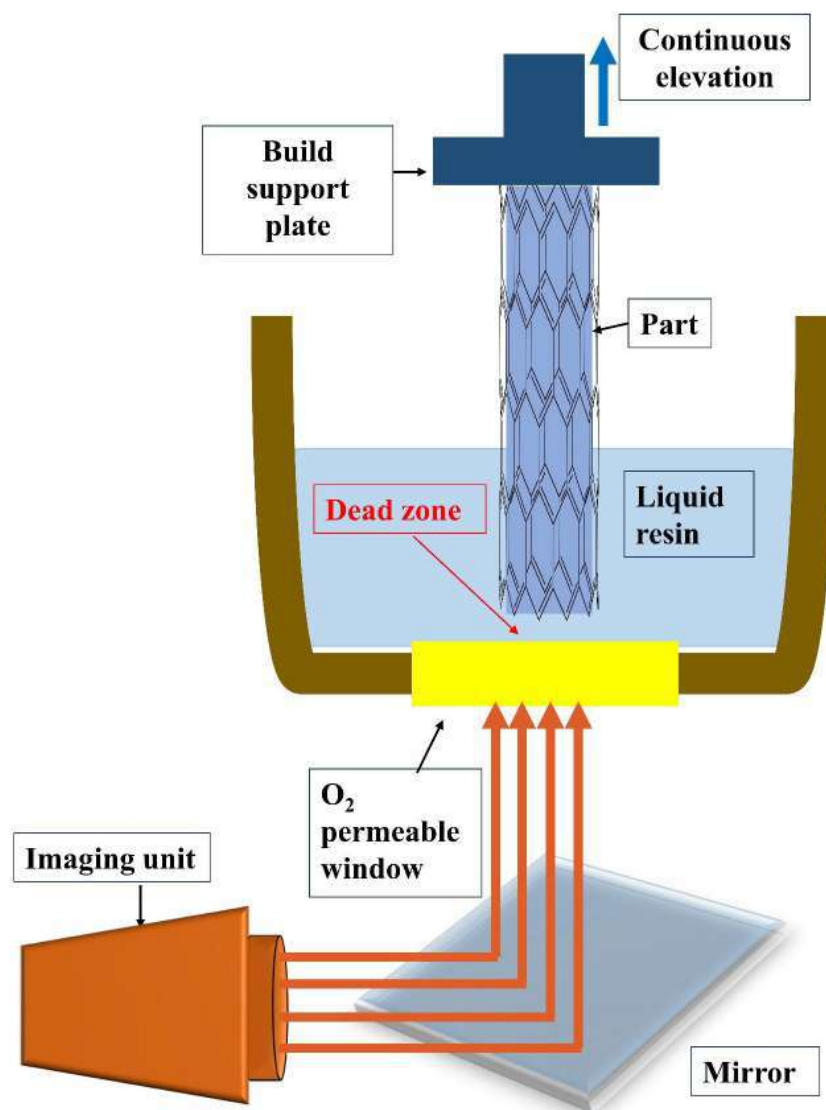


Fig. (9). A schematic illustration of CLIP 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

4.1.4. Two-Photon Polymerization (TPP) Printing Technique

TPP is a microfabrication technique in which near-infrared femtosecond laser sources are exposed to a photosensitive resin. Photosensitive polymers absorb two or more photons at the same time in the non-linear optical process and later, the regional resins get solidified to form 3D nano/microstructures [71]. Additionally, the resolution of TPP is influenced by the exposure time, photoinitiator ability and laser power density [72]. Furthermore, TPP is capable of developing drug-encapsulated particles from polylactide (PLA) based photocurable polymers. There are several achieve-

ments of the TPP printing process. Shavkuta *et al.* used TPP in conjunction with a micromolding process to design the particles loaded with insulin from methacrylate-functionalized PLA [73], and thus, this combination is useful for drug carriers with a controlled drug release profile, adaptable size and shape. Also, Cordeiro *et al.* used the TPP 3D printing technique to manufacture several designs of microneedle array templates [74]. This microneedle was found to be efficient in drug delivery and better at skin insertion. Besides this, Do *et al.* used the TPP method to construct rhodamine B-loaded poly (ethylene glycol) dimethacrylate (PEGDMA) devices [75]. Therefore, it has applications in the fabrication of drug-delivery devices (Fig. 10) [47].

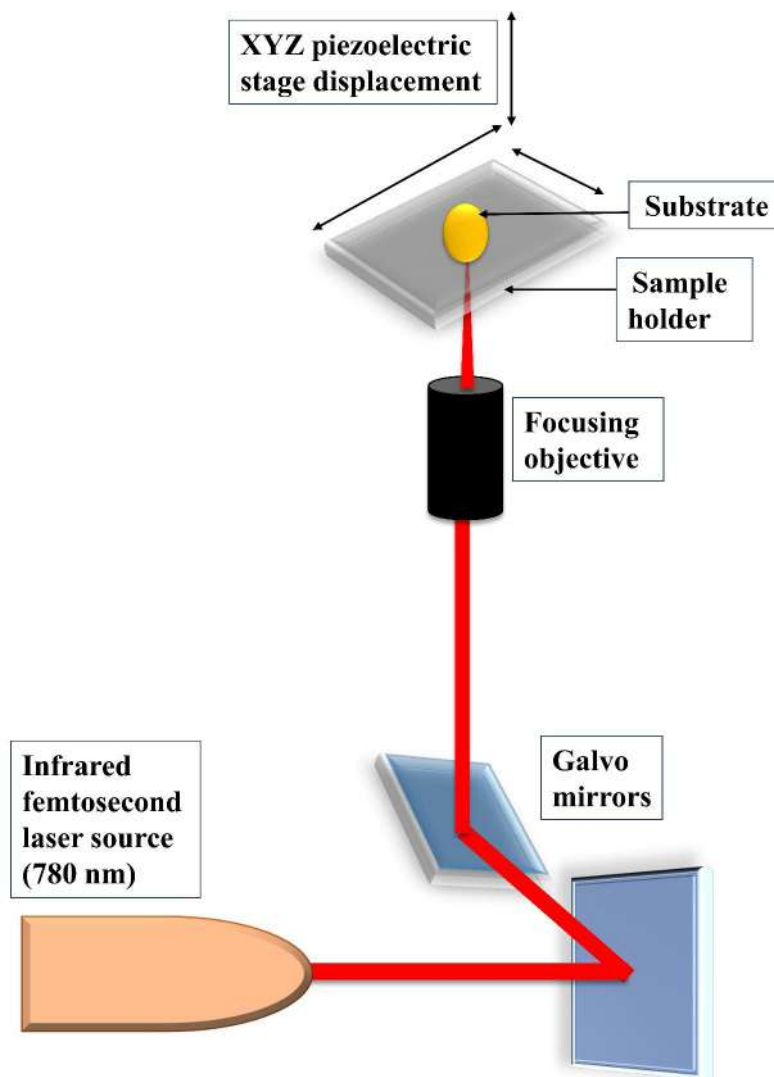


Fig. (10). A schematic illustration of TPP 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

4.2. Selective Laser Sintering (SLS) Printing Technique

SLS is a laser-based 3D printing technique that uses the laser beam of CO₂ rather than the binders for the accurate sintering of a particular area of powders in every layer. It employs heat through a laser beam and combines the powder to form a 3D structure. There are three main components of SLS, which are the laser system, powder bed, and spreading platform [28]. The first step of SLS is to produce long filaments, which include thermoplastic polymers, by using hot melted extrusion and active pharmaceutical ingredients (APIs) [76]. In SLS, commonly used thermoplastic polymers are as follows: polylactic acid (PLA), polycarbonates (PC), polymethylmethacrylate (PMMA), polyvinyl al-

cohol (PVA), polylactide (PLLA), polyamides (PA), polyurethane (PU) polyethylene (PE), poly(ether-ether-ketone) (PEEK), and polycaprolactone (PCL) [77]. The process chamber is filled with inert gas, commonly nitrogen, to avoid the oxidation of materials. Moreover, the process chamber works at a temperature that generally ranges less than the melting point of raw materials (40-50°C) for the entire printing process, and thereafter, the powder must be cooled to eliminate stress and curl deformation [64, 78]. The excellent sintering process is obtained when the size of powder particles ranges from 58-180 μm, and the thickness of the layer ranges in size around 0.1-0.3 mm [77, 79]. SLS has several advantages, such as solvent-free, high resolution (approx. 30 to 60 μm), single step

method for drug delivery as well as less time consuming due to the absence of liquid binders so that the evaporation of solvents is not required [80].

In recent years, SLS has been widely acknowledged due to the easy disintegration of drugs by using high-energy laser beams. It has been found that SLS has applications in the drug delivery system and tissue engineering [81-85]. In 2017, Fina *et al.* developed paracetamol tablets by using Kollicoat IR, which includes an immediate release feature, as well as Eudragit L100-55, which includes a modified release property [80]. It has been observed that the mechanical properties of this tablet fulfil the need of the US pharmacopeia, and also, no degradation of the drug was found. Additionally, Hamed *et al.* applied SLS printing technology to manufacture amorphous lopinavir (LPV), which is an inhibitor used to treat the HIV virus and study the formulation outcomes [86]. In this way, SLS received huge attention in the pharmaceutical field (Fig. 11).

4.3. Extrusion Molding Printing (EMP) Technique

It is a very often used methodology that is primarily categorised into three types based on the molding substances: Pressure Assisted Microsyringe extrusion moulding method (PAM), Fused Deposition Modeling method (FDM), and Melt Extrusion Deposition (MED) 3D printing method [17, 87].

4.3.1. Fused Deposition Modeling (FDM) Printing Technique

FDM, also known as fused filament fabrication, is a widely used 3D printing technique. This method works by converting the drug-loaded polymers into a semi-fluid state by heating them to a critical state and then ejecting them through the printing nozzle based on the parameters, which solidify over the printing surface, and the product can be achieved [88]. This technique involves several parameters in its working phenomena, such as nozzle diameter, product filled percentage, extrusion speed, temperature, layer width, and head movement printing speed. Moreover, the preparation of drug-loaded filament is the fundamental step in the development of FDM, which is obtained by the passive soaking technique. In this technique, filament substances are placed in the solvent of ethanol or methanol, which contains the drug, and then dried. Nevertheless, due to the less probability of getting drug load through this approach, Hot Melt Extrusion (HME) method, including single or twin screws, is an alternative way for the filament preparation. The filament substances that are mainly used are as follows: Polyvinyl alcohol (PVA), Polycaprolactone (PCL), Polylactic Acid (PLA), polylactide-coglycoside (PLGA), and other derivatives of cellulose [31, 89-93]. Despite this approach, the preparation of drug-loaded filament can be avoided by

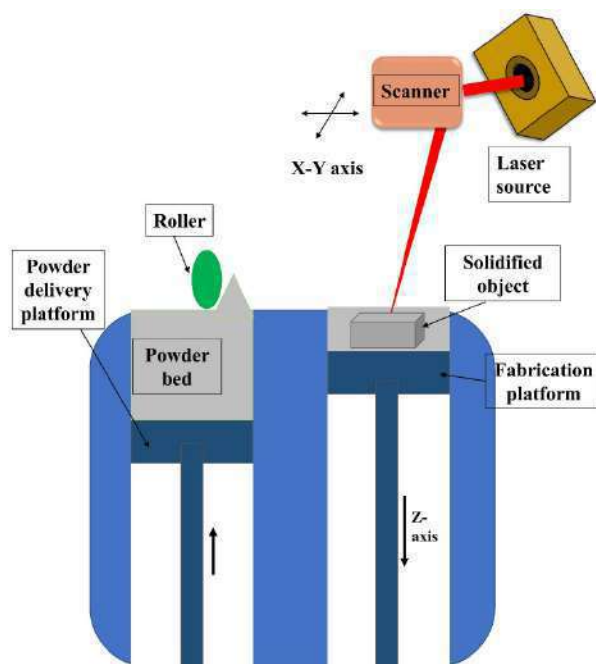


Fig. (11). A schematic illustration of SLS 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

making the polymer compatible with the 3D printer as well as the original form of the drug as a raw material [94]. Additionally, dosage forms based on TPU, which are loaded with 60% (w/w) crystalline drug, are efficiently developed by Verstraete *et al.*, whereas the HME method linked with the FDM method is also effective in developing a tablet, as discussed by Zhang *et al.* in 2017 [95, 96]. These results demonstrated the potential of FDM technology in the application of solid forms of dosage preparation.

The advantages of the FDM technique include low cost, easy operating process, accuracy, promising parameter properties, an association of HME, excellent mechanical properties of the product and also, it is more flexible to design complex pharmaceutical procedures, such as chamber-like and core-shell structures [97, 98]. However, the disadvantages of the FDM technique include high-temperature heating action in printing, generally greater than 150°C, which is not appropriate for thermally unstable drugs like 4-aminosalicylic acid, which decays over 210°C [99].

Through this study, various modifications are made in FDM technology to **minimise** thermal stress, such as the preparation of drug-loaded filaments by using low-melting point povidone, which was successfully developed by Kollamaram *et al.* [100]. It showed that low-melting point filaments can reduce the temperature of the printing procedure up to 90 °C. Another study showed that the temperature of printing can be diminished by eliminating filament with soft extruded polymer threads as well as preparing filament by using water as a temporary plasticizer that reduces the temperature up to 54 °C [101, 102]. In addition to this, researchers have found that Direct Powder 3D Printing (DPP) is used for tablet tailoring, which is a single-step FDM process with the absence of HME. In this process, after filling the powder into a stainless-steel extrusion cartridge, the powder mixtures were heated, which led to the printing of tablets into honeycomb structures [103]. FDM technology has major significance in the pharmaceutical field (Fig. 12).

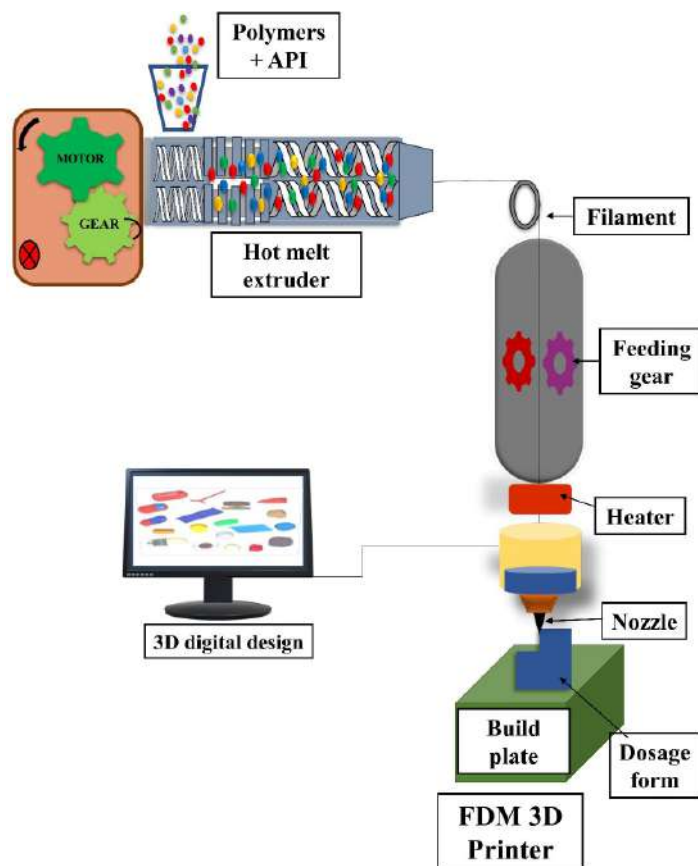


Fig. (12). A schematic illustration of hot melt extrusion coupled with FDM 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

4.3.2. Melt Extrusion Deposition (MED) Printing Technique

The Melt Extrusion Deposition (MED) 3D printing technique belongs to the extrusion-based category. Unlike FDM technology, it offers a significant advantage by eliminating the need for filament preparations when working with drugs and excipients during the printing process. In this method, the initial materials are active ingredients and excipients in the form of powder. The powder of materials and active pharmaceutical ingredients were directly used for MED without any additional processing. The powder feedstocks were converted into molten states, and layer-by-layer deposition was followed to produce the desired geometries of the object. MED filament-free method is also reliable for the production of high drug loaded (60%) thermoplastic polymers. The nozzle printer array has high throughput, precise control of deposition, and operation of multiple materials that can build the accurate, reproducible and large-scale production of the desired product. Moreover, Good Manufacturing Practice (GMP) compliant MED 3DP technology was developed in which each printing stations contain one nozzle that is

synchronised with each other for the fabrication of certain parts of the structure, such as shell, delay layer, core, filler, etc. Therefore, it leads to the tailoring of multi-component tablets by using compartment models, which provide controlled kinetics, on-set time release, and mode of release and fulfill desired product needs.

The predictability of tablet release serves as the platform for the 3DP Formulation by Design (3DPfBD) approach, which is a novel development approach that provides an effective process of product development. It has several advantages, such as excellent compatibility with drugs or excipients, a broad range of excipients that can be used, no filament preparation, no degradation of product, and GMP compliance. It is crucial for controlled drug delivery. Many desired aspects of current pharmaceutical production are also implemented, resulting in a compact, modular, continuous manufacturing, scalable, versatile, and intelligent MED 3D printing system. The technology enables the efficient production of modified-release medication tablet products at any required scale, suggesting a viable route for next-generation pharmaceutical manufacturing (Fig. 13) [17].

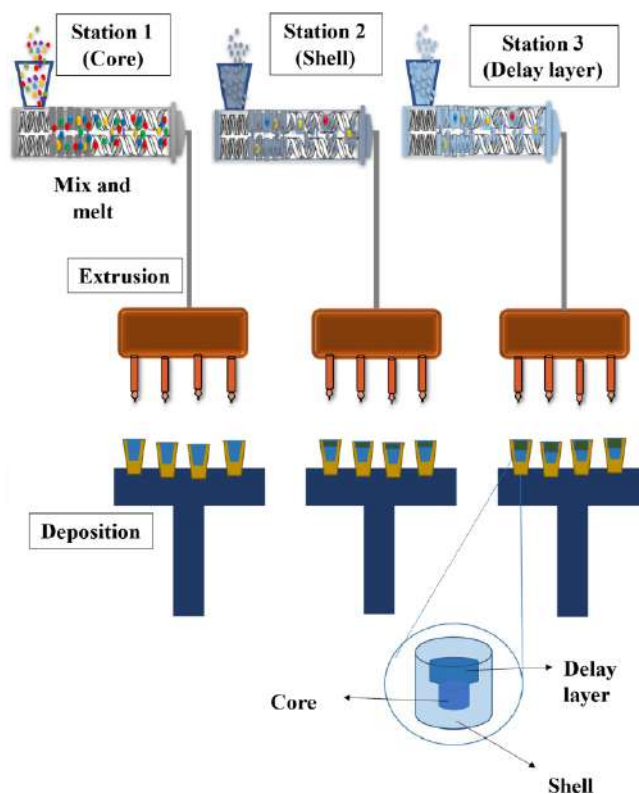


Fig. (13). A schematic illustration of the fabrication of core-shell structured tablet with a delay layer by using MED 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

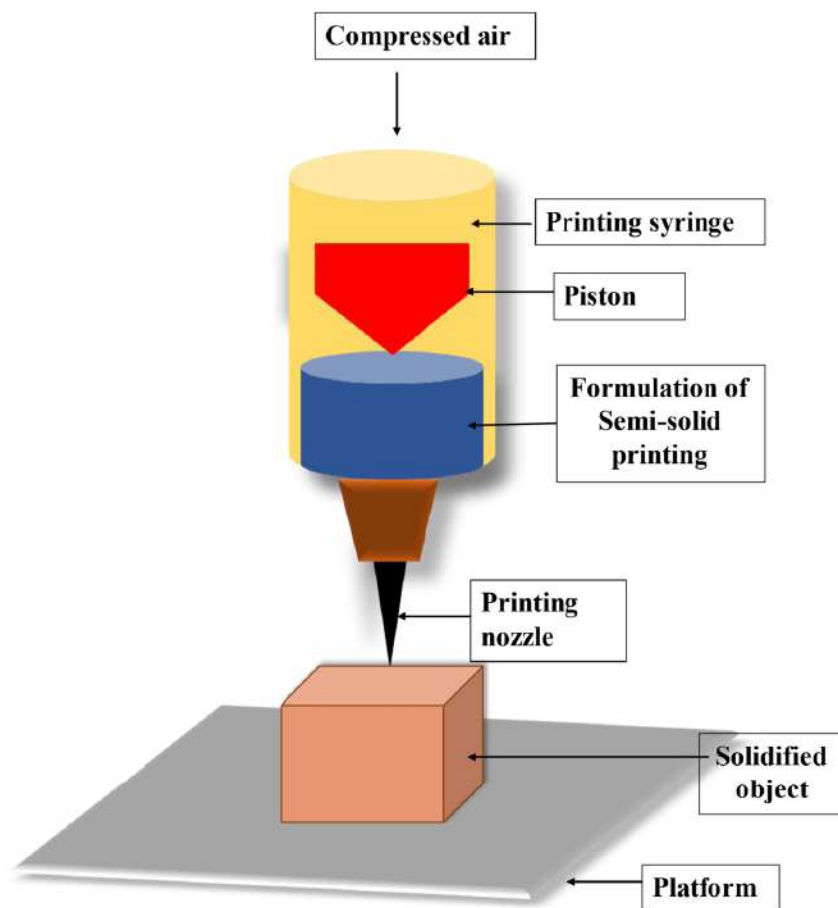


Fig. (14). A schematic illustration of PAM 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

4.3.3. Pressure-Assisted Microsyringe (PAM) Printing Technique

PAM is a 3D printing technology that is also known as the Semi-Solid Extrusion method (SSE) [104]. The extrusion can be pneumatic, solenoid or mechanical piston based [28]. This method exerts pressure or screw gear rotation on the syringe-based print head for the uniform extrusion of the semi-solid materials and places it on the printing surface layer by layer for the printing process according to the command of the software. The exerted pressure for the printing is required around 0.4-3.8 bar and the syringe print head diameter is around 0.35-0.85 mm. In the PAM technique, raw materials play a significant role in the semi-solid process due to the pressure directly exerted for the extrusion of semi-solid materials into the head of the printer without distortion. It allows the microstructure production, which is around 5-10 μm or less [29]. The PAM method has advantages like no requirement

of heating, so it is appropriate for thermally unstable drugs, for example, guaifenesin [105, 106]. However, it has some drawbacks, such as the usage of heavy machinery tools, *i.e.*, hot extruder motor element for the extrusion process by applying torque, as well as the usage of organic solvent for making semi-solid materials, which may not be suitable for the remaining organic solvents in the tablets [107, 108]. The PAM technique is potentially good for pharmaceutical applications (Fig. 14).

4.4. Inkjet Printing Technique

The inkjet printing method is based on the placing of liquid droplets onto a substrate under the command of a digital controlling system. The combination of drugs and other materials, which are known as ink, are settled as droplets in a layer-by-layer form over the substrate. Inkjet printing is mainly classified into two types, namely Drop on Demand (DoD) and Continuous Inkjet printing (CIJ) (Fig. 15) [63, 109].

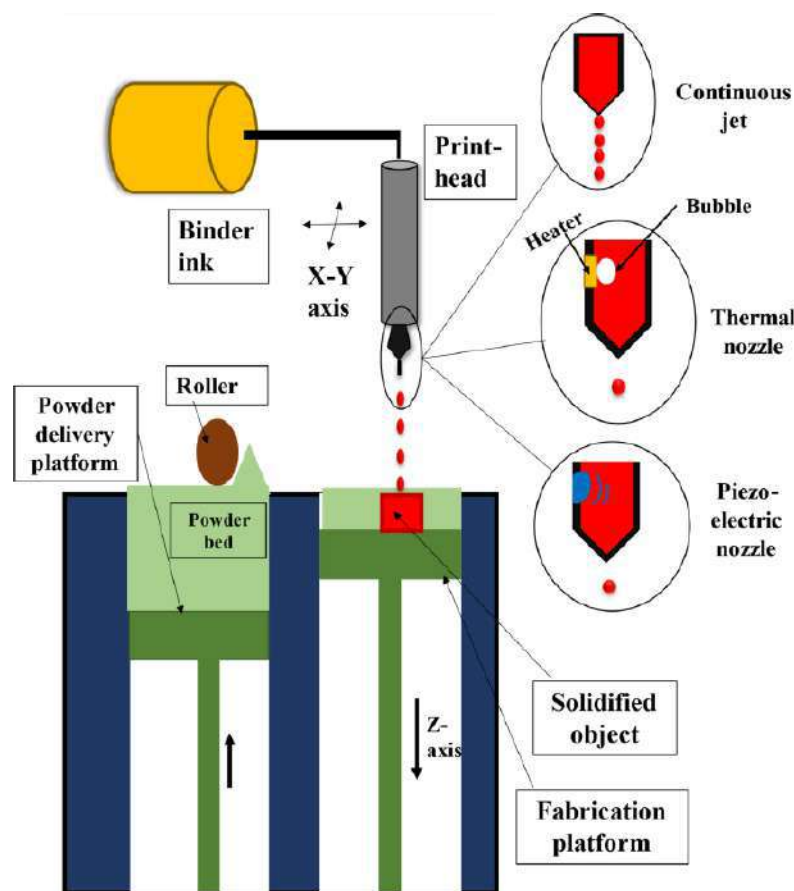


Fig. (15). A schematic illustration of inkjet-based 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

4.4.1. Continuous Inkjet Printing Technique

This type of printer discharges a jet of droplets of liquid over a substrate in a continuous manner. The evenly sized droplets are formed due to the pressure generated into the inkjet, and thereafter, droplets discharge from the nozzle whose diameter is around 50-80 μm [29]. There are some advantages of continuous inkjet printers, which include rapid droplet ejection and no blockage in the nozzle. However, there are some disadvantages of this technology, which include unnecessary dispersion of ink, inflated maintenance, and low resolution [110].

4.4.2. Drop on Demand (DoD) Inkjet Printing Technique

This method only ejects the liquid droplets (10-50 μm diameter with 1-70 pL volume) when it is necessary over a substrate according to the command of the signal [29]. DoD inkjet printers have sources, which are present in the printhead, which provide kinetic energy to the droplets near every nozzle [111]. Also, this

kind of printer has many nozzles, which are around 100-1000; however, a single specialised printhead is present. There are several advantages of the DoD method, which include cost-effective, easy to use, high précised, controlled droplet sizes, and less wastage of drugs [28]. However, it still gains more attention as compared to the continuous inkjet printing [112, 113]. DoD inkjet printers are categorised on the basis of the printhead, namely thermal inkjet (TIJ) and piezoelectric inkjet (PIJ) printers [52].

In the TIJ technique, thermal energy is the signal used to eject droplets out of the nozzle. Here, printheads carry resistors to gain exposure to the ink (fluid) and induce electric current to generate heat. This thermal energy leads to the bubble formation from the volatile fluid; thereafter, it enlarges and discharges fluid in the form of droplets from the nozzle. However, it has some drawbacks, such as the degradation of thermally sensitive active ingredients due to the usage of resistors with high temperatures of around 200-300 degree Celsius [110, 114].

In the piezoelectric inkjet printer, a certain amount of electric voltage is given to the piezoelectric crystal/s/element/actuator, which changes its shape to generate a signal that further generates pressure, leading to the discharges of ink from the nozzle. Thereafter, the elements attain their original shape, and the nozzle is again filled with the fluid for the activation [113, 115]. There are some advantages of this technique, which include efficiency at room temperature due to the presence of more biocompatible and less volatile fluids [114]. Hence, the piezoelectric print head is **in** demand for numerous applications.

4.4.3. Miscellaneous Inkjet Printing Technique

4.4.3.1. Valve Jet Printing Method

This method is also known as electromagnetic printing, which is applicable in the pharmaceutical field and is based on small-sized solenoid valves. In contrast to the TIJ or PIJ, this technology is better due to its large orifice sizes, robustness, and ability to print coarser suspensions [116].

4.4.3.2. Glass Inkjet Printing Method

This method discharges the droplets at high frequencies, and it has shown applications in the pharmaceutical field due to the inertness of glass that will stay unreactive with other materials [117].

4.4.3.3. UV-based Inkjet Printing Method

This technology has UV photo-initiation along with inkjet printing, which is useful to harden the substances quickly. In this method, the ink contains cross-linked functional groups that get signals through light, and further, a photo-initiator is involved in the process [118].

4.5. Drop On Powder (DOP) Printing Technique

The DOP printing method is also known as binder jetting, drop on solid, and plaster printing technology [29]. It is an application of the inkjet-based printing method. In this method, the print head ejects the droplets so that it can combine the powder particles in a deposited powder over the surface [119] in layer-by-layer form, which is uniformly placed by using a roller. The nozzle of the printer contains binder fluid, which is operated to jet above the powder bed by moving in the x-y direction [28]. The ejecting droplets with binders, for example, hydroxyl propyl methylcellulose (HPMC) and PVP K30, are deposited on the powder bed at a controlled speed according to a certain pattern designed in the computer. The powder soaked the

liquid drops, which solidifies the layer. The solidification process that takes place in DOP is similar to the wet granulation used in tablet formation [120]. Solid bridges are formed due to the crystallisation of dissolved particles and the evaporation of the solvent. Furthermore, the layers are formed by sliding the previous layer of the surface along the vertical axis and then printing the new layer in place of the previous layer from the feeding cell. Furthermore, this cycle continues until it completes the construction of 3D objects. Many parameters are involved in the preparation process, like the droplet spacing, layer thickness, nozzle diameter, distance between the print head and spread powder, movement of the print head, droplet velocity, line spacing, and frequency of the droplets [121-123]. These parameters facilitate the behavior of drug release and physical properties (viscosity, concentration and surface tension) [124]. The flowing nature of printing ink depends on the physical properties, and it can be altered by adding binders or Active Pharmaceutical Ingredients (APIs), for example, HPMC, CMC-Na, PVP, HPC, and PEO [125-127]. In view of the fact that material integrity totally depends on the weak force rather than the mechanical compression force, the dosage forms are easily tailored with interlinked pores in the micro range for the preparation of tablets [128].

Moreover, DOP is **categorised** into two types based on the printhead, namely thermal and piezoelectric [121]. The thermal printhead allows a smaller number of solvents with high vapour pressure to vaporize. It uses a heater with a temperature of around 200-300 °C to vaporize a small amount of fluid, which forms small bubbles that eject the droplets [129]. It has been found that below 0.5% of the liquid in the print head comes under the influence of high temperature for a few microseconds [130] with no degradation of proteins (insulin and human growth hormone) for the thermal print head [131]. In comparison to piezoelectric print heads, thermal print heads are inexpensive for the fabrication process. The piezoelectric printhead contains piezoelectric crystals, which get charged by providing the voltage. This causes the distortion of the liquid, which ejects the drops from the nozzle. Hence, piezoelectric printheads are in more demand for various substances. Furthermore, there are advantages to the DOP method in post-processing, including the restoration of unprocessed powder and the removal of residual volatile solvent through thermal sintering [28]. Spritam, which is the first 3D printed drug, was constructed by using the binder jet-based zip dose method [34]. It is a novel microfabrication process that has application to construct dosage forms in a layer-wise fashion [132].

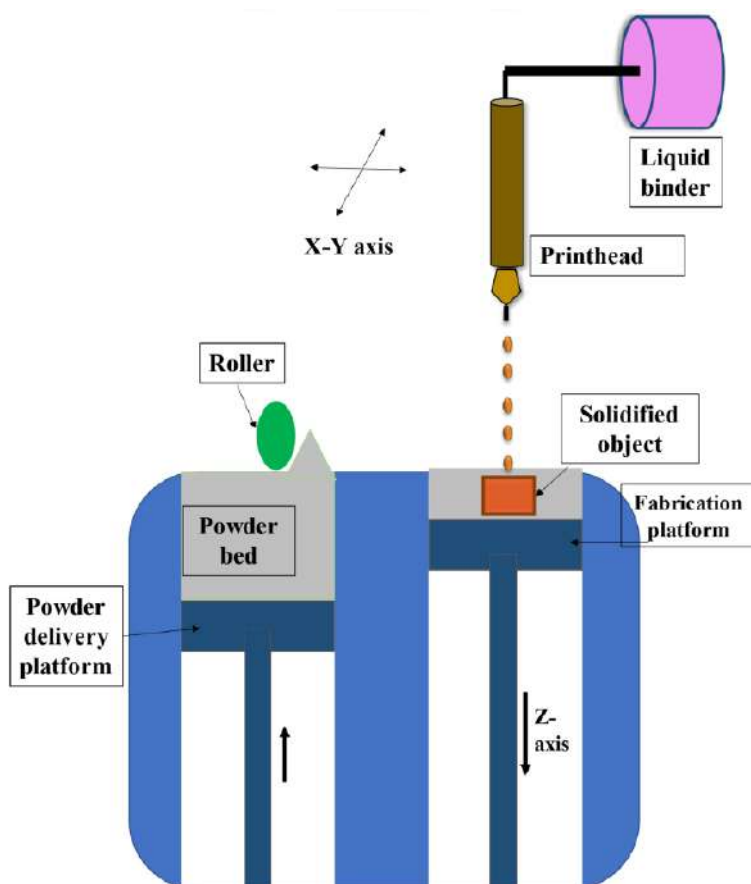


Fig. (16). A schematic illustration of DOP 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

However, DOP has some drawbacks as it shows defects in the printed product due to high fragility and low resolution. Therefore, further exploration of this method to overcome the problem is still needed (Fig. 16).

4.6. Electrohydrodynamic (EHD) Printing Technique

Electrohydrodynamic 3D printing is a growing technology that can model thread-like materials by placing the materials layer by layer to fabricate a controlled system. EHD has several components, which are required for the printing process: a thin nozzle print head, syringe pumps, a moving platform along the X-Y-Z direction with a controller, and a high-voltage power supply [133]. Several materials having viscosities between 1-10,000 mPa have been processed to develop drug carriers, such as polycaprolactone (PCL), polyvinyl alcohol (PVA), polyethylene oxide (PEO), and cellulose acetate (CA) [134]. There are several ad-

vantages of EHD technology, such as highly controllable resolution, providing a suitable atmosphere for polymers and many drugs like thermally stable drugs, manufacturing **micro-** to nanoscale fibers, a controllable digital system for deposition of materials, and fabrication of systematic complex geometries [135]. The complex geometries formed by this technology include dual-core graphene composite matrices, film patches, wounding dressings, cylindrical capsules, Janus fibers, and coreshells [136-141]. Hence, EHD 3D printing is a flexible approach for drug delivery and the fabrication of **personalised** medicines by printing a specific pattern of therapeutics on a porous film (Fig. 17) [129].

5. APPLICATION OF 3D PRINTING IN THE PHARMACEUTICAL FIELD

The use of 3D printing is expanding quickly across all industrial manufacturing sectors owing to its advantages for improving production efficiency and lowering the cost and quantity of defects by preventing human factors [142, 143]. Given its significant flexibility

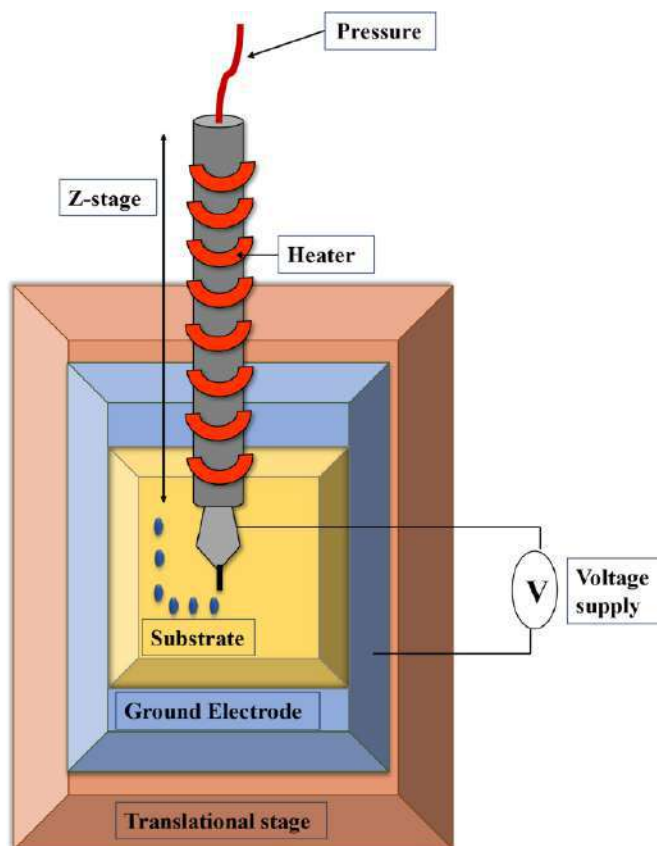


Fig. (17). A schematic illustration of the EHD 3D printing technique. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

and ability to create a variety of simple to complex geometries, 3D printing has altered not only industrial production but also the emphasis on industrial automation. To produce high-quality drug products with improved process robustness, 3D printing is quickly pioneering pharmaceutical manufacturing in the field of biopharmaceutical product development, where there is a reliance on producing medications using conventional manufacturing techniques [13, 144].

Utilizing 3D printing technology to foster drug items has gained critical interest in the pharmaceutical industry and universities as 3D printing innovation becomes more accessible to drug researchers. The assembly of medication delivery systems with precisely engineered constructions and the production of **customised** medications are two expected effects of the use of 3D printing in the pharmaceutical industry that will help bring the development of pharmaceutical products into uncharted territory. Due to its potential benefits, such as improved productivity, complex drug release profiles, multiple dosing, single-step processes at low cost, and customization/personalization of drug deliv-

ery, 3DP has seen widespread use in the pharmaceutical industry. This updated technology is a very helpful tool for more accurate drug dispensing with tailored drug release to meet the particular needs of each patient. Additionally, **personalised** medicine offers 3D printing a previously unheard-of opportunity to address the difficulties associated with treating heterogeneous diseases. Below is a description of the momentous implications of 3D printing in the pharmaceutical field.

5.1. Pre-medical Assessment of New Drugs

Before the approval of any kind of drug for commercial use, the pharmaceutical properties of the active ingredients of the drug are thoroughly examined and **analysed** by scientists for clinical safety and efficacy purposes in the early phase of drug development. To overcome drug failure during early-phase development and fulfil the high demand for promising drugs, it is crucial for companies to rapidly identify suitable drugs at the low expense as early as possible during the drug development process, ideally within preclinical studies [145, 146]. The 3DP technique can be considered for

this purpose, as it has proven its ability to fabricate dosage forms in the early phases of drug development with fewer resources, time and human efforts [147, 148]. 3DP is a very flexible procedure that makes it simple to modify doses to meet the demands of the trial. By physically changing the tablet's size or infill level, doses may be adjusted quickly and easily [91]. Whereas in conventional production, thorough pre-formulation studies, large batch sizes, scaling up and optimising the formula so as to create the desired dosage forms and significant labour costs are required [50, 149].

5.2. Person Specific Drugs (**Personalised Medicine**)

The majority of patients are supported by conventional dosage forms, which are only based on fixed strengths. **Personalised** medicine aims to offer the best medication at the optimum dose for the patient's individual symptoms at the right time according to the patient's genetic, physiological, or pathological background, taking into account additional variables, such as genetic makeup, gender, age, and weight for dose titration and dosage form design [14]. They increase patient compliance and are cost-efficient, more effective, and safer [24]. To provide such **personalised** drugs to treat specific patient populations for all age groups, the 3D printing technique can be a better tool, especially for treating complex diseases like Alzheimer's disease, cancer, and epilepsy [142, 150, 151]. 3D printing offers the preparation of a drug delivery system (DDS) with various doses, geometries, substances, and adjusted release rates considering the patient's personal characteristics [78, 152]. Additionally, it is possible to print pills in a kid-friendly format for kids who have trouble swallowing [98]. The 3D printing method does not require the installation of a comprehensive manufacturing setup with upscale equipment as with conventional methods, and it is flexible for on-site production. In this way, 3D printing techniques encourage a **personalised** drug approach [153-155]. In short, individualising and **personalising** therapies can enhance the therapeutic result, lessen side effects, and boost patient adherence to the regimen.

5.3. Complex Drug Therapies

In order to maintain drug levels in the blood for the desired therapeutic action for extended periods of time, patients frequently need to take conventional dosage forms of multiple pills for a single disease indication [156]. Such a strategy has a number of disadvantages, including low patient compliance, missed doses that cause blood levels to fluctuate, and high costs. With the use of 3D printing technology, it is now feasible to

design complicated, unmoldable dosage forms with distinctive properties and improved efficiency to facilitate long-acting drug therapy. Complicated dosage forms have narrow therapeutic parameters that would not be achievable with traditional manufacturing methods [155-157]. Such complex drugs loaded with high dosages are referred to as Fixed-Dose Combinations (FDCs) or polypills. It is now possible to individually adjust dosages and release patterns as well as the co-formulation of pharmaceuticals with interaction potential by physical separation of medications with the help of layer-by-layer printing [155]. A 3D-printing method of drug delivery would greatly benefit medications, such as asthma, cancer, cardiovascular diseases, TB, and epilepsy, where polypills are advised for patients.

5.4. Fabrication of Novel Drug Delivery Systems

The creation of solid pharmaceutical dosage forms has been significantly influenced by 3D printing. Compared to traditional methods, it offers the design of dosage, providing a great deal of flexibility and efficiency [158]. The process of making solid dosage forms traditionally entails a number of batch-wise operations, including mixing, granulation, milling, compaction, and compression. As a result, conventional multistep manufacturing is linked to increased batch-to-batch variability and decreased process robustness. The development of a variety of dosage forms, including solid dosage forms, implants, stents, and transdermal, rectal, and vaginal devices, can be done quickly and easily with 3D printing due to its high robustness, accuracy, and precision [36, 124, 156]. Additionally, it decreases the number of manufacturing steps, associated costs, failure risks, and quality consistency.

5.4.1. Oral Solid Dosage Forms

The easiest way to administer API is through oral dosage forms, which also have higher patient compliance than any other method. The layer-by-layer formation principle that underlies 3D printing gives the flexibility to produce geometric dimensions that are difficult to achieve using conventional approaches. These dosage forms can contain multiple drugs and excipients to achieve altered drug release properties. 3D printing gives you the freedom to alter the tablet's geometry, use different infill densities, or incorporate multiple medications for a release profile based on the lag phase. By using CAD, these features are obtained by altering the dosage form's geometric size and shape. Additionally, altering the film's characteristics by the use of plasticizers, such as polyethylene glycol (PEG), triethyl citrate, talc, or stearic acid, as well as modifying process variables like the roller printing speed, can

help manage the performance of the drug release [144] [143]. Children's favourite cartoon or animal-shaped tablets can be designed and printed using 3D printing technology by precisely adjusting the geometric shapes of the tablet [159]. Using extrusion-based 3D printing technology, paediatric-friendly chocolate-based chewable tablets were recently fabricated into six shapes resembling the simple structures of cartoon characters [160]. Additionally, 3D printing enhances the pharmacokinetic performance and solubility of poorly water-soluble drugs [122, 156, 161].

For disease indications that demand a quick start to the drug's activity, immediate-release tablets are necessary. These come in a range of dose forms, including buccal and sublingual tablets, orodispersible tablets, tablets for solution, fast-dissolving tablets, etc [13]. The traditional manufacturing of such formulations involves a number of steps, high-end equipment, and the selection of the best excipients in the right amounts to achieve the desired performance. Fabrication of such drugs with 3D printing is more productive. The tablets are typically printed using IJP, which has the medication distributed in a wet binder solution. To construct the entire tablet, the powder mixture for substrate production is applied layer by layer to the surface. Drug-loading filaments can be created using polymers like polyvinyl pyrrolidone (PVP), hydroxypropyl methylcellulose (HPMC), hydroxypropyl cellulose (HPC), and polycaprolactone. The effectiveness of medication loading and release can be changed by adjusting the polymer concentrations in the filament [162-164].

The choice of appropriate excipients or binder materials, as well as manufacturing processes for creating the desired dosage forms, are the main factors influencing dosage form development using 3D printing. Drug delivery systems created using 3D printing should undergo routine testing, including evaluations of hardness, friability, disintegration, and dissolution time, just like conventional dosage forms do.

Modified-release dosage forms offer a typical medication release profile according to the needs of the dis-

ease, in contrast to immediate-release tablets. Enteric release, delayed release, controlled release, and extended-release systems are just a few of the modified-release systems that have been created [98, 165, 166]. Biphasic release systems, multi-active tablets, and pulsatile drug delivery systems are examples of modified-release systems. 3D printing can also be used to create formulations with the complicated geometry necessary to generate a typical medication release profile.

5.4.2. Transdermal Drug Delivery System (TDDS)

Depending on the patient's needs, the 3D printing technique has been effectively used in a number of transdermal formulation strategies, including implants, microneedles, masks, and patches for both systemic and local API administration. Using a 3D printing technique, the geometry of the administered implant can be tuned according to the application site [167]. Dissolvable micro-needles developed using a piezoelectric ink-jet printing technique were fabricated with seasonal influenza vaccine using a drop-on-drop deposition technique, which aids in vaccine stabilization for percutaneous administration [168]. Transdermal films containing indomethacin produced using the piezoelectric ink-jet printing technique demonstrated effective drug penetration as well as better anti-inflammatory action when compared to a higher printing density of 600 Dots Per Inch (DPIs) [169].

6. ADVANCES IN 3D PRINTING FOR THE MEDICAL INDUSTRY

6.1. Branch of Medicines

Emerging as a modern and swift manufacturing method, three-dimensional (3D) printing has shown great potential in the medical and drug delivery fields. In this section, we explore the current advancements of 3D printing technology in healthcare and drug delivery, conveniently presented in Table 2 (Fig. 18).

Table 2. 3D printing technology in the medical field.

3DP technology	Formulation	API	Special characteristics	Medical field	References
SLA	Spherical implant	Ifosfamide, methotrexate, Cisplatin (CDDP)	Transdermal microneedles	Oncology	[290]
Power extrusion	Tablet	Lopinavir+ ritonavir	Mini tablets (6mm)	Paediatrics	[291]
FDM	Orodispersible	Aripiprazole	Personalized medicine	Geriatrics	[292]
Melt-extrusion	Tablet	Levofloxacin	Personalized medicine	Ophthalmology	[184]
DLP	Fast dissolving tablet	Diclofenac	Microneedle	Dermatology	[293]
SSE	Hydrogel patches	Doxorubicin	Solid self-emulsifying formulations	Virology	[294]

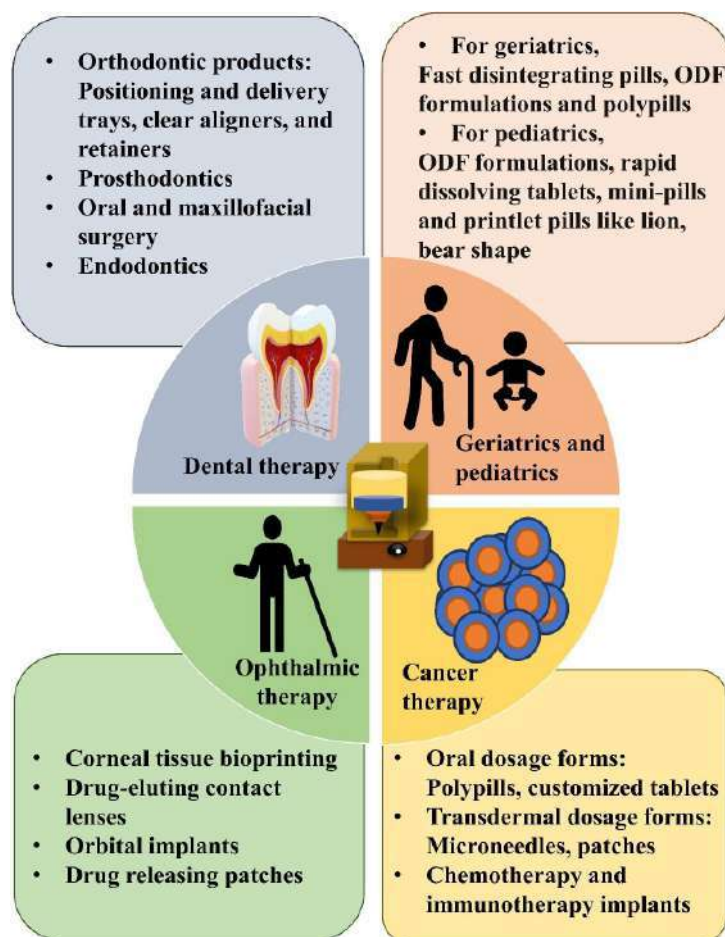


Fig. (18). Application of 3D printing technique in different branches of medicine. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

6.1.1. Pediatrics

Children's unique preferences for dosage form, taste, shape, and scent make them the most challenging segment of the population. Even though oral administration may appear most practical, it can be challenging when dealing with young children. A youngster might simply reject one dose form over another due to petty preferences for shape, colour, or flavour. This is where 3D printing may help and cater to each person's preferences [170]. Orally Dissolving Film (ODF) formulations, rapid dissolving tablets, and mini-pills created using 3D printing seem appropriate for delivery because swallowing is an issue in younger children.

According to a study on children's dosage form preferences, kids preferred mini-tablets with a 4 mm diameter over other formulations [171]. Giving dosage forms in the flavour and colour of their choice to children can boost their adherence to and compliance with their medication [172]. By extruding HPMCAS- and

PEG-based filaments loaded with indomethacin to produce formulations of various forms, such as a heart, ring, bottle, bear, and lion, Scoutaris *et al.* created candy-like formulations for paediatric medications with improved palatability [173]. Wang *et al.* (2020) created taste-masked donut-shaped tablets for pedological uses [174]. As a result, 3D printing has advantages over conventional production methods when producing paediatric dose forms. From the foregoing, it may be inferred that dosage forms can be made with the precise dose, shape, and size that will improve paediatric populations' drug adherence, therapeutic outcomes, and safety.

6.1.2. Geriatrics

Most urbanized nations have greater life expectancies and, as a result, a generally ageing population, with the majority of people anticipated to live above the age of 65. These nations also typically have nutri-

tion, cutting-edge medical facilities, and better patient care. Senior patients suffer from a variety of illnesses, including neurological ones, such as dysphagia and dementia. Compared to adults in the overall adult population (18 to 60 years old), medications and the elderly (those above 65) face far more complex and difficult management issues due to the latter typically requiring different characteristics from adult drugs. As swallowing problems get worse with age in the majority of the senior population, it can be difficult to take medications as prescribed. Fast-disintegrating pills and orodispersible film formulations can be used to treat this issue. The elderly population has a variety of illnesses that necessitate numerous medications, which leads to polypharmacy problems [175]. The problem of polypharmacy can be overcome by using poly-pills that are 3D printed specifically for the needs of the patient. Additionally, some of them experience dementia, which can hinder drug compliance. This can be avoided by using 3D-printed dosage forms with embossed graphics that can be **customised** for each patient and show the date, time, and/or day of the week for administration [176].

6.1.3. Oncology

A CT scan or MRI is the first step in the diagnosis, staging, and planning of a tumour's treatment. The two imaging methods help to determine the shape, volume, size, and extent of tumours as well as reveal information regarding metastasis. In CAD, **customised** tumour models can be created based on a patient's CT or MRI scan. To investigate applications in diagnosis and treatment, these models are further printed and closely match the cancer structure [177].

The process of creating **customised** medications starts with a cancer examination and is largely accomplished through 3D printing. Using an extrusion-based printing approach, a **personalised** anticancer drug delivery prosthesis that enables targeted chemotherapy delivery was created. A polydimethylsiloxane carrier prosthesis that included paclitaxel and doxorubicin successfully delivered the medications for more than 3 weeks. The mice's breast cancer spread and recurrence were prevented by the 3D-printed **personalised** prosthesis [178]. To encourage localised drug distribution, three-dimensional printed microneedles with different anticancer agents have been extensively explored for skin cancer.

In addition to aiding in the delivery of anticancer medications, three-dimensional printing also helps with cancer diagnosis, particularly when using cancer-specific diagnostic tools. Three different cancerous

cell types were successfully isolated using a 3D-jet-printed microfluidic device to separate cancerous cells from blood samples. The device was outfitted with anti-epithelial cell adhesion molecular antibodies that captured the circulating tumour cells (CTCs), which were then used for diagnosis and treatment planning [179]. To isolate CTCs, a similar microfluidic device using the negative enrichment of hybrid cells principle was created using the jet printing technique [180].

This technology can be used in the medical field to lessen the discomfort associated with cancer therapy. It might be compared to employing chemotherapy and radiation therapy as long-lasting cancer treatments. It works well when used for breast cancer [181, 182]. Tumour cells are extracted and printed during this process. This makes it easier to test out various medications and choose the best course of action for the patient [2].

6.1.4. Ophthalmology

Hydrogel-based formulations for 3D-printed medication patches can also enable drug release effectively in the eye, such as the conjunctiva, without impairing vision or making blinking uncomfortable. In order to provide unique dosages that may be tailored to the needs of patients in hospitals, Tagami *et al.* developed lyophilized ophthalmic patches [183]. Levofloxacin was an antibiotic that was present in the drug-releasing patches. A hydrogel-based bio-ink made of hydroxypropyl methylcellulose (HPMC), mannitol, xylitol, and the medication were used to print the 3DP drug-releasing patch. The formulation was created using a freeze-drying method. Additionally, various concentrations of mannitol, xylitol, and HPMC were examined and contrasted. The viscosity property of the bio-ink was determined by the composition of the biomaterials, which, in turn, may have an impact on the printability of the patches [184]. Furthermore, visual impairment raises a number of issues with regard to medicine and treatment, particularly for the elderly population, which frequently takes several different drugs. This causes poor treatment management and medication adherence, which eventually results in therapeutic inefficiency. Orally disintegrating tablets that are ideal for people who are blind or visually impaired were created by Awad *et al.* using SLA. When these printlets are removed from their packaging, patients may recognise the drug because of the braille and moon patterns on their surface. Differently shaped tablets with additional information, such as dosage instructions or drug indications, have been developed. By increasing drug adherence and lowering medication errors, this ground-

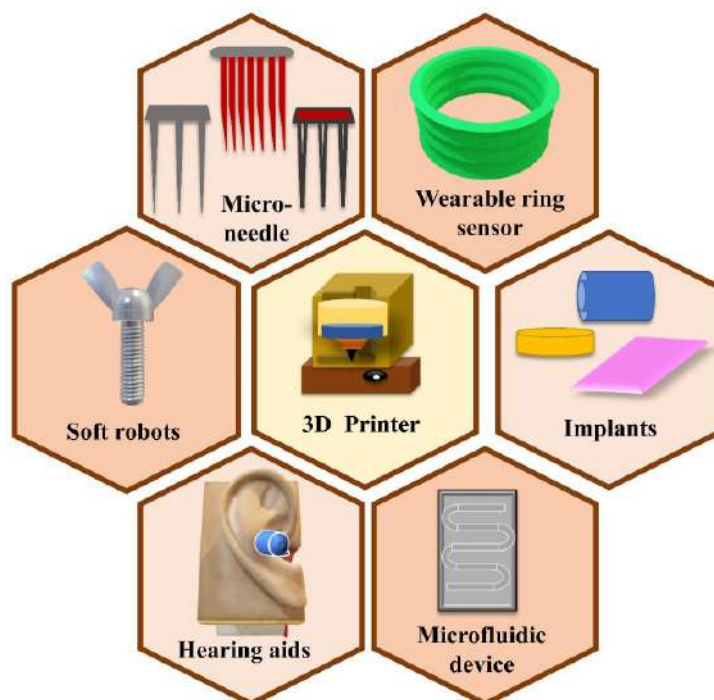


Fig. (19). Medical equipment produced with the help of 3D printing. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

breaking idea can significantly help the management of patients who are blind or visually impaired [185]. Although 3D printing (3DP) in the ophthalmic field is not yet fully comprehended and advanced, its undeniable potential to offer groundbreaking solutions for various eye diseases remains evident. The emergence of bioinks in 3D printing has the potential to address the scarcity of corneal transplantation and facilitate the advancement of tissue regeneration [184, 186].

6.1.5. Dermatology

The largest organ, the skin, is most prone to injuries caused by severe burns and conditions like dermatitis or diabetes. Full-thickness wound patients are physically and financially burdened. Given that they do not trigger allergic or harmful reactions, biodegradable patches have found use in the treatment of wounds [187]. In order to create constructs with customizable features, a hybrid printing method for hydrogel wound dressings was developed. This method combines the deposition of thermoplastic polycaprolactone with hydrogel scaffolds made of alginate and carboxymethylcellulose. The antibacterial properties of alginate are well known, and studies have demonstrated that carboxymethylcellulose can absorb dangerous germs [188]. In order to replicate the upper layers of skin, the epidermis and dermis, respectively, a similar

technology was used to print a bilayer membrane (BLM) made of a poly (lactic-co-glycolic acid) (PLGA) membrane and an alginate hydrogel layer. The membrane had a dual purpose: the multi-porous alginate gel promoted cell attachment and proliferation, while the PLGA prevented bacterial infection and maintained the needed levels of moisture. Electrospinning was used to create the PLGA mat, yielding fibres with a two-micrometre thickness and a ten-millimetre diameter. To create the final scaffold, sodium alginate hydrogels were created by applying the gel to the surface of the PLGA mat [189].

6.1.6. Dentistry

Dental labs may now correctly and quickly construct crowns, bridges, plaster/stone models, and a variety of orthodontic appliances, such as surgical guides and aligners, by combining oral scanning, CAD/CAM (Computer-aided Manufacturing) design, and 3D printing. Instead of making uncomfortable imprints, a 3D scan is obtained, which is eventually converted into a 3D model and sent to be 3D printed. An entire range of orthodontic products, including delivery and positioning trays, clear aligners, and retainers, can be produced using the printed model. As 3D CAD files, the models can also be easily stored digitally. With the use of 3DP, the entire operation may be digitalized, thereby

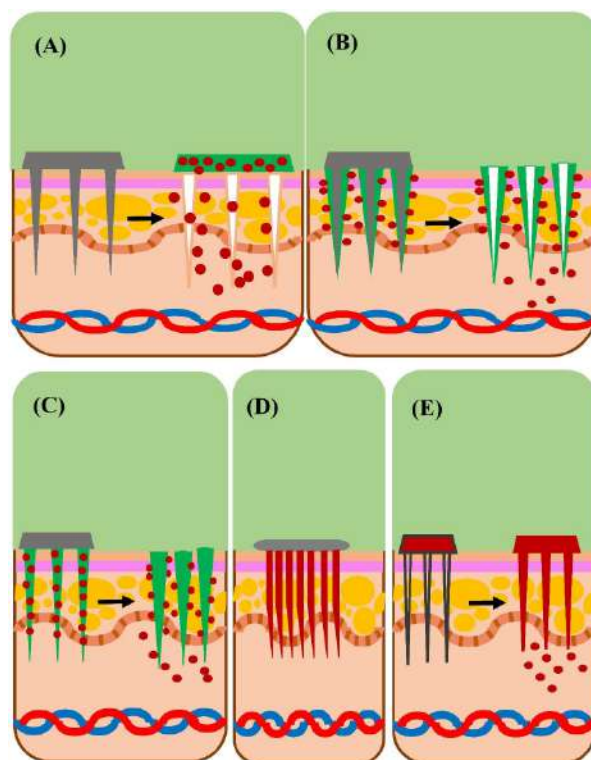


Fig. (20). Transdermal drug delivery using various types of 3D printed microneedle (MN); (A) Solid MN (B) Coated MN (C) Dissolving MN (D) Personalized MN (E) Hollow MN. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

reducing turnaround times and raising output. Additionally, they make it possible to do away with model storage and physical impressions [190].

The product Invisalign®, which consists of 3D-printed clear orthodontic devices that straighten teeth without the use of conventional metal braces, is the most frequently cited example of 3D printing in dentistry [40]. Small intraoral cameras could be used to scan a patient's misaligned teeth in the future rather than requiring them to send moulds to a specialised lab for scanning and retainer fabrication (a procedure that can take weeks) [191].

Recent improvements have been made as a result of 3D printer manufacturers realising the increased demand for machines capable of producing dental parts. As an illustration, Stratasys recently unveiled two CrownWorx™ and FraMEDorx™ semi-solid extrusion printers that were created exclusively for dental applications [192]. In order to enable dental laboratories to produce custom-made crowns and bridges, the printers extrude a type of wax.

6.2. Medical Equipment

3D printing technology has revolutionized medical equipment production by enabling customization, rapid prototyping, and cost-effectiveness. Its ability to create personalized devices tailored to individual patients' needs has improved comfort and patient outcomes (Fig. 19).

6.2.1. Microneedle (MN)

Microneedles are a type of TDDS comprising arrays of micro-sized needles (2D,3D projections) organised on the surface of a matrix that increases the interpenetration of biologically active molecules *via* the stratum corneum by developing microchannels or micropores under the skin [193]. These tiny structures can distribute drugs more effectively because they can pass through the SC barrier without damaging pain-producing nerve terminals [194]. Far-reaching materials seemed to be used for MN fabrication, like silicon, glass, metal, ceramics and different types of polymers [170]. Polymeric MNs are gaining attention because of their biodegradability, biocompatibility, strength and optical clarity [49]. Farias *et al.* used stereolithography to draft a cell-hydrogel having a 3D printed methacry-

late-based custom hollow microneedle assembly (1.3 conical frusta circular array) to figure out the potentiality of cells called human hepatocellular [195]. Economiduo *et al.* plotted 3D-printed microneedle arrays via stereolithography (SLA) using a biocompatible resin for the delivery of transdermal insulin [196]. By comparing the control of the entire skin, intensified penetration of diclofenac diethylamine gel was found after medicamentation with the MN finger splint. Likewise, bioinspired MNs, along with backward-facing barbs, were designed to increase tissue adhesion [197] (Fig. 20).

6.2.2. *Implants/prosthetics*

Implants and prosthetics are necessary to meet isolated patients' requirements and are susceptible to their pathology and unique anatomy. Conventional wrought/casting techniques require additional tools or devices that have inherent drawbacks concerning implant fabrication, like inadequate biomechanical joint reconstruction and inaccurate joint fixation. Correspondingly, more than one-fourth of hip implant revisions are re-revisions [198]. Multi-Material Additive Manufacturing (MMAM) fabricated implants underwent improvements like different kinds of drugs/effective ingredients loaded, maximum mechanical properties, and complicated structure implants in comparison with the conventional 3D printed implants [47]. A dosing structure called an embed, containing effective medications within a supported delivery conveyance grid, offers advantages to patients who require long-haul medication. For example, microstructured embeds of levofloxacin exhibit complicated delivery profiles acquired through a solitary embed. This embed indicates a bimodal profile with pulsatile [29].

A 3DP-based multi-drug implant was recently developed by Wu *et al.*, in which tobramycin (TOB) and levofloxacin (LVFX) as APIs were loaded and multifaceted scaffolds were used for the cure of chronic osteomyelitis [199]. The modelling of implants and prostheses by AM has reorganized the area of developing medical equipment, satisfying the growing need for personalized therapy. 3D printing authorizes the construction of tailor-made products that meet individual requirements resulting from specific patient anatomy as well as pathology. Additionally, it allows the development of structures with site-specific physical and mechanical properties and spatial and temporal control of bioactive components [78]. The individualized prosthetic accessories and tools make it possible to regain lost mobility, functionality, and a natural look. Herbert and colleagues created a prosthetic foot [200].

6.2.3. *Hearing aids*

Hearing aids are an incredible instance of medical devices that have become advanced from the development of VAT photopolymerization and 3D printing. In fact, more than 99% of patient-oriented hearing aids are fabricated using 3D printing nowadays. Prior to 3D printing being established, the fabrication of hearing aids took longer than a week. Today, the entire operation, involving scanning, design and 3D printing, could take less than one day. One of the top manufacturers of hearing aids is Envision TEC, which offers large-scale production and more than 16 biomedically certified materials, both soft and hard, ranging from translucent for ear moulds to skin tones for ear shells [190, 201].

6.2.4. *Biorobotics*

The ability of bio-inspired hybrid devices to simulate different biological activities has recently received a lot of interest. The biorobots are formed of synthetic scaffolds that support soft biological stuff like proteins, live cells, or tissues and are made of polymer elastomers or hydrogels. They can conduct several sorts of movements, such as walking or swimming, and can interact with their surroundings since they are more flexible than typical robots. The most exciting of these robots are the rotary machines, which are typically connected to the conversion of chemical energy from ATP (Adenosine triphosphate) hydrolysis into work [202-204]. Biorobots are in high demand due to the benefits of 3D (bio)printing tissues and organs since they act as little mechanical devices that can take part in tissue regeneration and drug administration. They might also aid in the comprehension of locomotives. To explain the mechanism of microbes, William *et al.* developed the long flagellar swimmer. The swimmer consists of a polydimethylsiloxane filament with a short, rigid head and a long, slender tail [205]. Direct production of soft robots utilizing MMAM offers a method for creating 3D objects out of different materials in a single step. In contrast to traditional robots with rigid bodies, soft robots are devices with compliant and flexible bodies (made of elastomeric materials) that enable complicated motions and actions. This section introduces a few soft robots that are employed as medical devices with the ability to administer drugs. The first example is a hybrid MMAM-made soft actuator with adjustable stiffness. This soft actuator combined an elastomeric body with a pneumatic system, a layer of shape memory polymer for controlling stiffness, and a layer containing silver particles for resistive heating [206].

6.2.5. Wearable Sensors

New wearable sensors, which can be thought of as adaptative electrochemical cells able to monitor chemical species in biological fluids in real-time, have been made viable due to additive manufacturing. The scientists described a 3D-printed device with integrated electronics and a screen-printed electrode that was formed into a ring and connected to a computer through Bluetooth. The electrode was covered with a semi-solid agarose-based electrolyte. The electrochemical device was tested for the detection of 2,4-dinitrotoluene (DN-T), a by-product of peroxide-based explosives' degradation that is frequently linked to the explosives 2,4,6-trinitrotoluene (TNT) and H_2O_2 in liquid and vapour phases. Katseli described a wearable glucose measuring device that was 3D printed, following the idea of a ring-shaped device [207]. After gold electrodeposition on the 3D-printed carbon black/PLA electrode for the electrocatalytic oxidation of glucose, glucose detection was made possible and was identified on perspiration before and after a meal. Without requiring an enzyme, the gadget is adaptable and ready to be used for continuous glucose monitoring.

Intriguing wearable technology for sweat analysis was made possible by 3D printing, as reported by Dias and colleagues [208]. A flexible thermal-printed electrode was positioned at the 3D-printed reservoir at which perspiration was collected from the volunteer's body. The instrument was able to measure zinc ions in sweat using anodic stripping voltammetry and a working electrode that had been modified to contain bismuth. The ability to create flexible devices with an integrated electrochemical system is a key benefit of 3D printing technology in the creation of wearable sensors [209].

6.2.6. Microfluidics

A microfluidic device is a collection of tiny channels made to hold tiny amounts of reagent. Microfluidic devices have been used to accurately examine biological and chemical processes, diagnose diseases at the point of care, and cultivate cells in regulated environments [210, 211]. These devices have a significant reduction in reagent usage, low manufacturing costs, and high throughput. The ability to cast microfluidic devices from a liquid that cures at low temperatures, its surface inertness, its transparent appearance (which makes it ideal for optical detection), its non-toxic nature, its gas permeability, and its ability to chemically modify its surface make poly(dimethyl

siloxane) (PDMS) one of the most frequently used materials [212, 213]. By applying adhesive to seal the tubing or drilling holes, microfluidic devices can be connected with fluidic tubing, although bad tubing connections can result in abrupt device failure, leakage susceptibility, or the generation of dead volumes that impair device performance. To enable label-free and direct measurements of electroactive compounds, these devices can also be integrated with electrochemical detectors. Therefore, 3D printed devices and microfluidic devices both offer certain advantages from a strategic standpoint. However, using a 3D printer to precisely and repeatedly create complicated micromachined components, fluid connectors and junctions, and other parts offers potential benefits [214].

6.3. Role of 3D Printing Techniques to Counter COVID-19

The rapid spread of COVID-19 has strained healthcare systems worldwide, leading to a scarcity of essential supplies, such as N95 respirator masks, face shields, ventilator valves, testing kits, and other vital personal protective equipment (PPE). As the pandemic continues to unfold, ensuring adequate production and distribution of PPE becomes increasingly critical. To address these shortages, an innovative and promising solution lies in the application of 3D printing technology. Renowned for its ability to fabricate complex architectures, 3D printing emerges as a novel approach to meet the pressing demand for essential medical equipment during this unprecedented crisis [12].

In response to the demands for essential services, especially in the healthcare sector, the establishment of adaptable factories capable of manufacturing materials and devices on demand becomes imperative. Within this context, the integration of a robust and advanced manufacturing network, empowered by the distribution of 3D printing facilities, holds significant promise. These small factories can be strategically located at hospitals and transportation hubs, enabling the swift and efficient provision of medical necessities. The COVID-19 crisis has served as a crucible for the redeployment of 3D printing capabilities, showcasing its competitive advantage in meeting emergency requirements [215].

There are various 3D printing applications against COVID-19, as shown in Fig. (21), such as face masks and shields, ventilator circuit splitters and valves, nasopharyngeal swabs, and field respirators. Table 3 presents the equipment associated with 3D printing techniques for COVID-19.

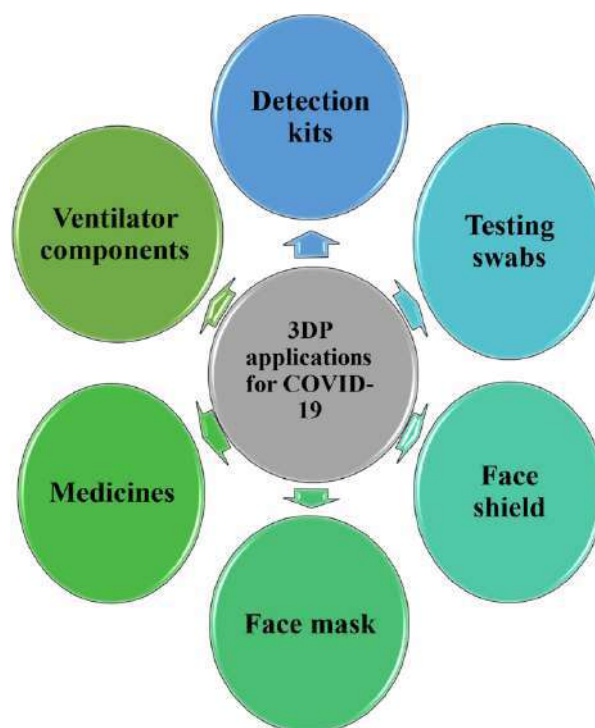


Fig. (21). Use of 3D printing technique against COVID-19. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

Table 3. COVID-19 related equipment associated with 3D printing techniques.

S. No.	Medical Devices/PPE	3D Printing Techniques	References
1.	Facemasks	FDM, SLS	[9]
2.	Respiratory Valves	FDM, SLA	[11]
3.	Face-shield	FDM	[12]
4.	Field Respirators	Not Specified	[10]
5.	Ventilation Devices	FDM	[12]
6.	Mask Fitter	FDM	[10]
7.	Surgery Mask	FDM	[9]
8.	Nasopharyngeal Swabs	FDM, SLA, SLS	[12]
9.	Safety Goggles	FDM, SLS	[10]

6.3.1. Face Mask

The use of 3D printing technology fulfills a significant need for facemasks in the COVID-19 pandemic crisis. As the most effective method of preventing inter-human transmission, facemask use is necessary when in public. A customized 3D protective facemask is possible due to 3D printing. The 3D-printed reusable parts and filter membrane support make up the unique protective facemask. A removable, non-woven particle filter can be used to assemble these parts. With the aid of this specialised 3D protective facemask, the use of dis-

posable surgical masks can be reduced. The reusable cartridge that is inserted between the facemask can also be manufactured using 3D technology [10].

6.3.2. Ventilator Circuit Splitter

Every area of the world has been greatly harmed by the COVID-19 problem, but the health sector has been particularly hit harder. There was a severe global ventilator shortage as a result of the virus uprising. Additionally, the manufacture and movement of medical devices were halted by the interruption of the worldwide

supply chain. Employing six Briggs T-tubes and a Puritan-Bennett 840 Series ventilator, the concept of using a single ventilator for several patients was tested on four sheep to simulate human size. The Briggs T-tube is a sophisticated device that was not always accessible. Due to 3D printing technology, digitized designs are readily accessible online. Briggs T-tubes could now be produced in bulk where they were needed due to 3D printing. The Royal Women's Hospital in Australia has created a splitter and flow restrictor device. Fusion 360 has been used by San Rafael, CA, USA, for computer-aided ideas and design. Several low-cost FDM 3D printers are used to build the ventilator splitter. The desktop 3D printer (Original Prusa i3 MK3S, Prusa Research, Prague, Czech Republic) with one complete set of two splitters, comprising expiratory and inspiratory limbs and one inspiratory flow restrictor, had a production time limit of six hours [11].

6.3.3. Ventilator Valves

For patients with acute respiratory distress, including those with COVID-19, ventilator valves are attachments that provide oxygen at regulated doses. Single-use valve sets can be produced using three-dimensional printing technology *via* a filament extrusion system or a polymer-laser powder bed fusion procedure. Biomaterials like polyamide and polysulfone, polycarbonate, silicone rubber, and stainless steel can be used to design the various valve components on 3D printers. Furthermore, these disposable valves eliminate the need for time-consuming sterilization procedures [12].

6.3.4. Face Shield

Face shields are mostly used in the medical, dental, and veterinary fields to safeguard patients by covering their full faces [216]. Polylactic acid (PLA) was used to quickly produce the face shield using a material extrusion-based 3D printer. Finite Element Analysis (FEA) in ANSYS Workbench was used to simulate head-holding and wearing situations and verify the structural design of the shield. A single face shield (with a mass of less than ten grams) may be created in less than 45 minutes, according to the experiment. Elasticity, comfort, Design for Additive Manufacturing (DfAM), single frame design, biodegradability of filaments, ease of maintenance, lightweight, productivity, quick production, and multi-facility manufacturability were the criteria used to optimise the final face mask design [217]. A face shield is a frame worn on the head that shields the user's eyes, nose, and mouth from respiratory droplets, saliva inhalation, dust, and pollen [218]. A face shield's frame has straightforward geometry and is easily fabricatable with the aid of 3D print-

ing [173]. During the COVID-19 epidemic, Delbarre *et al.* used 3D printing to create cloth shields for slit lamps. The face shield is made using 3D printing with Fused Deposition Modelling (FDM). A headband, a shield, and an elastic strap are all 3D printed in face shields. Utilizing PLA material, 3D printing technology was used to create the face shield structure. The face-shield prototype can be used by the surgeon for protection after assembling the transparent film in the frame [10].

6.3.5. Nasopharyngeal (NP) Swabs

The most accurate and secure method for gathering a patient sample for the diagnosis of COVID-19 is using nasal and NP swabs. NP swabs are flexible sticks that are about 6 inches long and have a bristled end. They are rotated into the space between the nose and mouth to ensure that adequate material is gathered. Then, the swab is put into a container with a culture medium and taken to the lab for analysis. The availability of nasal swabs required for COVID-19 test kits was significantly hampered by the COVID-19 epidemic [9].

6.3.6. Field Respirators

In specific work zones where a patient exhibits respiratory symptoms and when handling the remains of suspected patients who have passed away, full-face respiratory protection equipment is necessary (death due to COVID-19). A tool used for temporary emergency ventilation is a field respirator. These respiratory protection devices are made to prevent patients from breathing in dangerous airborne bacteria. By allowing air to escape and keeping the interior dry, the field respirators facilitate easy breathing for the wearer. Using 3D printing technology, Petsiuk *et al.* created a fully open portable bag-valve mask-based ventilator compression system. As a temporary emergency ventilator, an automatic ventilator can be made available [219].

7. 3D BIO-PRINTING

3D bioprinting concerns the dispensing of cell-loaded biomaterials for the manufacture of complicated functional living tissues or organs. It has been used in medication to fabricate tissues like bone, skin, and cartilage. Therefore, a different technical concept compatible with the deposition of living cells becomes compulsory. Precise cell deposition control, scalability, customization, high resolution, and cost-effectiveness are a few benefits of 3D bioprinting.

Bio-inks are expressions that originate from cells and may comprise bio-materials as well as biologically active components [220].

Table 4. Different tissues, printing methods, and cell responses in terms of 3D bio-printing.

Tissue	Printing Techniques	Cell Response	References
Bone	MED/FDM	<ul style="list-style-type: none"> • After 21 days of cell culture, cells on aligned scaffolds maintained their orientation. • On scaffolds containing Hap and coating, increased cell proliferation and osteogenic differentiation were observed. • <i>in vivo</i> bone production and improved osteogenic differentiation for scaffolds coated with CaSH. 	[295]
Cardiac	MED/Extrusion printing	<ul style="list-style-type: none"> • Favor cell contractions • maturation. 	[28]
Cartilage	FDM	<ul style="list-style-type: none"> • Enhanced chondrogenesis for scaffolds using cytokines. Better cartilage healing for cytokine-loaded scaffolds <i>in vivo</i>	[28]
Cornea	NFES (Near field electrospinning)	Enhanced mineralization, osteoblast differentiation, and extracellular matrix (ECM) deposition on Hap-infused scaffolds.	[295]
Kidney	MED	Rhombus pores with unidirectional cell alignment and elevated gene expression.	[295]

Bioinstructive materials can directly influence cell performance by providing specific biochemical as well as physical cues and direct tissue formation [221]. Bioinstructive materials give multi-scale guidance for cells in a 3D environment by establishing cell signaling to closely imitate specific biological, compositional and mechanical properties of native tissues [222, 223]. The cues can be introduced inside the scaffold matrix or on the scaffold surface, and they are divided into biochemical and physical ones. Physical cues involve electrical, mechanical and topographical stimuli like roughness or hierarchically ordered structure. Biochemical signals involve specific drugs, growth factors, proteins and integrated insoluble particles [224]. They direct cell behaviour by modulating the proliferation, migration patterns, adhesion and differentiation of stem cells [225-227]. For improved performance, both kinds of cues can be mixed in a single material system. Table 4 presents the different tissues, printing methods, and cell responses in terms of 3D bioprinting (Fig. 22).

7.1. 3D Bio-printing Applications

7.1.1. Cardiac Tissue

Mechanical cues used in heart tissue engineering support cell contractions as well as maturation. According to studies, the levels of cardiac markers are increased when using scaffold designs with enhanced elastic characteristics or growing cells in dynamic environments [228, 229]. The most popular technique for creating scaffolds for the regeneration of heart tissue is extrusion bioprinting. However, recently, MED also gained appeal for that application because it could

print flexible scaffolds and had a fresh hydrogel printing alternative [230].

7.1.2. Bone Tissue

Bone tissue engineering is the foremost field implementing bio-instructive materials, mainly based on FDM of PCL as well as PLA, which has high energy and moderate degradation rates [231-233]. To intensify the osteogenic potential of printed scaffolds, biochemical cues like hydroxyapatite (HAP) (insoluble particles) are integrated [234-236]. Additionally, components like Strontium (Sr) particles, bio-glass, or tricalcium phosphate (TCP) are also added to scaffold matrices to promote bone formation [237-239]. Bone substitutes with physical clues, such as modified pore shape and size, are made using MED and FDM [231, 240-244].

7.1.3. Cartilage

FDM and MED printing techniques were used to create fibers that reinforced various hydro-gel matrices for the regeneration of cartilage tissue [245, 246]. The incorporation of soluble cues like growth factors, cartilage-based extracellular matrix (ECM), or proteins into scaffolds is made possible by the use of hydrogels, which enhance regeneration [247-249].

7.1.4. Neural Tissue

Electric stimulation is the main stimulus for brain regeneration. A conductive coating or conductive compounds (such as gold) that promote the differentiation and elongation of neural cells are used to deliver this cue [250]. These results are amplified by electric stimulation [251, 252].

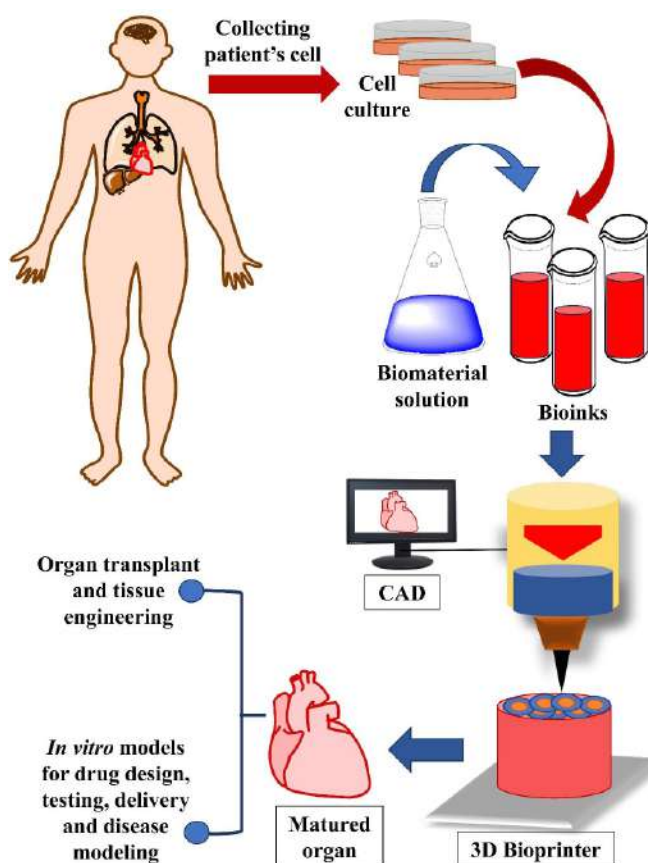


Fig. (22). Pathway of 3D bioprinting. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

7.1.5. Skin Tissue Engineering

For sophisticated skin regeneration techniques, 3D bio-printing has been available for the past ten years [253]. The different methods can now be divided into two categories: bottom-up and top-down. The former tries to create massive tissue blocks that replicate the structure of actual tissue, while the latter aims to create little complicated constructions. Cell aggregates, micro-beads, or hydrogels with cell content are examples of bottom-up technologies. Cells are seeded into biodegradable scaffolds for top-down techniques, and active elements like growth factors are added to encourage cell proliferation and growth. Generally, skin bio-printing has generated a lot of attention, and major cosmetic businesses like *L'Oréal* and Procter and Gamble, as well as printer makers like Rokit, are working to build skin models. For instance, *L'Oréal* has created a unique technology called Episking that can be applied to cosmetics, therefore adhering to the three R's (Replacement, Reduction and Refinement) for enhanced animal welfare and more compassionate animal research [37].

7.1.6. Other Tissues

Hydrogel extrusion printing enables the creation of scaffolds with the appropriate stiffness, and bio-printing is the technique most frequently utilized for the regeneration of soft tissues (such as skin, muscle, or liver). Alginate and gelatin are well-known bio-compatible bio-inks, and stiffness can be controlled, for example, by adjusting the amount of cross-linker used [254-256]. The regeneration of skin can be enhanced, especially by using soluble cues that improve cell differentiation and cell proliferation [257, 258]. Successively, due to its ability to guide cells toward an applied force, mechanical stimulation has been shown to be helpful for tendon and muscle regeneration [259-261]. With approximately 40 different types of cells in the lungs, co-culture can be a crucial trigger for lung regeneration because cells secrete the necessary signalling molecules [262, 263].

7.2. Emerging Perspectives in 3D Bioprinting to Fight COVID-19

The distinct and unexpected pattern of COVID-19 infection and the dearth of potent vaccinations and antivirals have brought the world's human population to the brink. However, the global response to the pandemic was remarkably quick, with early community initiatives and a quick increase in COVID-19-related research. There are now various attempts being made to repurpose existing medications as viable counter measures and produce efficient vaccine technologies. Tissue engineering-based therapies and *in vitro* tissue models created from stem cells can be a blessing in this kind of overwhelming pandemic crisis. Traditionally, tissue engineering has placed a strong emphasis on creating synthetic structures for organ regeneration or replacement. Despite the vast promise, only a small number of engineered constructions have been effective in human clinical trials to date [264]. In this vicious circumstance featuring a constellation of unanswered problems, tissue engineering technologies may offer creative solutions. Both healthy tissue models (such as human hair follicles and cartilage tissue) and diseased tissue models (such as an osteoarthritis model and ocular pathological conditions) can be created using tissue engineering [265, 266]. Even more breakthroughs are made possible by three-dimensional bioprinting, which requires the layer-by-layer precise positioning of living cells, biochemistry, growth factors, ECM orientation, etc. When combined, a 3D structure that mimics the native tissue's ultrastructure can be created [267]. In the pandemic situation caused by SARS-CoV-2, an attempt was made to suggest how organ-on-a-chip, 3D bioprinting, organoids, and advanced bioreactor models made of a coculture of cells from endodermal, mesodermal, and ectodermal origin can be used to create *in vitro* human tissue models that can be used for more effective diagnosis, drug delivery, and customized development of drugs and vaccines as well as the delivery of small molecules at targeted anatomical sites.

8. GUIDELINES IN 3D PRINTING

In 2015, the FDA approved the first 3D printing product, which significantly increased the motivation of biopharmaceutical manufacturers to adopt 3D printing as a new technology for creating pharmaceutical products and biomedical devices. Due to the rapid advancement, questions regarding regulation and liability in the event that a product fails or has a negative effect are some of the most frequently discussed topics with the 3D printing of medications and equipment. In order to provide potential regulatory insights and key chem-

istry, manufacturing, and control requirements for the approval of 3D-printed drug products and medical devices, the FDA published "Technical Considerations for Additive Manufactured Medical Devices" in December 2017 [268]. Following the FDA guidance, Health Canada also issued new guidance in late 2018, including a description of the essential elements of manufacturing operations, a summary of the 3D printing process, and important device design parameters for 3D printing of medical devices to promote high-quality personalized drug therapy and treatment solutions for patients. Discussions are currently being held by the FDA's Office of Testing and Research to find solutions to issues like how to investigate the key parameters of various printing technologies, how to assess the effectiveness of 3D-printed medications, how to study the release of preparations *in vitro* and *in vivo*, and how to regulate the quality of 3D-printed formulations [269]. Under the International Coalition of Medicines Regulatory Authorities (ICMRA), several regulatory organizations, including Health Canada, the Therapeutic Goods Administration (TGA, Australia), the European Medicines Agency (EMA), *Agencia Nacional de Vigilancia Sanitaria* (ANVISA, Brazil), the Health Sciences Authority (HAS, Singapore), and the Pharmaceuticals and Medical Devices Agency (PMDA, Japan), discussed the potential benefits of the developing 3D printing technology in 2019. Three of them began establishing new legal frameworks (Health Canada, HSA, and ANVISA) or developing new regulatory frameworks to promote the creation of novel products, including 3D bio-printed products [270].

9. LIMITATIONS OF 3D PRINTING

Though 3D printing technology has several advantages, there is still a need for modifications as well as exploration in the printing instruments, software, excipients, mechanical strength, false product and clinical practice [28, 87].

9.1. Technology

The printing process includes computer-based operation, which demands that the software programming be constantly reconditioned based on the formulation. In the case of DOP technology, multiple pauses and restarts of the print head are required, which is particularly demanding regarding the print head's stability [121]. Additionally, the performance of printing formulations has been impacted by nozzle blockages, the movement and leakage of binders, and the variation in powder feed [271]. Several print nozzles that are related to extrusion moulding technology have been created and upgraded for compatibility with FDM and PAM

technologies. However, in order to get various formulations, the double nozzle location may be off, which has a significant impact on the product's characteristics, including content homogeneity, hardness, and friability. Devices using lasers and heat may degrade active pharmaceutical ingredients, cause unintended drug-polymer interaction, and resin toxicity [47, 272]. Therefore, it is vitally necessary to further optimise and improve the mechanical apparatus, operational processes, driving control mechanisms, and essential components of 3D printers. Furthermore, the recovery and disposal of unused powders in the case of SLS and DOP, as well as any occupational health risks, should be taken into account [273]. Also, the manufacturing practice (GM-P) standard is not fulfilled by the 3D printers used in medicine; thus, it is necessary to validate the production process and the end products to guarantee their safety for human health [87].

9.2. Excipients

All types of 3D printing technologies have specific needs for the qualities of excipients throughout the preparation process. The carrier excipient must be suitable for the drug due to the involvement of melting and heating procedures in some printing technologies, such as FDM, in which PVA is used as an excipient. However, it has a high melting point, which is inappropriate for thermally sensitive drugs [274]. Therefore, 3D printing technology based on low temperatures uses excipients like triethyl citrate, PVP, Kollidon, and HPMC for the enhancement of drug loading capacity and drug degradation [96, 100, 275]. In the SLA and SLS methods, photopolymers are used as excipients, which are unsafe as per the guidelines of the FDA. Moreover, a smaller number of excipients are used mostly because of their bad odour, toxicity, and protection from light for the elimination of premature polymerization. In addition, options in solvents are also finite in the case of DOP and SSE methods [276]. Hence, there is a need to explore the excipients that are suitable for pharmaceutical use, such as non-toxic in nature, stable, biocompatible with drugs, and biodegradable [87].

9.3. Mechanical Strength

The mechanical characteristics of the product act as a quality control criterion that can be used to verify the repeatability and acceptability of the tablets for post-processing. The performance of the product is influenced by factors, such as surface tension, nozzle fineness, and viscosity [277]. Whereas the impact on the look and quality of the products are influenced by the post-processing of printing, which involves drying

methods. In SLA, the loading efficiency of the drug contained in the polymer matrix is decreased due to the post-washing step (washing unreacted resins with isopropanol from the printed material). Hence, the post-curing step is essential to increasing the mechanical robustness of printed structures [47]. Furthermore, the Spritam drug is developed, which is highly porous in nature and provides fast degradation, but it lacks mechanical strength (<40 N). Hence, there is a need to improve the optimization techniques, such as the printing process, computer operations and nozzle refinement, for the betterment of the mechanical properties [87].

9.4. False Product

This challenge arises from the usage of 3D printing technology by neglecting its regulatory aspect, which generates false products that do not meet the quality standards. These fake medications may be obtained at a very reasonable cost; however, they can cause major health issues in humans. Moreover, the WHO estimates that fake medicines affect 10.5% of the low and middle-income nations. This can be prevented by using effective safeguards. One study used FDM 3D printing with piezoelectric 2D inkjet printing to establish a unique track and trace false measure for 3D printed medications. For tracking purposes, QR codes and data matrices were placed on the surface of the 3D-printed printlets for scanning by using a smartphone, which provides information about the unique patient, provider, and medicine. Nevertheless, incorporating a data matrix or QR code onto the surface of the printlet might influence its visual aesthetics and potentially influence patients' willingness to accept the medication. Therefore, it is important to assess this aspect in future clinical investigations. It is worth noting that by expanding the variety of additives and coloring agents present in the material inks, the randomized code could encompass an extensive range of permutations, thereby enhancing the incorporation of personalized medications through an enhanced tracking and authentication system throughout the supply chain [278].

9.5. Clinical Use

Installing 3D printing technology into the health centre may pose additional obstacles as it demands a highly qualified worker to handle the technical components, an expensive budget, as well as maintain quality control of printed drugs. Moreover, to satisfy the criteria of customised medicine in a clinical context, packaging and labelling standards must also be considered. More technical advancements are required to bring the ultimate 3D printer for clinical applications, which must be user-friendly, quick, cost-effective, and have a

high resolution, as current 3D printers have not yet overcome their disadvantages [28].

10. CONCLUSION

3D printing has advantages over conventional methods due to its accuracy, reproducibility, controlled size and shape, patient-specific, controlled release properties, safety, and cost efficiency.

There are various techniques involved in the processes of printing, extrusion and designing, such as ink-jet-based, VAT photopolymerization, SLS, EMP, DOP, and EHD. They have applications in the fabrication of personalized medicines, drug delivery (oral, rectal and vaginal), complex drug formation and suitable dosage forms. Furthermore, advancement in 3D printing is manifested in several branches of the medical field, including paediatrics, geriatrics, oncology, ophthalmology, dermatology, and dentistry because of its development in the production of various medical components, such as microneedles, implants, hearing aids, bio-robotics, wearable sensors, and microfluidics. Moreover, 3D printing technology also aids in the fight against pandemics like COVID-19 by using methods like FDM, SLS and SLA for the development of equipment like face masks, face shields, safety goggles, nasopharyngeal swabs, ventilation devices, and respiratory devices. In addition, integrating 3D printing techniques into biomaterials for the tailoring of living tissues of bone, skin, cartilage, cardiac, etc, is of utmost significance. In short, 3D printing plays an important role in the advancement of the healthcare system.

11. FUTURE PERSPECTIVES

Traditional preparation technology and 3D printing preparation technology work well together in several ways. After years of development, traditional preparation technology has reached a distinct industrial advantage. In contrast, 3D printing, an emerging technique, can achieve the precise sculpting of a variety of materials and can address many of the drawbacks of conventional preparatory technology.

Hybrid living materials are another area that has a great deal of potential to aid in the creation of bio-structutive materials. These substances are made of synthetic materials and living microorganisms (such as cells, bacteria, microalgae, or yeast). Microbes control the physical and chemical characteristics, creating new material qualities like self-regeneration or acclimatisation to their surroundings [279]. The creation of self-sufficient and self-regenerating scaffolds that can produce the proteins or enzymes required for cell proliferation and specific differentiation, which will improve

and speed up tissue regeneration, is what we anticipate will result from the continued development of hybrid living materials.

The field of additive manufacturing has made significant progress, resulting in the creation of smart 3D-printed materials that can change their properties and shape in response to outside stimuli over time, so-called 4D printing technology, which addresses the fabrication of shape memory materials, self-evolving structures, and actuators for biorobotics [280-285]. It is expected that 4D printing technology will allow the construction of smart scaffolds with specialised dimensions and shapes in the future. These scaffolds will vary in shape in accordance with the rate of tissue regeneration and maturation. It will also enable the use of minimally invasive surgical techniques to deliver the scaffolds to difficult-to-reach areas of the body.

The idea of on-demand manufacturing of medicine is that specialized software may produce the patient's own information, which is then utilized to print the prescriptions at a community pharmacy or even at home using a personal 3D printer. Instead of depending solely on healthcare professionals, patients may tailor their own dosage requirements based on their illness [13, 157, 286]. For drugs with a short shelf life, printing at the point of treatment can also be helpful, which may lead to the marketing approval of novel medications [286]. This would be especially important in regions of the world where there are not enough medical professionals to meet the demands of the population. The same strategy could be applied to military operations, disaster relief efforts, and remote villages.

The 3D printing strategy can also be applied to the advancement of clinical pharmacy practise. In the modern world, the pharmacist can use 3D printing technology to quickly deliver medication in a format that is customised according to the doctor's prescription [287]. This would eliminate any drug shortage and make it easier to implement personalised drug therapy into routine clinical practice [98, 165]. Hospital pharmacists must be educated about these advanced technologies since they will play an important role in the future implementation of 3D printing in pharmacy practice [288].

LIST OF ABBREVIATIONS

CA	= Cellulose Acetate
DEF	= Diethyl Fumarate
GelMA	= Gelatin Methacryloyl
HPC	= Hydroxyl Propyl Cellulose

HPMC	= Hydroxyl Propyl Methylcellulose
HPMCAS	= Hydroxyl Propyl Methyl Cellulose Acetate Succinate
MCC	= Microcrystalline Cellulose
PCL	= Polycaprolactone
PCLDMA	= Polycaprolactone Dimethacrylate
PCL-tMa	= Polycaprolactone Trimethacrylate
PE	= Polyethylene
PEG	= Polyethylene Glycol
PEGDA	= Poly (Ethylene Glycol) Diacrylate
PEGDMA	= Poly (Ethylene Glycol) Dimethacrylate
PEGMA	= Poly (Ethylene Glycol) Methacrylate
PEO	= Poly(Ethylene Oxide)
pHEMA	= Poly(2-hydroxyethyl Methacrylate)
PLA	= Polylactic Acid
PLGA	= Poly lactide-co-glycoside
PMA	= Propyl Methacrylate
PPF	= Poly (Ethylene Fumarate)
PVA	= Polyvinyl Alcohol
PVP	= Povidone
TCP	= Tricalcium Phosphate

CONSENT FOR PUBLICATION

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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REVIEW ARTICLE

Prominent Perspective on Existing Biological Hallmarks of Alzheimer's Disease

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Abstract: Biomarkers are the most significant diagnosis tools tending towards unique approaches and solutions for the prevention and cure of Alzheimer's Disease (AD). The current report provides a clear perception of the concept of various biomarkers and their prominent features through analysis to provide a possible solution for the inhibition of events in AD. Scientists around the world truly believe that crucial hallmarks can serve as critical tools in the early diagnosis, cure, and prevention, as well as the future of medicine. The awareness and understanding of such biomarkers would provide solutions to the puzzled mechanism of this neuronal disorder. Some of the argued biomarkers in the present article are still in an experimental phase as they need to undergo specific clinical trials before they can be considered for treatment.

Keywords: Alzheimer's disease, biomarkers, β -amyloid peptide, tau protein, neurodegenerative diseases, diagnosis.

1. INTRODUCTION

Hailing from a century-old era, Alzheimer's still holds the position of an unsolved medical mystery. Scientific minds working on this memory impairment are still clueless about its treatment. The sole hold on this situation is therapeutic, which could partially slow down the progression of this disorder. Unfortunately, AD patients can only be comforted by these side effects causing drugs. The answer to this delayed diagnosis of AD lies in the findings of the biomarkers that can pace the research of treatment as well as therapeutics. Biomarkers, also known as neurochemical indicators, give a clear indication of either the risk or the presence of the disease in an organism [1, 2].

AD symptoms precede very slowly. Thus, it is imperative to investigate biomarkers of AD [3]. Some well-known neuropathological indicators of AD have been discussed here and depicted in Fig. (1). The study of biomarkers is prominent in medicine as they lay the foundation for drug development. The effect of the newly designed drugs is first critically measured on volunteers during the clinical trials by examining the specific biological hallmark. This review aims to highlight specific biomarkers of AD that can be targeted for the detection of AD primarily and can result in a hopeful treatment.

Putting an end to something always demands the identification of its specific origin or the multiple causes/reasons behind its emergence. If we are unable to find the cause, it would be impossible to reach the final destination. The search for specific biomarkers for Alzheimer's disease (AD) has been the same story in clinical history for a century. Covering 70% of the pie-chart of dementia, AD is the highest afflicting neurodegenerative dysfunction [4, 5]. The actual cause of its incurability is still unknown as it lacks diagnosis at its earliest onset. Unraveling the clinical hallmarks of AD can not only be helpful in its treatment but also for its early diagnosis and permanent cure. The defining features of AD are the unrequired deposits of amyloid plaques and neurofibrillary tangles [6, 7]. The global prevalence of this disorder is projecting a future plan of hitting a population of only 14 million in the USA by 2050 [8]. Despite a lot of theories and research about the neuropathological events involved in AD, there is neither prevention nor cure available. Efforts are still focused on the slow progressive rate of AD, which is of no help as the incurability is constant till the present [9, 10]. Such a state strongly underscores the necessity to explore the fundamental root cause of the dysfunction development and its prominent clinical markers for sooner diagnosis. Moreover, unsolved mysteries of the mechanism of neurodegeneration initiation need to be unfolded to prevent, delay, or cure AD. The interplay of such responsible causes has been discussed in his mini-review, which triggers the untold story of AD. The understanding of the outline of these clinical markers is important as they hold the baseline for future clinical success. So, this mini-review explores and encompasses the current status of the potential clinical hallmarks

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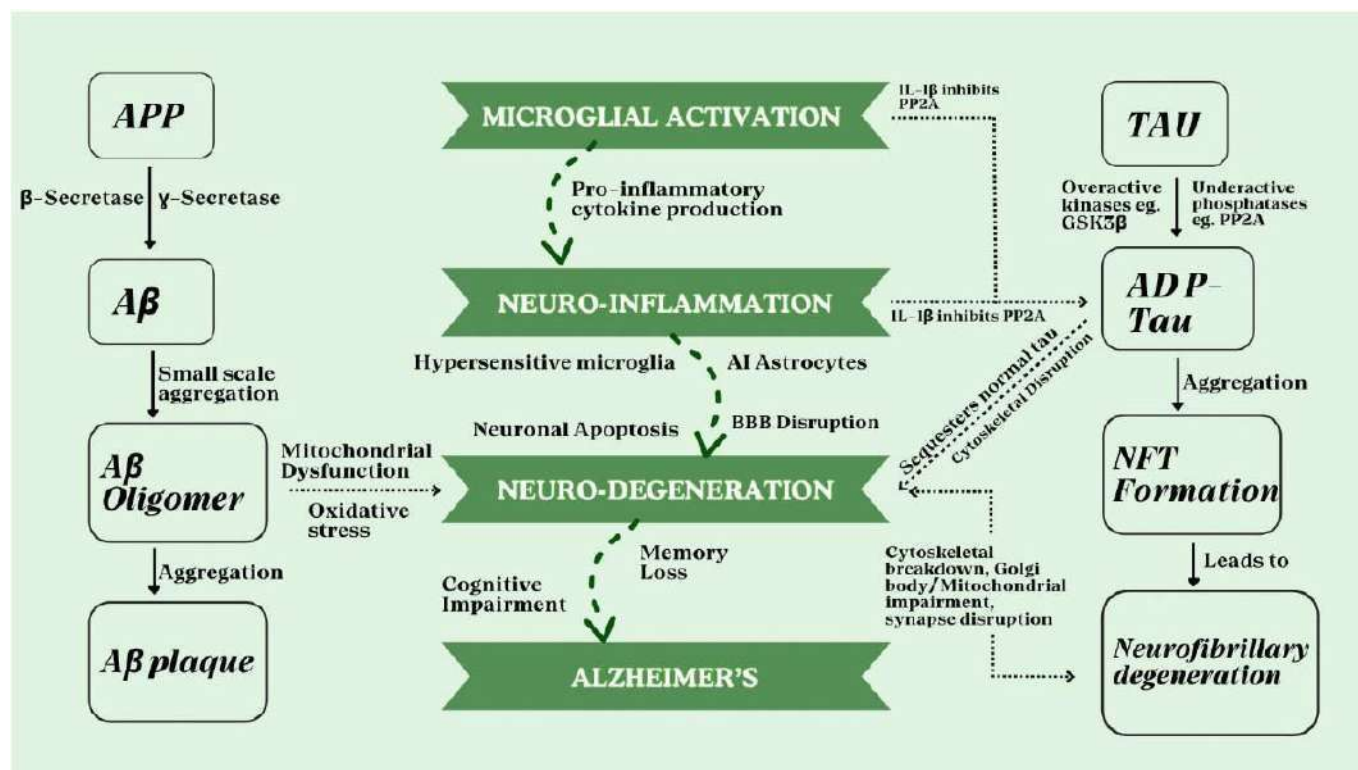


Fig. (1). Biomarkers signaling in Alzheimer's disease. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

of AD. This study could improve clinical studies in a lot of diagnostic and treatment approaches.

The diagnostic pathway proceeds *via*. two different techniques. The techniques used to investigate the biomarkers have been broadly classified into two categories.

1.1. Invasive

Invasive techniques are used to study precise brain areas and cerebrospinal fluid as early biomarkers [11], as shown in Fig. (2). Since these are invasive techniques, they are time-consuming, expensive, and likely to cause discomfort to patients. Hence, minimally invasive techniques and noninvasive techniques are the mandates for early diagnosis of neurodegenerative disorders.

1.2. Non-invasive

The routine diagnosis of AD and mixed forms of dementia from CSF has various limitations, including the invasive nature of lumbar puncture and collection of CSF, the difficulty of patient screening, and the need for multiple-year follow-up on the same patient. To expand the range of AD diagnostic tests, it is crucial to create sensitive and specific ELISA for additional site-specific phosphorylated tau isoforms. It is currently unclear how closely analyte concentration in the blood links to pathological alterations in the brain. Thus, it is obvious that it is necessary to look for biomarkers in other body fluids. With the advent of noninva-

sive neuroimaging techniques that enable the visualization of structures *in vivo* in recent decades, the progress in the diagnosis of AD has been considerably improved. Novel magnetic resonance imaging (MRI), metabolic changes picked up by Positron Emission Tomography (PET), and imaging of amyloid are a few examples. The development of omics technologies over the past few years, including genomes, transcriptomics, proteome, metabolomics, secretomics, *etc.*, has made it possible to analyze a variety of AD hallmarks. These instruments make it easier to analyze human fluid samples of many types, such as blood, tears, urine, or saliva, with easy collection and accessibility under non-invasive techniques. Numerous proteins associated with neurodegenerative diseases, including Tau, amyloid beta, alpha-synuclein, and the huntingtin protein, are known to be abundant in saliva and to reflect physiological activity. These proteins' concentrations in saliva are helpful biomarkers for the kind of diseases they are associated with [12]. Fig. (3) manifests the non-invasive biomarkers of AD.

2. BIOLOGICAL HALLMARKS OF ALZHEIMER'S DISEASE

The elevated exponential rate of people afflicted with AD has highlighted the necessity of taking substantial steps in the direction of finding the neurodiagnostic biomarkers responsible for AD. The prominent biological hallmarks of AD include diffused extracellular amyloid plaques and intraneuronal neurofibrillary tangles in the brain [13]. Apart from

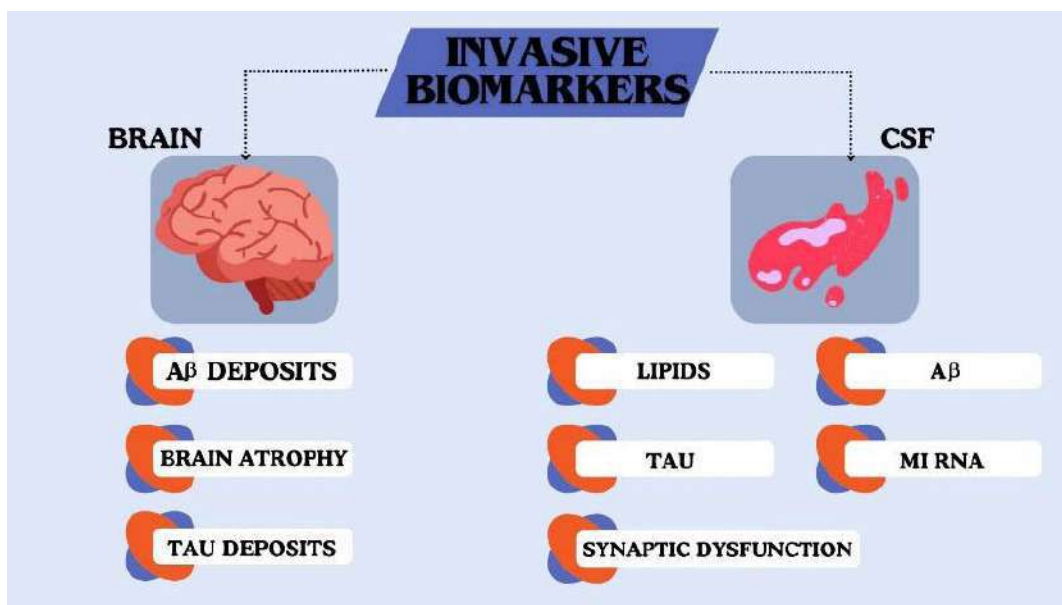


Fig. (2). Invasive biomarkers of Alzheimer's disease. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

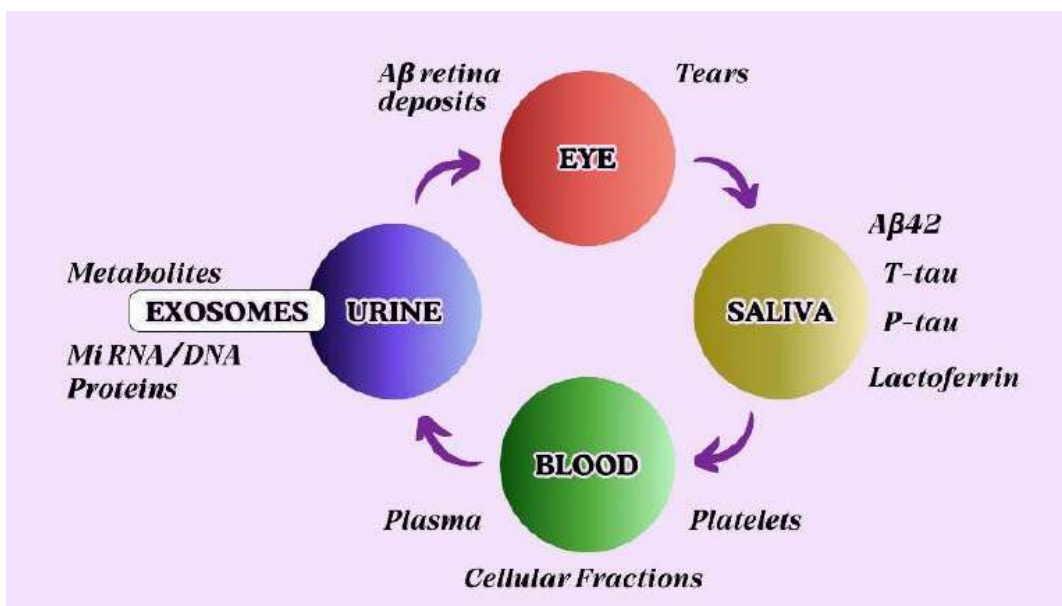


Fig. (3). Non-invasive biomarkers of Alzheimer's disease. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

them, many other clinical factors like cerebrospinal fluid, metal toxicity, mitochondrial dysfunction, neurofilament light chains *etc.*, are proclaimed as promising indicators. With regard to this, Reitz *et al.* and his team in 2011 have critically discussed the prevalence, environmental risk factors, and other protective factors [14]. Therefore, the search

for blood biomarkers that are associated with AD should start with recognized CSF markers, such as biomarkers related to A β and Tau, and also take into account elements related to inflammation, protein aging and cell death, and cerebrovascular dysfunctions. Information regarding crucial AD biomarkers and the changes associated with them has been summarized in Table 1.

Table 1. Essential biomarkers of AD.

S. No.	Biomarkers	Mild AD	Severe AD	References
Amyloid Biomarkers				
1	APP (sAPP β) blood	No change	No change	[15]
2	Three subtypes of APP (106, 110 and 130)	Present in platelets	Present in platelets	[16]
3	APP (sAPP β) blood	Decrease in blood	Decrease in blood	[17]
4	A β peptides (A β 1-42 and A β 1-40 peptides)	Overproduction, accumulation	Overproduction, accumulation, amyloid plaques formation	[18]
5	A β 42/ A β 42	Increase	Increase	[19]
6	Plasma A β (1-42) and A β (1-40)	Elevated, reduced, or remains unchanged	Elevated, reduced, or remains unchanged	[20]
7	A β (1-42)	-	Increase in plasma of women	[21]
8	A β (1-42)	Increase in plasma	Increase in plasma	[22]
9	A β (1-42) autoantibodies	Decrease in serum	Decrease in serum	[23]
Tau Biomarkers				
1	Total tau (t-tau)	Increases in CSF	Increases in CSF	[24]
2	Total tau (t-tau)	Increases in CSF	Increases in CSF	[25]
3	Phospho-tau-231 has shown	Decrease longitudinally from mild to moderate	Elevated	[26]
4	Phosphorylated forms of Tau (phospho-tau-199, -231, -235, -396, and -404)	Elevated	Elevated	[27]
Neuronal Biomarkers				
1	Neurofilament light chain protein (NFL)	Elevated blood and plasma	Elevated blood and plasma	[28]
2	S100b and neuron-specific enolase (NSE) proteins	Reduced	Reduced	[29]
Biomarkers of Neuroinflammation				
1	Glial fibrillary acidic protein (GFAP)	Elevated	Elevated	[30]
2	GSK-3	-	Elevated in white blood cells	[31]
3	Chemokines, cytokines, growth factors, and binding proteins	Elevated in plasma	Elevated in plasma	[32]
4	YKL-40	Increase both in serum and CSF	Increase both in serum and CSF	[33]
5	Neurogranin (synaptic protein)	Increase in the CSF	Increase in the CSF	[34]
Other Biomarkers				
1	Ab toxicity and ubiquitin levels	Elevated in the cerebral cortex	Elevated in the cerebral cortex	[35]
2	telomeres	Smaller in peripheral blood cells	Smaller in peripheral blood cells	[36]
3	C-reactive protein (CRP)	High	High	[37]
4	Level of vasodilator and vasoconstrictor	Increased	Increased	[38]

2.1. Blood-based Biomarkers

Recently, biomarkers of AD research have taken a front seat, especially blood-based biomarkers. Hansoon *et al.* have reviewed blood based biomarkers for clinical trials and practices [39-41]. When identifying AD in patients with cognitive impairment from all other neurodegenerative disorders, phosphorylated Tau (p-tau) in plasma shows excellent diagnostic accuracy [42-44]. There is a need to elucidate the specific research that needs to be conducted before blood-

-based biomarkers can be widely used. Doecke *et al.* [45], with his research team in 2012, have also worked on the identification of plasma biomarkers of AD for the purpose of early diagnosis. For this, they screened AD-afflicted and healthy individuals at the same time. This panel of plasma biomarkers showed an appreciable extent of sensitivity and specificity, which could help in the easy distinction between AD and healthy individuals. This evidence could strongly help in AD diagnosis. Fig. (4) represents crucial plasma biomarkers.

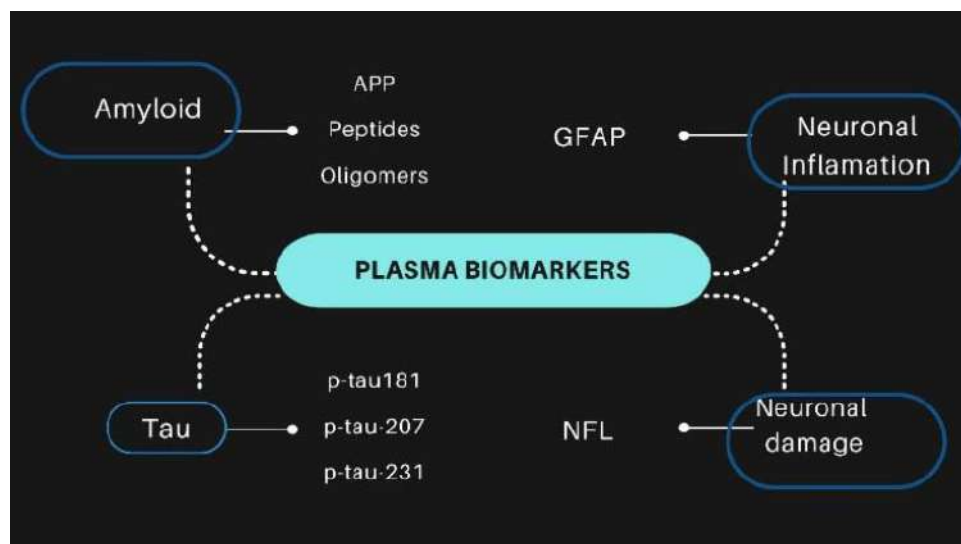


Fig. (4). Plasma biomarkers. (A higher resolution / colour version of this figure is available in the electronic copy of the article).

2.1.1. Plasma Amyloid Beta

Just like the reduction of A β 42/A β 40 in CSF biomarkers, Plasma A β 42/A β 40 biomarkers are strong indicators of AD. A β is isolated from plasma and quantified using mass spectrometry. By using these techniques, it is possible to see group-level decreases in plasma A β 42/A β 40 levels in amyloid PET-positive individuals relative to PET-negative individuals. The fact that plasma A β 42/A β 40 levels are completely altered even in the pre-symptomatic stages of the disease is a significant characteristic. For this reason, this biomarker, similar to CSF A β 42/A β 40, can accurately identify A β pathology in cognitively unimpaired individuals with accuracy levels comparable to those seen in cognitively impaired individuals [46]. For biological reasons, CSF A β 42/A β 40 is a more robust brain A β pathology biomarker than plasma A β 42/A β 40. In clinical laboratory practice, standardizing and maintaining the stability of this kind of test over time with the kind of rigor required to accurately identify the subtle difference between persons who are A β -positive and -negative is a difficult task [47].

2.1.2. Plasma Phosphorylated Tau (P-tau)

Tau phosphorylated at amino acid 181 (p-tau181), 217 (p-tau217), or 231 (p-tau231) have been reported by experts to detect different stages of AD [48, 49]. To evaluate the kinetics of various tau isoforms and fragments in the human Central Nervous System (CNS) and in neurons produced from induced Pluripotent Stem Cells (iPSCs), Sato *et al.* [50] devised stable isotope labeling and mass spectrometry techniques. It was also claimed that both tau tangles and β -amyloid plaques raise the concentration of plasma P-tau217, which is consistent with the theory that P-tau is implicated in the β -amyloid-dependent development of neocortical tau tangles [51]. Recent research on plasma phosphorylated tau has developed methods to study soluble p-tau indicators that have a stronger correlation with cerebral amyloid- β than

with PET-measured tau aggregation [52]. Various reports on plasma phosphorylated Tau are directed toward AD pathology [53, 54].

2.1.3. Plasma Neurofibrillary Tangles (NFL)

Salvado *et al.* [55] carried out a head-to-head comparison between many plasma biomarkers and neuropathological measurements of neurofibrillary tangles and amyloid plaques. They found that while plasma Glial Fibrillary Acidic Protein (GFAP) is uniquely linked to tau pathology, plasma A β 42/40 and plasma p-tau231 are specifically linked to amyloid disease. In individuals with cerebral white matter rarefaction, plasma Neurofilament Light (NfL) is elevated even after taking Alzheimer's disease pathology into consideration. Rodriguez *et al.* [56] reported that A β -positive cognitively impaired groups showed a particular increase in CSF and plasma NTA-tau concentrations. Global uptake and voxel-level correlations between CSF and plasma NTA-tau concentrations and tau PET were found to be stronger than those with A β PET and MRI. Both CSF and plasma NTA-tau are preferentially related to tau disease, according to regression models. Vrillon *et al.* [57] demonstrated in memory clinic settings, CSF NfL, plasma neurofibrillary heavy chain levels, and plasma NfL levels function similarly in positive and differential AD diagnoses. Unlike illnesses affecting motoneuron function, plasma pNfH did not show any additional benefit when compared to plasma NfL. The performance of CSF and PET indicators must be matched by continued research and the creation of reliable tests. In conclusion, blood-based biomarkers are becoming more and more important for AD diagnosis, monitoring, prognostication, assessing treatment response, and population screening-especially in primary care settings. With these advancements, AD diagnostics will be transformed, and more accessible and early detection and management options will be provided [58, 59].

2.1.4. Plasma Glial Fibrillary Acidic Proteins (GFAP)

Pereira *et al.* [60] reported that when compared to persons without amyloid- β pathology, the plasma GFAP concentration was considerably higher in all amyloid- β -positive groups ($P < 0.01$). Furthermore, in all amyloid- β positive groups, there were significant correlations between plasma GFAP and increased amyloid- β -PET signal. Plasma GFAP is a viable candidate to be added to the blood-based biomarker panel for AD because it is linked to AD-type pathology and has the ability to reliably predict clinical progression to AD dementia [61]. It has been demonstrated that the strong predictive value and clinical utility of GFAP as an ideal option to identify high-risk individuals and further prevent early in clinical trials or treatment timely in patients, as it is a highly specific marker of astrocyte activation and a substantial structural element of astrocytes. It is yet unknown, nevertheless, if GFAP is merely a sign of a broader astrocyte activation or even if it is the primary initiator of the inflammatory cascade reactions [62]. Using one-way Analysis Of Variance (ANOVA) and Receiver Operating Characteristic (ROC) curves, it was found that the area under the ROC curve (AUC) of 0.928 for GFAP indicated that it was a more effective diagnostic tool. The two serum indicators for the diagnosis of AD have cut-off values of GFAP >31.40 pg/mL and NfL >40.09 pg/mL. For the diagnosis of AD, the corresponding sensitivity and specificity for NfL were 59.6% and 76.2%, respectively, while the corresponding values for GFAP were 90.4 and 82.1% [63].

2.2. Cerebrospinal Fluid (CSF) Biomarkers

Cerebrospinal Fluid (CSF) is the first call for accessing AD treatment and therapeutic interventions [64]. CSF are most explored due to their ability to spot people with mild cognitive impairment, which can further assist in tracking their AD progression. Seyfried and group have supported this using a novel method known as selected reaction monitoring mass spectrometry, and the findings say that neuronal proteins are capable of differentiating cognitive decline issues [65]. Moreover, bioinformatics methods used by Li [66] *et al.* have led to the identification of six hub proteins in CSF, which could successfully differentiate between AD and other neuronal disorders. CSF biomarkers also aid in the assessment of plaques and tangles accountable for cognitive decline. Recently, many researchers have pointed the importance of CSF biomarkers [67, 68, 69]. Trombetta *et al.* [70] CSF tested a panel of 25 well-validated biomarker assays, and all were elevated in AD patients. Oxidative stress and metabolic markers influenced the multianalyte profile of AD. The authors concluded that it's critical to evaluate several biomarker domains in order to comprehend the heterogeneity of diseases. Mravinová *et al.* [71] observed that When proteins from various groups were combined in ratios (tau-associated protein/amyloid-associated protein), the proteins' association with cognitive decline as assessed by cognitive scores was dramatically increased. In a discovery cohort with 98 patients, Tao *et al.* [72] conducted tandem mass tag proteomic analysis of matched Cerebrospinal Fluid (CSF) and serum samples. Targeted proteome assays based on par-

allel reaction monitoring were utilized to validate candidate biomarkers in a separate multicenter cohort of 288 individuals. In the discovery cohort, they measured 3,238 CSF and 1,702 serum proteins. Of these, they identified 171 and 860 CSF proteins and 37 and 323 serum proteins, respectively, as possible early diagnostic and staging indicators. Twelve and eighteen serum proteins and fifty-eight CSF proteins were confirmed as early diagnostic and staging indicators in the validation cohort, respectively. Recently [73] the role of neural lipids has been observed in the prediction of mild to AD. Bateman *et al.* [74], in their longitudinal study, revealed very fascinating conclusions. They analyzed 128 participants for cognitive assessments, brain imaging, CSF, and blood tests. The cross-sectional analyses revealed exciting results, such as the concentrations of amyloid-beta 42 decline 25 years before the symptom was revealed. Using positron-emission tomography, A β deposition and Tau protein's presence in the CSF were observed 15 years before AD struck. Hypometabolism of cerebral and fresh memory loss was found to diminish 10 years before the AD diagnosis. Meanwhile, global cognitive impairment was observed 5 years earlier, and the afflicted people met diagnostic criteria only 3 years before. This study concluded that the pathophysiological alterations of the CSF start at least over 20 years before the symptoms are visible. Based on the same biomarkers, Mattson *et al.* [75] and his research group worked to determine their accuracy. For this, an extensive study was conducted involving AD patients and controls from 12 centers in Europe and the US. Here, also follow-up study was done for 2 years till the symptoms progressed for the neurological disorder. The concluding results showed a total number of 271 participants were diagnosed with AD and 59 with other forms of dementia. Fig. (5) summarizes the criteria for establishing a good biomarker for the diagnosis of AD.

Subsequently, Shaw *et al.* [76], again remarked CSF as the most sensitive biomarker for AD, in an experiment performed in the Alzheimer's disease Neuroimaging Initiative (ADNI) cohort with 96.4% detection sensitivity. They also found that CSF can also indicate mild cognitive (MCI) impairment to AD conversion. In 2006, Blennow *et al.* did a follow-up study for 4-6 years of 180 patients having mild cognitive impairment (MCI) in association with CSF biomarkers. Here, the clinical studies clarified that people struck with MCI have a higher chance of encountering with AD in their life. This occurred due to the elevated concentrations of T-tau, position threonine 181 (P-tau181), and A42 in CSF [77].

2.2.1. CSF Amyloid-beta (A β)

The instability of A β (1-42) plasma levels can be attributed to a number of factors [78, 79]. As of right now, the FDA has approved two assays: Roche Elecsys pTau181/A β 42 ratio and Fujirebio Lumipulse G β -Amyloid Ratio (A β 42/40) for assessing these biomarkers in CSF. 2, 3 According to these assays; there is brain amyloid pathology when there is a lower A β 42/40 ratio or a higher pTau181/A β 42 ratio in CSF [80]. Ab levels in the blood fluctuate over time and between individuals and may differ in mild, early, and late stages of

- Reflect physiological aging processes.
- Reflect basic pathophysiological processes of the brain.
- React upon pharmacological intervention.
- Display high sensitivity.
- Display high specificity for the disease as compared with related disorders.
- Allow measurements repeatedly over time.
- Allow reproducibility in laboratories worldwide.
- Should be measurable in non-invasive, easy-to-perform tests.
- Should not cause harm to the individuals being assessed.
- Tests should be inexpensive and rapid.
- Samples should be stable to allow easy and cheap transport.
- Easy collection of fluids not only in hospitals.
- Changes should be at least two-fold to allow differentiation of controls.
- Define good cut-off values to distinguish diseases.
- Data published in peer-reviewed journals.
- Data reproduced by at least two independent researchers.

Fig. (5). Criteria for establishing a good biomarker.

AD. In addition, blood platelets contain high levels of A β , which directly affects plasma levels [81]. The most senile form of AD marker is Amyloid-beta (A β) proteins found in the A β 42, A β 40, and A β 42/40 ratio as detected by positron emission tomography (PET), which eventually uplifts their weightage in comparison to other biomarkers [82]. The CSF also shows their prominent presence [83]. To validate the presence of amyloid in CSF, Queiroz *et al.* used a tandem mass spectrometry technique coupled with fiber-in-tube. It is well known that the alteration caused in amyloidogenic proteins a major reason for these serious neurodegenerative issues [84, 85]. The protein misfolding and resulting structures, such as polymorphic oligomers and fibrils, can often lead to cell death as they are toxic species. Beyer *et al.* have worked for over 17 years to establish the risk associated with the disorder. AD diagnosed around 60 participants and nearly about 200 controls were involved in this study. Their A β abnormal foldings and Ttau biomarkers were studied, revealing that A β is more specific in foretelling the AD risk factor [86].

Gliozzi *et al.* [87] showed the same by performing an interactive study using model membranes, which results in the formation of amyloid aggregates. These aggregates deposit in various tissues and causes AD, but this can still not be detected at the early onset of AD. They have also assumed that environmental conditions may contribute to aggregation and ultimately, to neurodegeneration. A fluorescent probe called Q-OB, which is generated from quinoline, has been created to detect A β oligomers [88]. This was achieved by precisely adjusting the hydrophobicity of the biannulate donor motifs in the donor- π -acceptor structure. When it comes to dynamically monitoring A β oligomerization during amyloid fibrillogenesis *in vitro*, Q-OB has exceptional sensing power. Furthermore, authors utilized this approach to fluorometrically examine the kinetics of A β self-assembly in the cerebrospinal fluids (CSF) of individuals with AD for an early diagnosis method. Various electrochemical immunosensors have

been developed [89] for detecting AD biomarkers (A β and p-tau protein) and their subtypes (A β O, A β ₍₁₋₄₀₎, A β ₍₁₋₄₂₎, t-tau, cleaved-tau (c-tau), p-tau₁₈₁, p-tau₂₃₁, p-tau₃₈₁, and p-tau₄₄₁).

2.2.2. CSF Phosphorylated-tau

One another prominent mechanism involved in AD is Tau pathology [90]. There have been recent reports on biomarkers for moderate cognitive impairment: CSF tau and β -amyloid [91]. A form of protein that is involved in forming neurofibrillary tangles in Alzheimer's patients. Tau is pronounced hyperphosphorylated (39 potential locations) in AD, which causes axonal transport impairment and a lack of function. Authors have reported [52] that the results of PET-assessed tau aggregation are less strongly correlated with soluble p-tau biomarkers than with cerebral amyloid- β . This suggests that p-tau biomarkers should be carefully interpreted within the framework of amyloid/tau/neurodegeneration. The AD group had significantly lower NfL levels but higher total-tau levels. Significant relationships between NfL, p-tau181, and total-tau, as well as between NfL and cognitive capabilities, were discovered in the FTD group. A β 42/40 ratio had an inverse correlation with both total-tau and p-tau181, but not with NfL. In the AD group, NfL levels were directly connected with both of these measures. The CSF biomarkers p-tau181 and p-tau231 identified healthy AD, and MCI populations. When matched to controls, AD intensely surges the revealing of Tau that has been phosphorylated at position 181, with a cut-off of >60 pg/ml. PET imaging shows a few Tau-related biomarkers like total tau (t-tau), phosphorylated Tau (p-tau), and tau/A β 42 ratio [92]. Apparently, it was found that Tau emerges peripherally as well as from the brain. Now, it is evident that the brain-related Tau are much more responsible for the neuronal disorder; thus, to distinguish between peripheral and brain-derived Tau, Gonzalez-Ortiz *et al.* brought about an anti-tau antibody that certainly bind to the one that originated from the brain. This is because the former is not a specific biomarker, and may

produce discrepancies [93]. Subsequently, their concentration is also region-defined. This was proved by Dang *et al.*, who, in their study, involved 83 AD patients and 38 normal patients and examined their brain spatial biological patterns. The biomarkers inter-relationship with AD was considered using various tests and algorithms, where they were tagged as the region-specific clinical marker [94]. Rodriguez *et al.* [95] commented on the significance of p-tau 205 in AD biomarking.

According to Braak *et al.* [96], Tau alterations start even 20 years before the A β plaques. The detailed study of Hasegawa on tau pathology has revealed the information that the tau fibrils are characteristically distinct in every other disease. In fact, plaques are only found with the tau tangles in the brain. Thus, it may be the tau alterations may be the reason for the A β plaques [97]. Medina *et al.* observed Tau as a protein that binds to microtubules and then regulates its morphology and activities in the brain. When the pathological alterations occur, they form neurofibrillary tangles. They have reviewed developments in AD and tauopathies [98]. Subsequently in the same year, Serpell *et al.* pondered the cellular distribution, its nuclear location, and functions of Tau and how this alteration varies or changes drastically in the disorder state. Globally, it has been accepted that the Tau is a prominent hallmark of AD [99]. In fact, tau Tau has also been assessed separately by researchers for novel drug development in correspondence with them. The tau accumulation and their regional distribution in a human brain and the aging of Tau has all been taken into concern. The review of Harada *et al.*, helps in the critical understanding of how the tau Tau fibrils interact with amyloid plaques in an AD brain and how their combination assists to the disorder early diagnosis [100].

Šimić *et al.*, have mentioned in their article that the abnormal extra neuronal deposition of aggregated proteins/plaques and the intraneuronal aggregation tau protein are the most common reasons for AD. It is now completely accepted that misfolded or abnormally structured proteins are the reason for AD [101].

2.2.3. CSF-Neurofilament Light Chain (NfL)

In 2019, a new kind of biomarker came under notice: Neurofilament light chain (NfL), which has been marked as a prominent fluid clinical marker by Preische *et al.* for AD. The generation of this chain has been noticed upon the progression of neurodegeneration into CSF [102]. Their presence has been confirmed *via*. Immunoassay. This cytoskeletal protein comes into existence upon neuronal damage; thus, it is not specific to AD.

It has been observed in their research that CSF and serum are correlated and elevated at the primary stage of AD. This elevation of serum NfL was revealed from the longitudinal analysis of people, and surprisingly, it was estimated that this elevation occurred almost a decade earlier before the estimated onset of AD. The elevation was also accompanied by cortical thinning, diagnosed by magnetic reso-

nance imaging (MRI). The study conducted at Mini-Mental State Examination and Logical Memory test shows that assessing NfL dynamics in serum can help in early prediction of AD, indicating that it is a prominent biomarker [103]. Another bioindicator is the Phosphorylated neurofilament heavy chain. They show a resemblance to NFT and mark the axonal damage relating to neurodegeneration [104]. The elevated levels lead to the progression of disease by their presence in CSF.

2.3. Disguised Factors Targeting Alzheimer's Disease

With time, other factors have also been explored which, in disguised form, act as biomarkers of this neuronal disorder. Other important etiological factors responsible for AD are oxidative stress, excess metal ions, *etc.* Again, in 2014, Mitra *et al.* focused on a potential cause of AD *i.e.*, the presence of excess metal ions causing toxicity, but the pathological mechanism is less known than how it affects neurons. Their studies have shown that elevated levels of redox metal ions (iron and copper) in the brain could irreversibly damage neurons. As their repair was inhibited by metal chelators and reducing agents. In their review, they have laid interest in the oxidative genome damage repair pathway, which could help prevent AD [105]. Eventually, in 2014, Hane *et al.*, studied the role of metal ions like (copper and zinc) in the AD pathological pathway. They highlighted the point that the metal ions plausibly change the kinetic path of the A β peptide, forming toxic oligomeric end-products. Here, the authors have critically reviewed how these metals severely affect the reaction path and lead to more neuro-toxic species. Studies have shown that the excess of copper ions can serve the purpose of neurotoxicity [106]. Few by-products, like oxysterols (formed by cholesterol biosynthesis), have a spectrum of biological reactions corresponding to AD pathology. Some oxysterols bear cytotoxic and pro-apoptotic properties. They can induce inflammatory responses and are potent enough to interfere with the lateral domain organization. Studies done on them by Olkkonen *et al.* in 2012 have unraveled that their physiological functions assist as signaling molecules involved in maintaining cellular and body lipid homeostasis. Still, to claim oxysterols as a specific biomarker, their role in the mechanisms of AD is less investigated [107]. The study of clinical hallmarks got an entirely new platform when Fisar and his group studied mitochondrial dysfunctions in co-relation with AD in 2014. Mitochondrial dysfunctions are also indicators of neurodegenerative dysfunction like AD as the impairment in mitochondria may result in AD. In this review, Hroudová *et al.* discussed concepts like reactive oxygen species, impaired mitochondrial dynamics, and apoptosis. Mitochondrial dysfunction also tends to damage the electron transport chain, which is again a responsible factor for the pathogenesis of AD [108]. Moreover, in 2019 a novel factor was underscored, which is also responsible for triggering AD. Mansour *et al.* have reviewed the evidence that air pollution can trigger AD. People with hearing and encoding disability for complex sounds may also be victims of AD. This happens as the auditory brain-

stem's nuclei are sensitive to neurodegenerative disorders. People who regularly encounter air pollution are found to show an accumulation of Tau, senile amyloid plaques, and suffer oxidative stress. Thus, it concludes that the physiological assessment of such people's brain-stem can help in prior indication of AD [109]. In AD, there is an abnormality in the lysosomal pathway-mediated autophagic breakdown of intracellular components. While cells from healthy individuals vigorously internalize A β , macrophages and monocytes from AD patients typically have limited A β phagocytic activity.

3. LIMITATIONS OF BIOMARKERS OF AD

Despite the full coverage of the background story of biological hallmarks of AD, some important questions remain unanswered. These need to be clarified to access AD at its early onset. It is necessary to determine their possible predictive usefulness with respect to the duration of recovery and the likelihood of incomplete recovery or CTE. There is still very less information on the mechanism of biomarkers and how blood concentrations relate to blood-brain barrier dysfunction¹. Moreover, serum and plasma are already highly enriched in a number of proteins (~50-70 g/L), which makes it difficult to detect and leads to less successful results when using biomarkers in blood as opposed to CSF. As of now, there is insufficient data to demonstrate the superiority of biomarkers over other diagnostic techniques for AD (such as CSF/imaging). Therefore, compared to blood-based biomarkers, CSF has fewer difficulties with availability and diagnosis in A/T/N framework-based biomarkers. A major limitation in the field is that markers discovered by one group cannot be reproduced by other groups. The predictive value of the existing biochemical and neuroimaging markers is quite low. Although the prognostic importance is currently limited to the latter stages of the disease, combining neuroimaging investigations with the detection of some CSF proteins improves diagnostic sensitivity and specificity, particularly in AD. The fact that markers found by one group cannot be replicated by other studies is a significant constraint in the field.

CONCLUSION

We have reviewed the prominent hallmarks of AD and discussed various plasma and fluid biomarkers that are relevant to clinical investigations and early predictions with recent insights. Alzheimer's disease (AD) is characterized by neurofibrillary tangles (NFTs) of Tau protein in patients' brains and senile plaques made of A β . Four CSF biomarkers-A β 42, A β 42/40, Tau, and pTau181-have undergone in-depth analysis and have been established as essential markers for AD. Apart from the direct role of biomarkers, the importance of the correct protocol of sample collection has been an area of interest. More information is required on biological variation (*e.g.*, the impact of renal function, body mass index (BMI), and peripheral neuropathy) as well as biomarker performance in a variety of groups. Clinical laboratory practice already uses plasma NfL analysis in several labo-

ratories worldwide. The biomarkers for AD diagnosis that have been explored and used the most include CSF A β 42, CSF A β 42/A β 40, CSF p-tau, tau PET, amyloid PET, structural MRI, *etc.* It has been well established that Tau and A β 42 levels are significantly lower in plasma than in CSF. There is no doubt that once the biomarkers of AD are identified from its core origin, they will projectile in the direction of instant early detection and treatment of the disease. To conclude, a precise clinical diagnosis is crucial when looking for a biomarker. Future research work may help identify more and more highly specific clinical insights for unraveling the biomarkers of this neuronal disorder. With this, drug efficacy can be modified, and novel therapeutic approaches may be introduced. Great insights into biomarkers can give possible solutions when it comes to curing AD. The identification of promising biomarkers can be a truly fascinating finding, which could completely open new ways in the prevention of the most dreadful form of dementia. Hitting the biomarkers of AD at an early stage represents a way better solution than prescribing anti-AD drugs.

LIST OF ABBREVIATIONS

AD	=	Alzheimer's Disease
APP	=	Amyloid Precursor Protein
A β	=	Aymoid Beta
CRP	=	C-reactive Protein
CSF	=	Cerebro Spinal Fluid
GFAP	=	Glial Fibrillary Acidic Protein
MRI	=	Magnetic Resonance Imaging
NFL	=	Neurofilament Light Chain
NFT	=	Neurofibrillary Tangles
NSE	=	Neuron-Specific Enolase
PET	=	Positron Emission Tomography
p-Tau	=	Phosphorylated Tau

CONSENT FOR PUBLICATION

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Extraction, Characterisation, Biological Properties and Applications of Essential Oils: A Review

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Abstract

In recent decades, essential oils have emerged as natural supplements to synthetic substances in medicine, agriculture, food industries etc. The modern techniques for extraction of essential oils have significantly reduced the time consumption and increased the yield in comparison to the conventional techniques that have been in use for so long. Advanced characterisation techniques like Gas chromatography (GC), Liquid Chromatography (LC), Mass Spectrometry (MS) etc., provide high accuracy in characterisation depending upon the nature of essential oils or other major phytoconstituents. Studies have shown essential oils to possess biologically significant activities like antibacterial, antifungal, anti-inflammatory, antioxidant, antihistamine, anticholinesterase, anti-cancer, antiaging etc. These activities of essential oils have made them eligible for their application in food preservation, medicines, industries, agriculture etc. Thus, the traditional knowledge of plants and extraction of essential oils from their different parts of significance can contribute to a healthy society if efforts are made towards enhancing their natural properties for maximum utilisation. The present review discusses different sources and compositions of essential oils, common extraction and characterisation techniques, some biological properties of essential oils and their applications in various industries.

Keywords: Essential oils, Mass spectrometry, antifungal, anticholinesterase, phytoconstituents.

1. Introduction

Essential oils are volatile odorous oils extracted from various parts (leaves, bark, roots, etc.) of plants. The essential oils extracted from different aromatic plants (like spices or medicinal plants) differ in their odour and flavour owing to the variety in the type and amount of constituents present in them. Some common plants and their parts used for essential oil extraction along with their major chemical constituent(s) are listed in Table 1. The organoleptic compounds, responsible for the aroma and flavour are present at varied concentrations in different parts of the plant depending on the part of the plant chosen for extraction and also on some growth parameters like climate and soil characteristics. Their molecular weights are usually less than 300 and they have some characteristic properties in common. These properties are optical activity, high refractive index, immiscibility with water, sufficient solubility to impart aroma to water, and solubility in most organic solvents such as alcohol and ether. Several methods can be utilized for the extraction of essential oils e.g., effleurage, expression, hydro distillation, steam distillation etc. However, steam distillation is the most used technique for commercial-scale production in related industries. Essential oils are considered secondary metabolites functional in plant defence against microbes (Tajkarimi et al., 2010). The essential oils and their phytoconstituents that have been investigated are known to possess several biological properties including antioxidant (Tit & Bungau, 2023), antimicrobial (Garzoli, 2023), antiparasitic (AlGabbani et al., 2023),

antimutagenic(Rasgele & Altin, 2023), anticancer(Sharma et al., 2022a), anti-inflammatory (Zhao et al., 2023), anti-ageing s(Raina et al., 2023), anticholinesterase(Raina et al., 2023)etc.

Table 1. List of common plants and their parts with major component(s) of essential oil

Common name	Scientific name	Part of plant	Major compound(s)	References
Basil	<i>Ocimum basilicum L</i>	Flowers, leaves, stem	Linalool, estragole, eugenol, methyl chavicol	(da Silva et al., 2021)
Turmeric	<i>Curcuma longa L</i>	Leaves, rhizomes	Turmerone, phellandrene, curcumin	(Ray et al., 2022)
Clove	<i>Syzygium aromaticum L.</i>	Buds	Eugenol, caryophyllene	(Abadi et al., 2022)
Peppermint	<i>Mentha piperita</i>	Leaves	Methanol, methanone	(Pérez-Vázquez et al., 2022)
Ginger	<i>Zingiber officinale</i>	Rhizomes	Citral, zingiberene	(Kalhoro et al., 2022)
Bay leaf	<i>Laurus nobilis L.</i>	Leaves, flowers	1,8-cineole, linalool, methyleugenol	(Ordoudi et al., 2022)
Cinnamon	<i>Cinnamomum zeylanicum</i>	Leaves, bark	Cinnamaldehyde, eugenol	(Stevens & Allred, 2022)
Tea tree	<i>Melaleuca alternifolia</i>	Leaves, bark	Terpin-4-ol, terpene, 1,8-cineole, p-cymene	(Borotová et al., 2022)
Thyme	<i>Thymus vulgaris L.</i>	Leaves	Thymol, p-cymene, Terpinene	(Ghafariarsani et al., 2022)
Orange	<i>Citrus aurantium var.</i>	Fruit	D-limonene, β -myrcene	(Radünz et al., 2021)
Nutmeg	<i>Myristica fragrans Houtt.</i>	Seed	Sabinene, limonene, methyl eugenol, myristicin	(Nikolic et al., 2021)
Black pepper	<i>Piper nigrum L.</i>	Leaves, seeds	β -caryophyllene, limonene	(Ashokkumar, Murugan, et al., 2021)
Lavender	<i>Lavanda angustifolia L</i>	Flowers, leaves	Linalool, Linalyl acetate, β -Caryophyllene	(Ciocarlan et al., 2021)
Ajowain	<i>Trachyspermum ammi L.</i>	Seeds, fruits	Thymol, p-cymene, γ -terpinene, carvacrol	(Mazzara et al., 2021)
Fenugreek	<i>Trigonella foenum-graecum L.</i>	Seeds	Linoleic acid, palmitic acid	(Akbari et al., 2019)

Fennel	<i>Foeniculum vulgare</i> Mill.	Seeds	<i>trans</i> -anethole, estragole, limonene, and fenchone	(Sabzi Nojadeh et al., 2021)
Cumin	<i>Cuminum cyminum</i>	Seeds	Cuminaldehyde, γ -terpinene, β -pinene	(Padilla-Camberos et al., 2022)
Allspice	<i>Pimenta dioica</i>	Berries	Eugenol, 1,8-cineole	(Padilla-Camberos et al., 2022)
Coriander	<i>Coriandrum sativum</i> L.	Aerial parts, seeds	Linalool, 2-decenal	(Raveau et al., 2021)
Clary Sage	<i>Salvia sclarea</i> L.	Aerial parts	Linalool, linalyl acetate, Germacrene-D	(Raveau et al., 2021)
Cardamom	<i>Elettaria cardamomum</i> L.	Seeds	α -terpinyl acetate, 1,8-cineole	(Vellaikumar, et al., 2021)
Mint	<i>Mentha piperita</i> L.	Leaves	Piperitenone oxide, 1,8-cineole	(Ilić et al., 2022)
Oregano	<i>Origanum vulgare</i> , L	Leaves	Thymol, bergamol, terpineol	(Radünz et al., 2021)
Sandalwood	<i>Santalum album</i> L.	Bark	α -and β -santalenes	(Raghavendra & Mahesh, 2022)
Rosewood	<i>Aniba rosaeodora</i>	Bark	Linalool, α -terpineol	(Teles et al., 2020)
Cedarwood	<i>Cedar atlantica</i>	Bark	δ -cadinene, β -farnesene	(Kačániová et al., 2022)
Parsley	<i>Petroselinum crispum</i>	Seed	Myristicin, sabinene, β -myrcene	(Foudah et al., 2022)
Star Anise	<i>Illicium verum</i>	Fruit	Trans-anethole, limonene, estragole	(Yu et al., 2021)

Conventionally, the extraction of essential oil was done through expression methods like enfleurage, effleurage and defleurage, hot maceration process, pelatrice method, cold press, dry press method, etc. but they carried some limitations as well. Modern technologies have been developed over the years to overcome these limitations and to enhance the efficiency of extraction. The modern methods are mostly based on the distillation process and solvent extraction. Hydro-distillation, hydro-diffusion and steam distillation methods are collectively called azeotropic distillation.

It is crucial to perform chemical profiling of essential oils to determine their composition and variation in concentration of different constituents present in essential oils extracted from different plants or different plant parts of the same plant or plant parts of different varieties of the same species. This distinction helps in determining the phytoconstituents responsible for

the biological activities of essential oils. The characterization of essential oils for their composition is done through chromatographic techniques like gas chromatography (GC), Liquid Chromatography (LC) etc. coupled with a detection technique like mass spectrometry (MS), flame ionization detection (FID) etc.

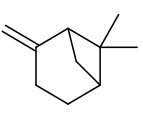
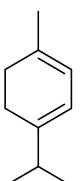
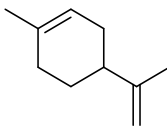
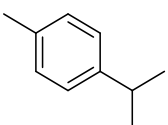
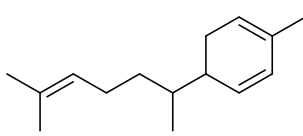
The biological properties of essential oils have generated a wide range of applications. These implications are relevant to both industries and the medicinal fields. The use of synthetic food preservatives has laid roots for skin allergies, cancer, intoxication, and other degenerative conditions. Essential oils have been known to possess antioxidant and antimicrobial activities, and their ability to protect food from pathogenic and spoilage microorganisms raises their eligibility to be used as natural additives in foods and food products. These can also be used as active compounds in packaging materials, by improving their water vapor barrier property associated with their hydrophobic nature. Essential oils are being sought as an alternative to these non-natural products in food preservation (Hussain et al., 2021).

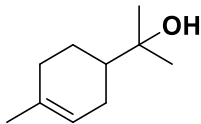
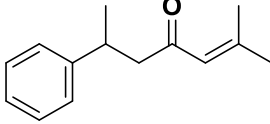
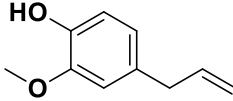
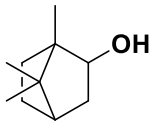
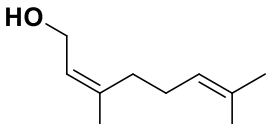
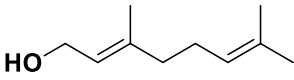
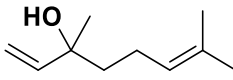
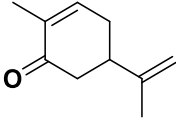
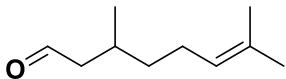
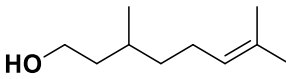
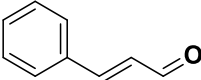
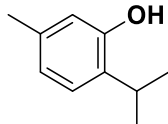
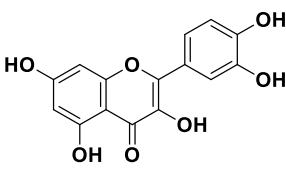
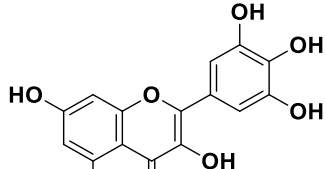
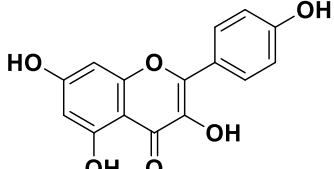
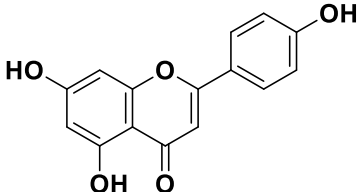
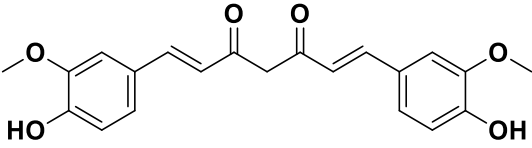
Apart from food preservation, essential oils have also been applied in the field of therapeutics and medicine. Cosmetics and aromatherapy are the leading heads in utilizing the benefits of essential oils. Owing to their insecticidal and plant growth-enhancing properties essential oils have been utilized in the field of agriculture.

2. Sources and Composition

Several plants can be utilized for the extraction of essential oil. However, the part of a plant which acts as the major source of essential oil can always be different. Also, the quantity of different components present in essential oils extracted from different parts of the same plant may vary. The essential oils are mainly composed of low molecular weight (<1000 Da) volatile components, around 85-99%. Essential oils contain over 300 compounds. The chemical composition of essential oils is mostly contributed by secondary metabolites (like terpenes, terpenoids, flavonoids, alkaloids, polyphenols, indigenous pigments, etc.), other aromatic compounds and aliphatic constituents. Terpenes and terpenoids have a structural backbone made up of isoprene units. The structural representation of common terpenes and terpenoids is presented in Table 2. The major compounds found in essential oils are mainly divided into two classes: Terpene hydrocarbons and oxygenated hydrocarbons.

Table 2. Structural representation of common terpenes, terpenoids and flavonoids found in various essential oils

Terpenes					
	pinene	α-terpinene	limonene	p-cymene	zingiberene

Terpenoids	 α -terpineol	 turmerone	 eugenol	 borneol
	 nerol	 geraniol	 linalool	 carvone
	 citronellal	 citronellol	 cinnamaldehyde	 thymol
Flavonoids	 quercetin	 myricetin	 kaempferol	
	 apigenin	 curcumin		

2.1 Terpene Hydrocarbons

Terpenes are a class of aromatic compounds that have a general formula of $(C_5H_8)_n$ and a basic structure formed from 5-carbon-based isoprene (C_5H_8) units. Based on the number of C-units present in the terpenes molecules, they are divided into six classes: hemiterpenes (C_5), monoterpenes (C_{10}), sesquiterpenes (C_{15}), diterpenes (C_{20}), triterpenes (C_{30}) and tetraterpenes (C_{40}). Further higher classes of terpenes are known as carotenoids. Monoterpenes are made up of two isoprene units and are the major components (around 90%) in essential oils.

2.2 Oxygenated Hydrocarbons

These compounds are derived from terpenes and are termed terpenoids (or isoprenoids). Terpenes are modified by the addition of functional groups like alcohol, aldehyde, ketones etc. to form terpenoids. Some examples of terpenoids are represented in Table 3.

Table 3. Examples of Terpenoids

Class	Examples
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Phenols	thymol, eugenol, carvacrol, chavicol
Alcohols	borneol, isopulegol, nerolidol, α -santalol, lavanduol, α -terpineol, santalol
Aldehydes	citral, myrtenal, cumin aldehyde, citronellal, cinnamaldehyde, benzaldehyde
Ketones	carvone, menthone, pulegone, fenchone, camphor, thujone, verbenone
Esters	bornyl acetate, linalyl acetate, citronellyl acetate, geranyl acetate
Ethers	1,8-cineole, anethole, elemicin, myristicin
Oxides	1,8-cineole, bisabolone oxide, linalool oxide, sclareol oxide
Lactones	bergaptene, nepetalactone, psoralen, aesculatine, citroptene

3. Extraction of Essential Oils

The process of extraction is crucial in case studies based on essential oils as it defines the quality and quantity of the yield. The extraction method is selected based on the type, state, and form of the plant material. Inappropriate selection of extraction methods may result in loss of bioactivity, natural characteristics, or physical properties. Discolouration, off-odour/flavour, increased viscosity, etc. might also take place. In the worst cases, even alteration of the chemical signature of essential oil may occur. Almost any part of a suitable plant can act as a source and essential oil can be extracted from it to be utilized in applications like food preservation and others. The modern methods are mostly based on the distillation process and solvent extraction.

3.1 Steam Distillation

This method is a common and efficient choice for the extraction of essential oils. The process of steam distillation involves passing steam through crushed or chopped plant material in upward direction. The vapours flowing through the plant material carry the volatile components along with them. The heat carried by steam bursts and breaks the cell structure of plant material and causes the release of phytochemicals. The temperature of steam must always be sufficient for this rupture. The vaporized mixture is then condensed and collected, where the aqueous and non-aqueous components get separated based on their lipophilicity. Figure 1 shows a diagrammatical representation of the steam distillation process. The steam distillation method is efficient in extracting 93% of essential oil and the remaining 7% can be extracted by further processing(Masango, 2005). This method can be coupled with hydrodistillation for better yields(El Kharraf et al., 2021).

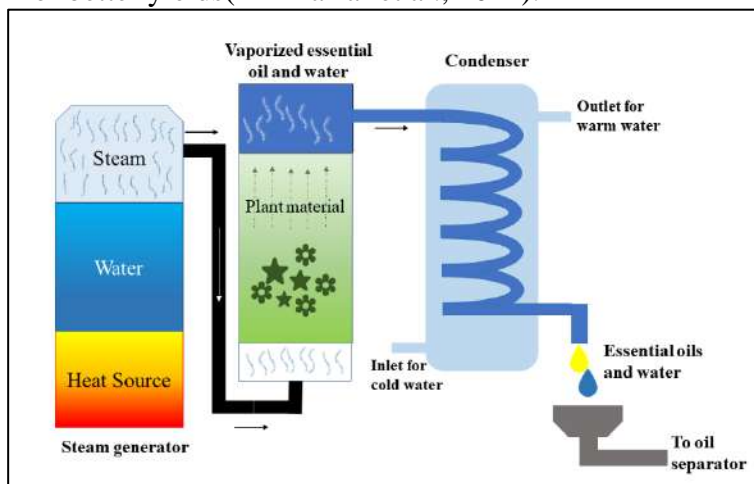


Figure 1. Schematic diagram of steam distillation process.

3.2 Hydro-distillation

Hydro-distillation method for extraction of essential oils involves boiling plant materials completely immersed in water. This method is suitable for capturing the hydrophobic phytochemicals having a high boiling point. The water surrounding plant materials protects them from overheating, which might cause damage to the desired outcome. Upon boiling the essential oil vapors move along with steam and the mixture is allowed to condense. The separation of aqueous and non-aqueous phases takes place upon condensing. Figure 2 shows a diagrammatic representation of the hydro-distillation process. Hydro-distillation method is utilized after coupling it with heating techniques in modern extraction procedures. Microwave-assisted Hydrodistillation(MAHD)(Elyemni et al., 2019), Ultrasonic-assisted hydro-distillation (UAHD)(Sneha et al., 2022) and ohmic-assisted hydrodistillation(Sharifi et al., 2022) are three such cases.

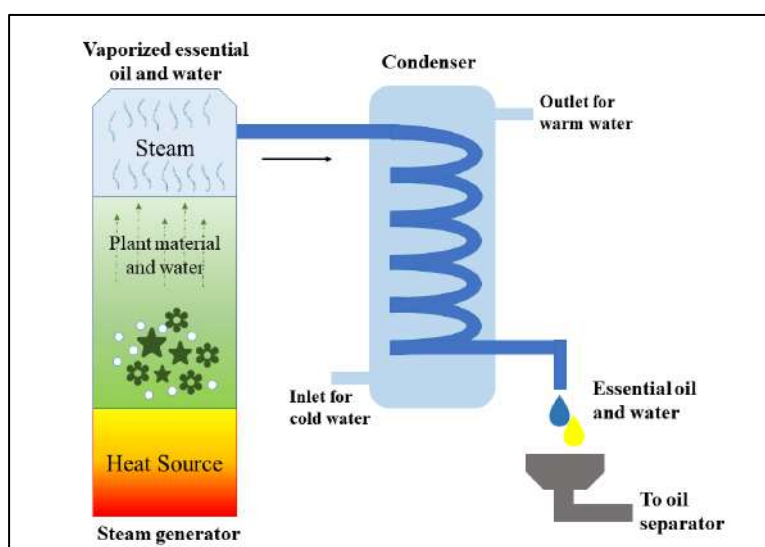


Figure 2. Diagrammatic representation of hydro-distillation.

3.3 Hydro-diffusion

The hydro-diffusion method is similar to the steam-distillation method, as it involves steam as the carrier of heat. In this method, steam is passed from the top of the plant material. This process also protects the plant materials from the damage caused by boiling. Hydro-diffusion method is advantageous over the hydro-distillation method as the processing time is lesser and the yield obtained for a given amount of steam is higher. The traditional hydro-diffusion method has been modified to perform hydro-diffusion and gravity methods(Bousbia et al., 2009).

3.4 Solvent extraction using an organic solvent

Organic solvents like methanol, petroleum ether, ethanol, dimethyl sulphoxide etc. can be utilized for the extraction of essential oils in place of water. Because of the non-aqueous nature of essential oils, this method provides a better yield. This procedure involves mixing plant material with the organic solvent and heating the mixture. This method can be operated efficiently at low temperatures. The mixture is then filtered and the solvent is separated from essential oil by evaporation.

3.5 Solvent extraction using supercritical carbon dioxide

Evaporation of the solvent in the case of organic solvent may lead to the loss of volatile components from essential oil. If not evaporated then the solvent residue may affect the activity of essential oils. Carbon dioxide (CO₂) is capable of forming supercritical fluid at high-pressure conditions. As soon as the room temperature is attained, CO₂ vaporizes leaving no solvent residue. Thus, using supercritical CO₂ is a better option when compared to organic solvents

4. Characterisation Techniques

The modern analytical techniques for the characterisation of essential oils are based on chromatography principles. The essential oil contains both volatile and non-volatile components. The volatile components are analyzed by Gas Chromatography (GC), while non-volatile components are analyzed by Liquid Chromatography (LC).

In both techniques, the components are eluted by the mobile phase and are separated based on their affinity with the stationary phase. In GC, the mobile phase is a carrier gas containing vaporized analytes, while in LC, the mobile phase is a solvent or mixture of solvents. The separated analytes are recorded, and a chromatogram (signal v/s time) is generated following a Gaussian distribution curve scheme. The chromatogram delivers both qualitative and quantitative information. The peak area and height determine the amount of analyte present; the peak width determines the band spreading, and the solute is identified by characteristic retention time, which is also a function of the nature of the solvent.

4.1 Gas Chromatography-Mass Spectrometry (GC-MS)

Mass spectrometry involves the ionization of analytes to generate the gaseous ions, with or without fragmentation. The ions are then analyzed for their mass-to-charge ratios and relative abundances (Todd, 1995). The analytes can be ionized by exposing them to electric fields or energetic species (like electrons, ions, or photons) or thermal methods. Although destructive, this technique is susceptible, requires a small sample size, is lower in expense, simple in design, and caters to fast data acquisition rates.

Gas chromatography coupled with mass spectrometry has great potential in determining the volatile compounds, which hold a significant share in the chemical constitution of essential oils. The mass spectrum of unknown compounds acquired from the GC-MS hyphenated technique is compared against the MS reference library created with standardized protocols of compound analysis. The incorporation of retention indices with MS libraries enhances the accuracy in the identification of compounds (Costa et al., 2007).

4.2 Fast Gas Chromatography

Compared to traditional GC, fast GC provides sufficient resolving power in less time by combining appropriate columns and instrumentation. With improved run conditions, analysis times can be reduced by 3–10 times (Korytár et al., 2002). This technique is more analytically sensitive and efficient in terms of speed. The objective of Fast GC is accomplished by altering some analytical parameters like length and internal diameter (ID) of the column, carrier gas, linear velocity, stationary phase, film thickness, oven temperature, and ramp rate. This method necessitates instruments equipped with high split ratio injection systems to aid smaller sample column capacities, increased inlet pressures, rapid oven heating rates, and fast electronics for detection and data collection.

4.3 GC – Olfactometry

Fuller et al. first modified the gas chromatography to determine the volatile odour activity. The standard GC is incorporated with an olfactory port along with or in place of other detectors. GC-O is utilized in addition to a flame ionization detector (FID), thermal conductivity detector (TCD), mass spectrometer, or photoionization detector.

4.4 Enantioselective GC:

The primary objective of Es-GC is to characterize the enantiomeric excess (ee) and enantiomeric ratio (ER) in chiral compounds. This technique requires a small sample size and provides high separation efficiency and selectivity along with high precision and reproducibility. The resultant information is crucial in characterizing essential oils and is considered equal to ‘fingerprint.’ Es-GC can be hyphenated to MS for more efficiency.

4.5 Liquid Chromatography-Mass Spectrometry (LC-MS)

Although non-volatile components of essential oils hold a small share in their chemical constitution, they are significant when analyzing samples like citrus essential oil obtained by cold pressing methods. Thus, information gathered from GC techniques is not sufficient. Such non-volatile compounds are analyzed using LC, referred to as High-performance LC (HPLC). In normal phase (NP-HPLC) applications, the slightly polar analytes are separated based on their affinities towards an opposite stationary phase and a non-polar mobile phase, and the result is obtained in terms of elution time of analyte, which is highly influenced by the degree of adsorption of the analyte on the stationary phase. In reversed-phase (RP-HPLC) applications, a non-polar stationary phase and a moderately polar aqueous mobile phase are involved. The purified fractions obtained from HPLC or LC techniques are analyzed by coupled mass spectrometry. UV detection and spectrofluorimetric detections have been engaged as analyzing tools.

5. Biological Activities

Essential oils are known to possess various biological activities that can prove to be a boon to humankind if utilized properly.

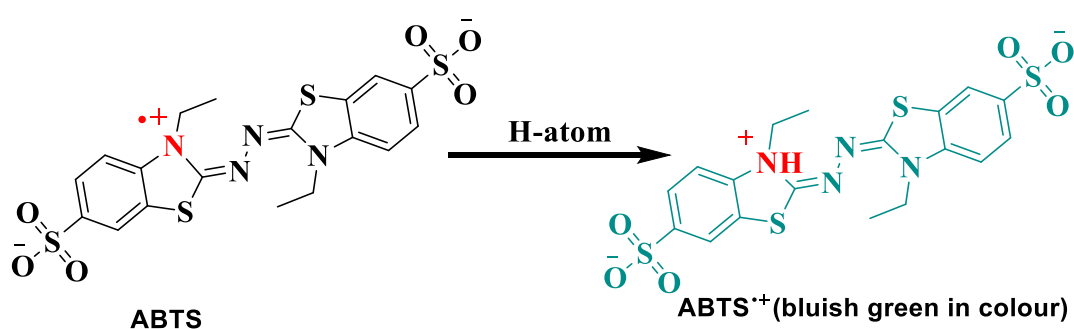
5.1 Antioxidant activity

The production of reactive oxygen species (ROS) and reactive nitrogen species (RNS) as byproducts of various biological processes occurring within the human body is harmful and deteriorating in nature. Studies have bridged the relationship between the oxidative damages caused by ROS and multiple diseases that include ageing (Head, 2008), cancer (Paz-Elizur et al., 2008), diabetes (Jain, 2006), and Parkinson’s disease (Blesa et al., 2015) among many others. To counter these ROS, our body requires antioxidants. Antioxidants are defined as compounds capable of inhibiting or de-escalating an oxidation process. Natural antioxidants, like Vitamin C, Vitamin E, polyphenols/flavonoids, etc., are molecules capable of preventing oxidation of a substrate even when it is present in a lower concentration than the substrate. Studies have reported their effectiveness in preventing the above-mentioned diseases. The antioxidant activities of essential oils can be evaluated through various Hydrogen Atom Transfer (HAT) and Electron Transfer (ET) methods. Some antioxidant assays are categorically listed in Table 4. A schematic representation of some popular assays has been depicted in Figure 3.

Table 4. List of antioxidant assays

Category	List of antioxidant assays
Hydrogen Atom Transfer	Oxygen radical absorbance capacity (ORAC) method
	Lipid peroxidation inhibition capacity (LPIC) assay

methods (HAT)	Total radical trapping antioxidant parameter (TRAP)
	Inhibited oxygen uptake (IOC)
	Crocin bleaching nitric oxide radical inhibition activity
	Scavenging of H ₂ O ₂ radical
	1,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging method
	Scavenging of superoxide radical formation by alkaline
Electron Transfer methods (ET)	Trolox equivalent antioxidant capacity (TEAC)
	Ferric reducing antioxidant power (FRAP)
	2,2-diphenylpicrylhydrazyl (DPPH) free radical scavenging assay
	Copper (II) reduction capacity
	N,N-dimethyl-p-Phenylenediamine (DMPD) assay
Other assays	Total oxidant scavenging capacity (TOSC)
	Inhibition of Briggs-Rauscher oscillation reaction
	Chemiluminescence
	Electrochemiluminescence
	Fluorometric Analysis
	Enhanced chemiluminescence
	TLC bioautography
	Cellular antioxidant (CAA) assay
	Dye-substrate oxidation method



(a) ABTS radical scavenging method

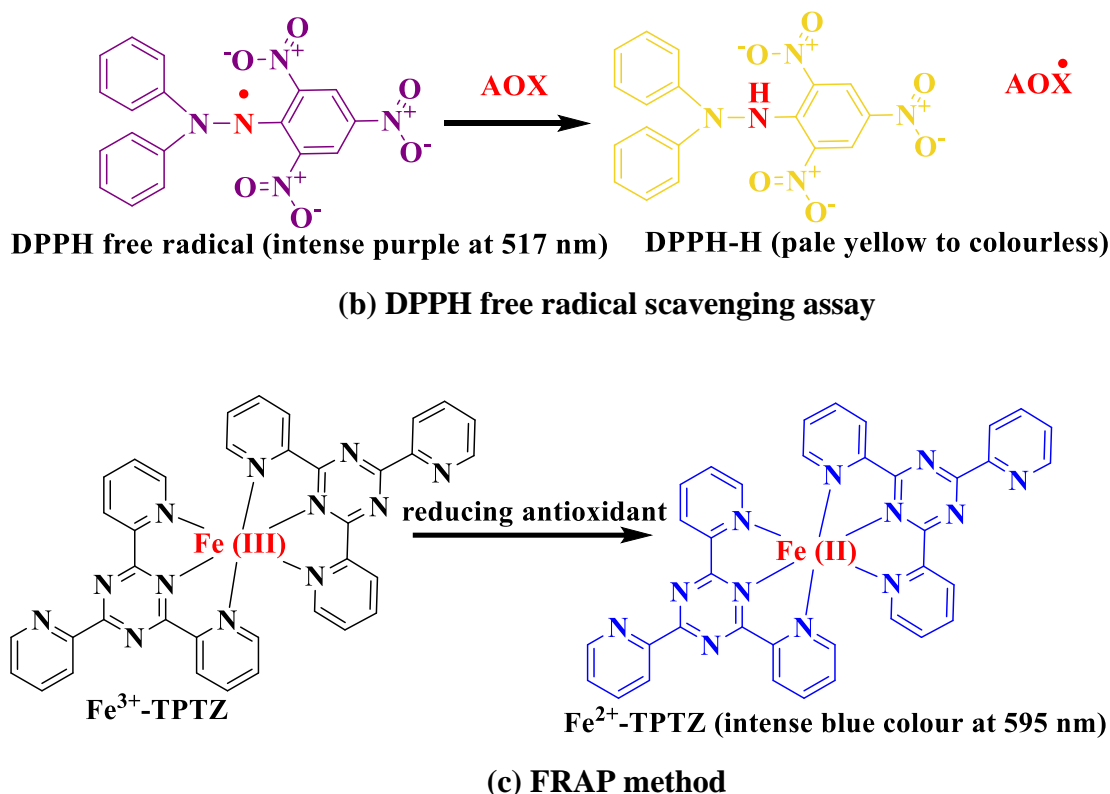


Figure 3. Mechanism of some antioxidant assays (a) ABTS radical scavenging methods, (b) DPPH free radical scavenging assay and (c) FRAP method.

5.2 Anticholinesterase activity

Alzheimer's disease (AD) is a slowly progressive neurodegenerative disease. It is a disorder that causes degeneration of brain cells and is the leading cause of dementia (Cipriani et al., 2011). AD is characterized by neurotic plaques and neurofibrillary tangles, that result from the accumulation of amyloid-beta (A β) peptide in affected areas of the brain, the medial temporal lobe, and neocortical structures (Selkoe, 2001). Disorders like Alzheimer's disease may cause a progressive loss of cognitive functions, which may further result in reduced oxygen supply to the brain, tumours, vitamin B₁₂ deficiency, other nutritional deficiencies, and so on (Nakaizumi et al., 2018). There is currently no widely effective treatment that can stop or slow the progression of Alzheimer's disease. Natural ingredients are expected to play an important role in the emergence of potentially neurodegenerative disorder therapeutic avenues. The utilization of secondary metabolites is beneficial (Sweeney et al., 2018). The inhibition of cholinesterase by essential oils has been investigated using Ellman's colourimetric method (Kamli et al., 2022). The mechanism followed in Ellman's method has been depicted in Figure 4.

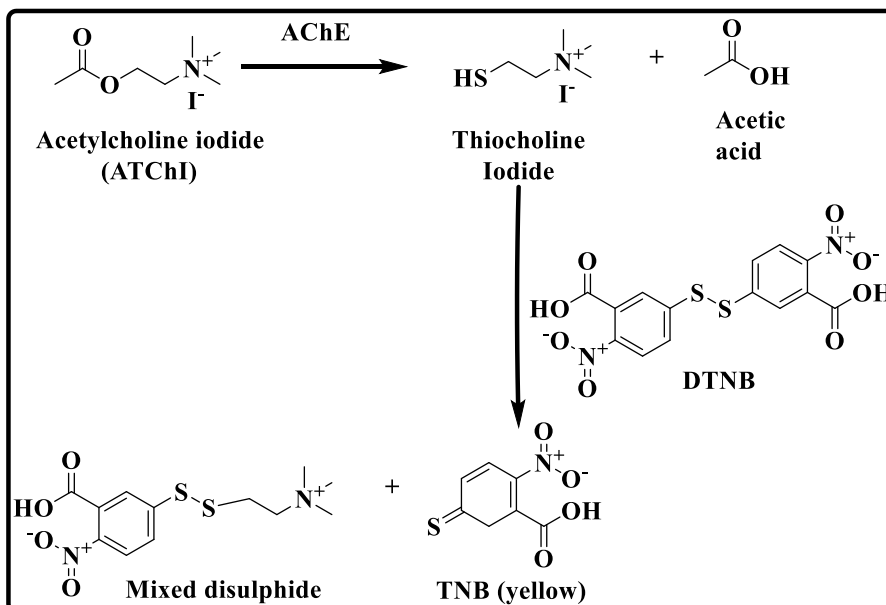


Figure 4. Mechanism of Ellman's method.

5.3 Antimicrobial activity

The bioactive components present in essential oils cause disruption in the cell wall of pathogens. Because of their hydrophobic nature, components of essential oil move rapidly across the lipids of bacterial cell membranes, disrupting cell wall structures and making them more permeable (Figure 5). Essential oils extracted from the plant parts of turmeric(Joshi et al., 2021), pepper(Le et al., 2022), clove(Yoo et al., 2021) etc. have been investigated for their antimicrobial activities.

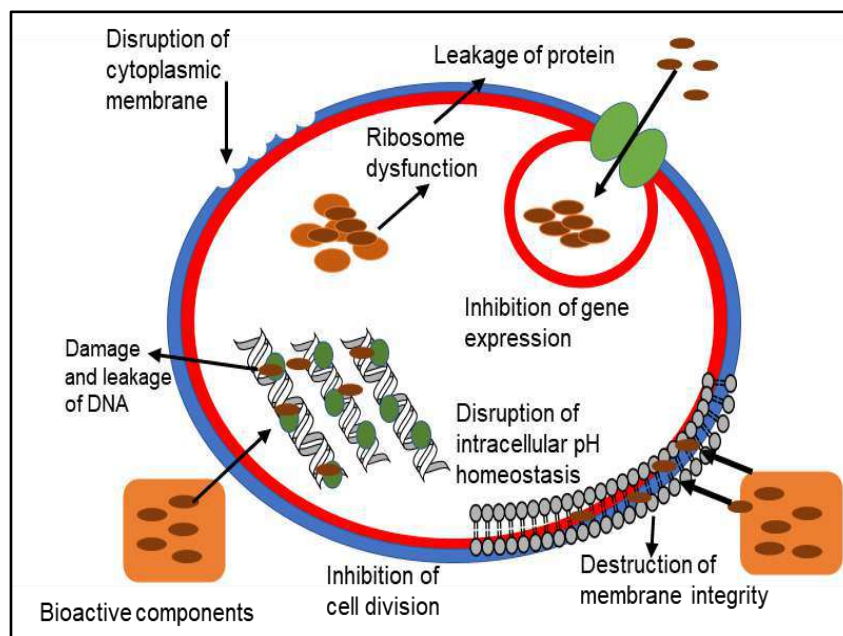


Figure 5. Schematic representation of the antimicrobial action of essential oils(Wang et al., 2020).

5.4 Anti-inflammatory activity

Inflammation is a defense process of human body involving the recognition and removal of foreign stimuli by the immune system. Immune-responsive compounds, cytokines and interleukins are produced by macrophages, keratinocytes and lymphocytes in the human body (Jacob et al., 2013). The components of essential oils like thyme, chamomile, eucalyptus, lavender etc. modulate the transcription of the pro-inflammatory cytokines to reduce inflammation (Pandur et al., 2021).

6. Applications

Essential oils have a wide range of applicability. Different sectors where essential oils have been applied include the Food and beverage industries, paper and printing industries, paint and textiles industries, medical sector, agriculture sector etc. These have also been applied to adhesives, cosmetics and toiletries. The major applications of essential oils are discussed below.

6.1 Food Preservation

Owing to their antimicrobial activity against common food-borne bacteria and fungi, essential oils have been studied and employed for food preservation and increasing their shelf life (Tongnuanchan & Benjakul, 2014). The food industry has utilized several essential oils in the form of flavouring agents and they also have shown potential as food-grade preservatives (Angane et al., 2022). Essential oils have been modified in the form of capsules (Yang et al., 2023), bioactive films (Mohamad et al., 2022), edible coatings (Ju et al., 2019), chitosan-based membranes (Maleki et al., 2022), food packaging (Mukurumbira et al., 2022) etc. to enhance their role as preservatives. Essential oils extracted from herbs and spices have proved to be better than synthetic chemical additives. Essential oils have been applied for the preservation of meat and meat products (Smaoui et al., 2022), bread (Rahman et al., 2022), dairy products (Badola et al., 2023), aquatic food (Shahidi & Hossain, 2022), fruits and vegetables (Pandey et al., 2022). Active packaging of food products using essential oils is highly advantageous as essential oils possess antioxidant and antimicrobial properties that help in shelf-life improvement. Also, the food waste in the case of such packaging can be reused as a source of essential oil. However, the usage of essential oils in food preservation is accompanied by some limitations due to their high volatility, low lipophilicity and easy degradation. These limitations can be resolved by encapsulating essential oils (Carpena et al., 2021).

6.2 Medicines and therapeutics

Essential oils are being studied for their biological properties and have shown results significant to the field of medicine and health care. Aromatherapy is a traditional and most popular application of essential oils in this field and utilizes them to treat several diseases. Aromatherapy utilizes the antiseptic and skin permeability properties of essential oils. Some plants whose essential oils are used in aromatherapy include clary sage, eucalyptus, lavender, lemon, peppermint, rosemary, tea tree etc. The utilization of essential oils in aromatherapy has been reviewed (Ali et al., 2015). The effect of clove essential oil on memory function has also been studied through aromatherapy (Ansariniaki et al., 2022). The application of essential oil to treating skin anomalies (Lee et al., 2022) and dermatological hair problems (Abelan et al., 2022) has been studied recently. Anticancer (Sharma et al., 2022b), anti-inflammatory (Jaradat et al., 2022), antiaging (Lohani & Verma, 2022), and neuroprotective (Rashed et al., 2021) potential of several essential oils have been investigated and they can be employed in the formulation of drugs to counter the aforesaid human-related problems.

6.3 Agriculture

Essential oils can prove to be beneficial in the field of sustainable agriculture. They have shown significant activities against plant pathogens, weeds and a broad spectrum of microorganisms in different *in vitro* and *in planta* studies carried out (Raveau et al., 2020). Due to their remarkable phytotoxic activities, essential oils are suitable candidates for the development of novel bio-herbicides (Wan & Rengasamy, 2022). They also have a potential role as pesticides to play in integrated pest management and organic farming as they are environment-friendly. The biological activities of essential oils have been applied to control plant pests and diseases (Basaid et al., 2021). The insecticidal properties of essential oils have also been studied (Bravim dos Santos et al., 2021). Essential oils have a potential role in extending fruit shelf life by fighting against postharvest pathogens (El Khetabi et al., 2022).

6.4 Cosmetics and Toiletries

Essential oils have emerged as natural ingredients in cosmetics and toiletries due to their odorous character and beneficial biological properties like antioxidant, anti-inflammatory, antimicrobial etc. They have been utilized in the manufacturing of fragrances and perfumes. These oils are used as active ingredients or preservatives in various skin and hair care products like moisturizers, lotions, cleansers, conditioners etc. The application of essential oils and their components in cosmetic products have been properly reviewed recently (Guzmán & Lucia, 2021).

7. Conclusion

Essential oils can be extracted from different parts of a variety of plants. Aromatic plants like spices, flowers, herbs, etc. possessing medicinal properties are chosen for the purpose. The extraction process can be properly chosen to maximize the yield. These oils can be utilized in their natural form or modified into capsules, bio-active films, etc. for their applicability in food preservation. Essential oils and their active agents can act as natural medicine or an alternative to commercially available medicines in the treatment of diseases associated with pathogens and metabolism. If studied properly the essential oils may prove to have the potential to deliver a synergistic effect with the drugs used in the treatment of different diseases. If properly explored to their full potential, essential oils can be a boon to humankind.

8. Future prospects

Owing to the global developments in recent years, the antiviral properties of essential oils can be peculiarly studied and applied for prevention and treatment. The use of natural aromatics for inhalation and their interaction with the central nervous system is an interesting field and can be further explored. Work can still be done to maximize their already existing potential in various fields of food preservation, medicine etc. by enhancing their activities through molecular size-modification, structural rearrangement of components etc. Despite considerable applications, essential oils also showcase some limitations. Firstly, being lipophilic they show less to no interaction with the polar moieties. Secondly, due to their high volatility and instability, their effects are acute. Another important aspect of essential oils is their chemical variability. Being majorly composed of secondary metabolites they are considerably affected by external factors which may degrade their quality over time. Recent studies have suggested the applicability of nanotechnology in the field of essential oils. Preparation of nano formulations of essential oils like nano emulsions, and nano-hydrogels not only promote hydrophilicity but also have the potential to mould essential oils into the desired frame of applications with enhanced stability and bio interaction. Essential oils can

also be encapsulated using nanocontainers and studied for their kinetics and release mechanism. Such methods and studies would intensify their biological applications.

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• गिरजा शंकर गौतम

सारांश- बिरहोर जनजाति छत्तीसगढ़ की उन सर्वाधिक पिछड़ी अल्पज्ञात जनजातियों में से एक है, जिनके उन्नयन से संबद्ध विभिन्न समस्याएँ दीर्घकाल से अब तक प्रासंगिक बनी हुई है। यह जनजाति पूर्व में घुमंतु प्रवृत्ति, शिकार एवं कंदमूल एकत्र कर जीवन व्यतीत करने के कारण विशेष उल्लेखनीय रही है एवं अशिक्षा, निर्धनता एवं स्वास्थ्य संबंधी समस्याओं से अब भी जूझ रही है। छत्तीसगढ़ में 42 प्रकार की जनजातियाँ निवास करती हैं, कमार, बैगा, पहाड़ी कोरवा, अबूझमाड़िया एवं बिरहोर यहाँ निवास करने वाली पाँच सर्वाधिक पिछड़ी जनजातियाँ हैं। इस शोध पत्र के माध्यम से छत्तीसगढ़ राज्य के कोरबा जिला के पाली विकासखंड स्थिति डोंगानाला एवं भंडारखोल गाँव में विस्थापन उपरांत निवास करने वाली बिरहोर जनजाति की शिक्षा एवं भाषा के महत्व को रेखांकित करना है। बिरहोर जनजाति स्वयं को 'जंगल का मानव' कहते हैं। यह कोरबा, जशपुर एवं रायगढ़ जिले के बीहड़ जंगलो में निवास करते हैं। सामान्यतः यह घुमंतु जनजाति के रूप में जानी जाती है।

मुख्य शब्द - भाषा, शिक्षा, स्थिति, जनजाति, घुमंतु

वर्तमान में बिरहोर जनजाति के लोग अपनी भाषा बिरहोरी से विमुख हो रहे हैं, आवागमन के साधन, सड़क, शिक्षा संपर्क के कारण ये छत्तीसगढ़ी के संपर्क में आ रहे हैं तथा अपनी बोली भाषा से दूर हो रहे हैं। अपनी शब्दावली से स्वयं बिरहोर भी विमुख हो रहे हैं या यूँ कहें की भाषांतरण कर रहे हैं। क्षेत्र भ्रमण के दौरान दैनिक प्रयोग किये जाने वाले शब्दों को संग्रह करने का प्रयास किया गया है। अतः इस विलुप्त हो रही जनजाति की भाषा व्याकरण का प्रलेखन जरूरी है। बिरहोरी में ध्वनि, रूप, वाक्य एवं अर्थ तथा अन्य भाषा के प्रभाव को केंद्रित कर कार्य किए जाने की आवश्यकता है। इस बोली का व्याकरण तथा शब्दकोश तैयार किया जा सकता है। इस प्रकार के कार्य से भाषा का संवर्धन तो होगा ही, साथ ही बिरहोर जनजाति के बच्चों में शिक्षा के प्रति रुचि जागृत करने में मदद मिलेगी यद्यपि यह सरल कार्य नहीं है। बिरहोरी संस्कृति के संरक्षण एवं संवर्धन के लिए प्रारंभिक प्रावधान के रूप में लोकभाषा, लोकगीत, लोककथा आदि को दृश्य-श्रव्य माध्यम के द्वारा संरक्षित किया जा सकता है। इस प्रकार का कार्य उन्हें

सामाजिक सांस्कृतिक रूप से संरक्षण प्रदान करेगा ही साथ ही शैक्षिक स्तर सुधार करने में मदद मिलेगी।

अध्ययनित विषय का परिचय

- अध्ययन क्षेत्र का परिचय- छत्तीसगढ़, जिला कोरबा, ग्राम डोंगानाला एवं भंडारखोल
- बिरहोर जनजाति में शिक्षा संबंधी समस्या
- बिरहोर जनजाति की भाषा शब्दावली
- निष्कर्ष एवं सुझाव

प्रस्तावना- भारतीय जनसंख्या का 8.2 प्रतिशत भाग वनों पहाड़ों, दुर्गम क्षेत्रों में निवास करता है। इन क्षेत्रों में निवास करने वाले मानव समुदाय को सामान्यजन आदिवासी, आदिम जाति, जनजाति, वन्य जाति, आदि नामों से जानते हैं। यह आदि जातियां देश के प्रत्येक प्रांत में पायी जाती हैं। देश के उत्तर पूर्वी भाग में मंगोल प्रजाति के लक्षणों वाली ढेरों आदि जातियां अलग-अलग राज्यों में पायी जाती हैं। इसी प्रकार आदिवासियों का एक विशाल क्षेत्र देश के मध्य भाग में है जिनमें झारखंड, बिहार, छत्तीसगढ़, ओडिसा और मध्य प्रदेश राज्यों में इनकी जनसंख्या बहुतायत है।² भारत सरकार किसी भी समूह को आदिवासी करार देने के लिए जिन पांच संकेतकों का सहारा लेती है, वे निम्नलिखित हैं- आदिम लक्षण, विशिष्ट संस्कृति, भौगोलिक पृथक्करण, समाज के एक बड़े भाग से संपर्क करने में संकोच एवं पिछड़ापन का उल्लेख आदिवासी भारत पुस्तक में योगेश अटल जी ने किया है।

वर्तमान में जनजाति समाज में तीव्र गति से परिवर्तन हो रहे हैं, इसलिए आज के संदर्भ में पूर्णतः परिभाषित करना कठिन है तथापि जनजाति समुदाय कि कुछ विशिष्टताएँ होती हैं-

- जनजाति का एक नाम होता है।
- जनजाति परिवारों का एक समूह होता है।
- जनजाति की अपनी एक भाषा एवं संस्कृति होती है।
- एक सुनिश्चित भूभाग पर वितरण होता है।
- गोत्र एवं अंतर्विवाही समूह की विशेषता होती है।
- स्वतंत्र राजनीतिक संगठन होता है, जिसमें मुखिया सर्वोच्च होता है।

बिरहोर जनजाति- बिरहोर ऑस्ट्रो एशियाटिक प्रो ऑस्ट्रेलाइड परिवार की जनजाति है। बिरहोर दो शब्दों से मिलकर बना है। बीर+होर जिसका शाब्दिक अर्थ है, जंगल का आदमी। बिरहोर प्रारंभ से ही जंगलों में घुमंतू जीवन व्यतीत करते रहे हैं और जंगल में ही रहकर कंदमूल खाकर एवं बांसो से काशतकारी कर, रस्सी बनाने जैसे कार्य कर जीवन यापन करते हैं। ये रोटी और आवास के लिए आज भी संघर्ष कर रहे हैं। बिरहोर का घर कुंबा कहलाता है बड़े घर को कोड़ा कुंबा तथा छोटे घर कोचो कुंबा कहते हैं, ये पितृसत्तात्मक हैं इनका निवास टंडा कहलाता है।

छत्तीसगढ़- छत्तीसगढ़ प्राचीन काल में दक्षिण कोसल कहलाता था प्रसिद्ध चीनी यात्री ह्वेनसांग ने सिरपुर की यात्रा की थी। वर्तमान में ओडिशा, झारखंड, तेलंगाना, महाराष्ट्र,

मध्य प्रदेश एवं उत्तर प्रदेश इसकी राज्य सीमा बनाते हैं। यहां पर्वतीय एवं मैदानी क्षेत्रों की बहुलता है। रिहंद, हसदो, शिवनाथ, महानदी, इंद्रावती छत्तीसगढ़ के प्रवाहमान प्रमुख नदियां हैं। अधिकांश क्षेत्रों में लाल पीली मिट्टी पाई जाती है। वर्ष 2011 की जनगणना के अनुसार राज्य की साक्षरता दर 71.04 प्रतिशत है।

कोरबा- छत्तीसगढ़ में ऊर्जा राजधानी के रूप में जाना जाता है। यहां राष्ट्रीय स्तर की उद्योग स्थापित है। यहां के मुख्य निवासी आदिवासी हैं जो की कुल जनसंख्या आबादी का 51.67 प्रतिशत है।³ पाली विकासखंड स्थित डोंगानाला एवं भंडारखोल में बिरहोर जनजाति के लोग निवास करते हैं। इन गांवों में राऊत, मरार एवं तेली जाति के लोगों के साथ साथ धनवार, गोंड, सांवता एवं कंवर जनजाति के परिवार यहां निवास करते हैं। इन्हीं परिवारों की शिक्षा एवं भाषा की समस्या का अध्ययन उद्देश्य रहा है।

भाषा संरक्षण एवं संवर्धन के लिए गणेश एन. देवी ने महत्वपूर्ण बात कही है। हाशिए पर जा चुकी कई भाषाओं तथा कुछ प्रमुख भाषाओं में अपनी उन्नति के प्रति उदासीनता दिखाई देती है। बच्चों की बड़ी तादाद अत्याधिक फीस देकर अंग्रेजी माध्यम की स्कूलों में पढ़ रही है। जब कोई बच्चा किसी भारतीय भाषा माध्यम कि स्कूल में प्रवेश लेता है तो उसे एक सामाजिक पिछड़ेपन के रूप में देखा जाता है। इन परिस्थितियों में भाषाओं के संरक्षण का काम, विशेष रूप से ऐसी भाषाएं जिनके संरक्षण की नितांत आवश्यकता है, काफी चुनौतीपूर्ण है। यहां काम महज व्यवस्था संबंधी परिवर्तनों से संभव नहीं होगा।⁴

जाहिर बात है उक्त परिस्थितियों में जनजातियों के लिए शिक्षा और भाषा संवर्धन और ज्यादा कठिन कार्य होगा। तमाम शिक्षाशास्त्री एक मत है कि प्राथमिक शिक्षा का माध्यम मातृभाषा होना चाहिए क्योंकि मातृभाषा में पुस्तकें पढ़ने से छात्रों के सोचने समझने की क्षमता में वृद्धि होती है। वे ज्यादा क्रियाशील रहते हैं तथा अपनी भाषा संस्—ति से जुड़े भी रहते हैं।

बिरहोर जनजाति में शिक्षा संबंधी समस्या- शिक्षक किसी भी समाज के लिए अत्यंत आवश्यक होता है। शिक्षा का महत्व केवल नौकरी या व्यवसाय से ही नहीं होता बल्कि शिक्षा अपने आंतरिक और बाह्य जगत के संबंध में जानने का अवसर प्रदान करता है। जनजातियों में शिक्षा स्थिति जटिल समाज के समान एक स्वतंत्र चर के समान नहीं होती बल्कि वहां अनेक तत्वों से प्रभावित होती है। जैसे जटिल समाज में एक बालक या बालिका अपने शिक्षा संबंधी कार्य के अतिरिक्त अन्य कार्यों में संलग्न नहीं होते परंतु जनजातियों में जीवन निर्वाह व्यवस्था में परिवार के सभी सदस्य प्रत्यक्ष-अप्रत्यक्ष रूप से अपने घर के आर्थिक गतिविधियों में संलग्न रहते हैं।

अध्ययन किस भाग में अध्ययनित ग्राम की बिरहोर जनजाति की शैक्षणिक स्थिति को जानने का प्रयास किया है एवं इसके साथ ही बिरहोर जनजाति के बच्चों द्वारा अनुभव की जाने वाली शिक्षा संबंधित समस्याओं को जानने का प्रयास किया गया है।

बिरहोर बालक-बालिकाओं के परिवार की संरचना- अध्ययन के इस भाग में बिरहोर बालक-बालिकाओं की परिवारिक संरचना को जानने का प्रयास किया गया है। किसी भी परिवार का प्रकार, परिवार में भीड़-भाड़ की स्थिति बच्चों को घर में किस

प्रकार का माहौल मिलता होगा, पर बहुत अधिक निर्भर करता है। क्योंकि संयुक्त और विस्तृत परिवार में यदि आवास स्थल छोटा हो तो अध्ययन के लिए पर्याप्त और शांत स्थान मिलने की संभावना कम हो जाती है।

तालिका क्रमांक 01
बिरहोर बालक - बालिकाओं के परिवार की संरचना

क्रमांक	परिवार का प्रकार	आवृत्ति	प्रतिशत
01	एकल	22	62.9
02	संयुक्त	08	22.9
03	विस्तृत	05	14.2
	योग	35	100

बिरहोर बालक-बालिकाओं की आयु- अध्ययन के इस भाग में सामान्य जानकारी के रूप में अध्ययनित ग्राम की बिरहोर बालक-बालिकाओं की आयु स्थिति को जानने का प्रयास किया गया है। बढ़ती आयु के साथ समाज और संसार को समझने और जानने का अनुभव भी बढ़ते जाता है, जिसका प्रत्यक्ष प्रभाव शैक्षणिक स्थिति पर पड़ता है।

तालिका क्रमांक 02
बिरहोर बालक - बालिकाओं की आयु

क्रमांक	बिरहोर बालक-बालिकाओं की आयु	आवृत्ति	प्रतिशत
01	5-10	25	71.4
02	11-15	09	25.7
03	15-17	01	2.9
	योग	35	100

अध्ययन समुदाय में शाला त्यागी बच्चों की आयु का अध्ययन करने से एक अत्याधिक संवेदनशील स्थिति प्राप्त होती है। अध्ययन समूह के अधिकांश बच्चे केवल 5 से 10 वर्ष की आयु में ही शाला त्याग कर दिए हैं, जो उनकी संपूर्ण आयु के लिए अत्याधिक गंभीर समस्या है। जबकि द्वितीय क्रम में 25.7 प्रतिशत बच्चे 11 से 15 वर्ष की आयु में शाला त्याग किए हैं और 2.9 प्रतिशत बच्चे 15 से 17 वर्ष की आयु में शाला त्याग किया है। निश्चित रूप से इतने कम आयु में बच्चों द्वारा शाला त्याग करना प्रारंभिक स्तर पर उनमें शिक्षा संबंधी जागरूकता का उत्पन्न नहीं कर पाना है।

बिरहोर बालक-बालिकाओं का लिंगानुपात - आयु के समान अध्ययन के इस भाग में बिरहोर जनजाति के बच्चों के लिंग स्थिति को भी जानने का प्रयास किया गया है। हालांकि शिक्षा संबंधी कार्यों में लिंग कोई विशेष स्थान नहीं होता परंतु घर की गतिविधियों और आर्थिक क्रियाकलापों में लिंग का महत्वपूर्ण और प्रत्यक्ष प्रभाव पड़ता है, जहां एक ओर घर में बालिकाएं अपने घरेलू कार्य में संलग्न रहती हैं वहीं दूसरी ओर बालक घर की आर्थिक क्रियाकलापों में संलग्न रहते हैं जो बच्चों के शिक्षा और स्कूल से दूर होने का कारण हो सकता है।

तालिका क्रमांक 03 बिरहोर बालक - बालिकाओं का लिंगानुपात

क्रमांक	बिरहोर बालक-बालिकाओं की आयु	आवृत्ति	प्रतिशत
01	स्त्री	25	71.4
02	पुरुष	09	25.7
	योग	35	100

अध्ययन समूह में अधिकतम 65.7 प्रतिशत पुरुष और 34.3 प्रतिशत स्त्री है। जनजाति समुदाय के बालकों को अधिकांशतः अपने आर्थिक क्रियाकलापों में संलग्न रहना पड़ता है। परंतु जनजाति समुदाय की 35.3 प्रतिशत स्त्री जो शाला त्याग किए हैं, वह भी घर के विभिन्न प्रकार के कार्यों में संलग्न रहते हैं। इस प्रकार से बिरहोर जनजाति के बालक-बालिका दोनों शाला त्याग जैसे समस्या से जूझ रहे हैं।

बिरहोर बालक-बालिकाओं की परिवार की आर्थिक स्थिति- किसी भी परिवार की आर्थिक स्थिति उस परिवार के अन्य पक्षों को प्रत्यक्ष रूप से प्रभावित करती है। क्योंकि आर्थिक स्थिति से सामाजिक प्रतिष्ठा के निर्धारण, आवश्यकता की पूर्ति सभी तत्व निर्भर करता है। शिक्षा संबंधी खर्चों में भी जनजाति समुदाय अपने जीवन निर्वाही व्यवस्था के कारण खर्च का वहन नहीं कर पाते। इसके अतिरिक्त जनजातियों के जीवन निर्वाही अर्थव्यवस्था के कारण परिवार के सभी सदस्य कार्य करते हैं जिसमें बच्चे भी संलग्न रहते हैं। विशेषकर तेंदूपत्ता संग्रहण, चार संग्रहण, महुआ संग्रहण इत्यादि के समय, बच्चे लघु उत्पाद संग्रहण को शाला से अधिक महत्व देते हैं।

तालिका क्रमांक 04

बिरहोर बालक - बालिकाओं की परिवार की आर्थिक स्थिति

क्रमांक	बिरहोर बालक-बालिकाओं की आयु	आवृत्ति	प्रतिशत
01	निम्न	29	82.9
02	निम्न-मध्यम	06	17.1
	मध्यम	00	00
	योग	35	100

महत्वपूर्ण अध्ययन के रूप में शाला त्यागी बालक-बालिकाओं के घर की आर्थिक स्थिति को जानने का प्रयास किया गया है। क्योंकि आर्थिक स्थिति अन्य लगभग सभी आयामों को प्रभावित करती है। उपरोक्त तालिका से स्पष्ट है अध्ययन समुदाय के अधिकांश परिवार निम्न आयु वर्ग से संबंधित है, जिनका प्रतिशत 82.9 है, जबकि अन्य बच्चे निम्न-मध्यमवर्ग वाले परिवार से हैं। अध्ययन समूह का कोई भी परिवार मध्यम वर्ग से संबंधित नहीं है।

बिरहोर बालक बालिकाओं की माता-पिता की शैक्षणिक स्थिति- किसी भी परिवार में माता-पिता के प्रत्येक प्रकार के व्यवहार और योगदान का बच्चों पर प्रत्यक्ष-अप्रत्यक्ष प्रभाव पड़ता है। यदि माता-पिता शिक्षित हो तो वे बच्चों को भी शिक्षा संबंधी कार्यों के लिए उत्साहित करते हैं। परंतु जनजाति समुदाय में बच्चों के माता-पिता के अशिक्षित होने के कारण इनके इच्छा के आधार पर नहीं अपितु उनकी मजबूरी के कारण है। अनेक जनजातीय यदि पढ़ना भी चाहते हैं तो जंगल के विपरीत परिस्थितियों के कारण में पढ़ नहीं पाते हैं।

तालिका क्रमांक 05

बिरहोर बालक-बालिकाओं के माता-पिता की शैक्षणिक स्थिति

क्रमांक	बिरहोर बालक-बालिकाओं की आयु	आवृत्ति	प्रतिशत
01	निम्न	29	82.9
02	निम्न-मध्यम	06	17.1
	मध्यम	00	00
	योग	35	100

महत्वपूर्ण अध्ययन के रूप में शाला त्यागी बालक-बालिकाओं के घर की आर्थिक स्थिति को जानने का प्रयास किया गया है। क्योंकि आर्थिक स्थिति अन्य लगभग सभी आयामों को प्रभावित करती है। उपरोक्त तालिका से स्पष्ट है अध्ययन समुदाय के अधिकांश परिवार निम्न आयु वर्ग से संबंधित है, जिनका प्रतिशत 82.9 है, जबकि अन्य बच्चे निम्न-मध्यमवर्ग वाले परिवार से हैं। अध्ययन समूह का कोई भी परिवार मध्यम वर्ग से संबंधित नहीं है।

बिरहोर बालक-बालिकाओं के अनुसार उनके शाला त्यागने का कारण- अध्ययन के इस भाग में बिरहोर बालक बालिकाओं के द्वारा शाला त्यागने के कारणों को जानने का प्रयास किया है। जनजाति जीवन पद्धति में शाला त्यागने के अनेक कारण हो सकते हैं जिसमें उनकी जीवन निर्वाही अर्थव्यवस्था महत्वपूर्ण कारण हो सकती है।

तालिका क्रमांक 06

बिरहोर बालक-बालिकाओं के अनुसार उनके शाला त्यागने का कारण

क्रमांक	बिरहोर बालक-बालिकाओं के अनुसार शाला त्यागने का कारण	आवृत्ति	प्रतिशत
01	आर्थिक समस्या	10	28.6
02	किसी विषय से डर लगना	08	22.8
03	पाठ्यक्रम समझ नहीं आना	10	28.6
04	घर में छोटे भाई बहनों की देखरेख करना	03	8.6
05	घर के काम में हाथ बंटाना	04	11.4
	योग	35	100

तालिका क्रमांक 07 से स्पष्ट होता है कि बिरहोर जनजाति के बच्चों में शाला त्यागने के अलग-अलग कारण प्राप्त हुए हैं। अध्ययन समुदाय के अधिकांश बालक बालिकाएं समान प्रतिशत 28.6 प्रतिशत में अपने शाला त्यागने का कारण आर्थिक समस्या और पाठ्यक्रम की समझ में नहीं आना को मानते हैं। जबकि 22.8 प्रतिशत बच्चे किसी ना किसी विषय के प्रति अपने डर को अपने शाला त्यागने का कारण मानते हैं। जिसमें अधिकांशतः गणित और अंग्रेजी जैसे विषय हैं। जबकि घर में छोटे भाई-बहनों की देखरेख करना, घर के काम में हाथ बंटाने को भी अपने शाला त्यागने का कारण मानते हैं।

बिरहोर जनजाति की शब्दावली- गोत्र एवं उनसे संबंधित टोटम शब्दावली

गोत्र	गण चिन्ह
बादी	बरगद पेड़
गंधेर	शेर
बाड़ी	मछली
कोसोंदी	कोसा पेड़
सोनवानी	स्वान

बिरहोर नामकरण शब्दावली-

नाम	कारण अथवा आधार
समारू राम	सोमवार को जन्म होने के कारण
मंगलू	मंगलवार को जन्म होने के कारण
बुधराम	बुधवार को जन्म होने के कारण
गुरुवारिन बाई	गुरुवार को जन्म होने के कारण
इतवारिन बाई	इतवार को जन्म होने के कारण
चौतराम	चौत माह में जन्म होने के कारण
फागुनी बाई	फागुन माह में जन्म होने के कारण
सावन साय	सावन माह में जन्म होने के कारण
कार्तिक राम	कार्तिक माह में जन्म होने के कारण
बिहानी बाई	सुबह जन्म होने के कारण

जानवरों व पक्षियों के लिए प्रयुक्त शब्दावली-

हिंदी	बिरहोरी	हिंदी	बिरहोरी
गाय	ऊरी	बैल	बैल
भैंस	भैंसा	बछड़ा	बेलाती
सांड	सोड़ाती	कुत्ता	सेता
बिल्ली	मुनु	शेर	कुला

पेड़ों- पौधों की शब्दावली

हिंदी	बिरहोरी	हिंदी	बिरहोरी
पीपल	पीपर	नीम	लीम
बांस	माइन, माऊ	सरई (साल)	सरजोम
सागौन	सगतान	केला	केरा
पपीता	पपीता	आम	ऊली

दैनिक बोलचाल में उपयोग होने वाली शब्दावली-

हिंदी	बिरहोरी	हिंदी	बिरहोरी
पानी	दाअ	आग	सिंगेल
हवा	होयतांते	मिट्टी	आसा
जंगल	बीर	आसमान	बादर
पेड़	घारू	घास	मरचा

गृहस्थी की शब्दावली

वस्तु का नाम	निर्मित सामग्री का नाम	वस्तु का उपयोग
चटाई	पत्ते से निर्मित	बैठने अथवा सोने हेतु उपयोगी
लोटा	एल्युमिनियम से निर्मित	पानी रखने व पीने हेतु उपयोगी
सूपा	बांस से निर्मित	अनाज साफ करने हेतु
टोकरी	बांस से निर्मित	अनाज रखने हेतु
चलनी	लोहे से निर्मित	अनाज साफ करने हेतु
थैला	रस्सी से निर्मित	सामान रखने हेतु
चिमनी	शीशी से निर्मित	प्रकाश व्यवस्था हेतु
झाड़ू	पत्ते से निर्मित	सफाई कार्य हेतु
बाल्टी	लोहे से निर्मित	पानी भरने हेतु
चिमटा	लोहे से निर्मित	आग पकड़ने हेतु
गिलास	एल्युमिनियम से निर्मित	पानी पीने हेतु
डूआ	एल्युमिनियम से निर्मित	भोजन निकालने हेतु

बिरहोर भाषा में प्रचलित शब्दावली का हिंदी शब्दार्थ

बिरहोरी भाषा	हिंदी अर्थ	बिरहोरी भाषा	हिंदी अर्थ
हुरू	धान	घैला	मिट्टी का घड़ा
मांडी	चावल से बना भात	नाहैर	हल
माई	माता	आपु	पिता
दाई	दादी	झाड़ी होरमी	गर्भवती महिला
राडी	विधवा	हनहर	सांस
होईहार	ससुर	कोंदा	गूगा लड़का
पटिया	चटाई	किचरी	कपड़ा
सेता	कुत्ता	पोखरा	तलाब
बिहागीत	विवाह का गीत	खोदा	गेदना
चुरी	हाथ का गहना	बुरु	पहाड़

निष्कर्ष- जनजाति समाज की जीवन शैली सामान्य ग्रामीण जनों और शहरों में निवास करने वाले व्यक्तियों के जीवन शैली से अलग होती है अतः मुख्यधारा में लाने के लिए उनकी संस्कृति और रीति-रिवाजों को ध्यान में रखकर पाठ्य सामग्री तैयार की जानी चाहिए। यदि उन्हें गणित सिखानी हो तो उनके यहां प्रचलित खेलों के माध्यम से सिखाया जा सकता है इतिहास में उनके नायक, समाज और संस्कृति से जुड़े पाठ तैयार किए जाने चाहिए। जनजाति में शिक्षा तथा उनकी भाषा को समृद्ध करने के लिए पारंपरिक लोक साहित्य, लोक संगीत, पारंपरिक खेलों से उन्हें जोड़ा जाए जिससे उनकी रूचि पठन-पाठन में बने। इस अध्ययन के दौरान देखा गया है कि बिरहोर जनजाति के बालकों में शिक्षा के प्रति लगाव ना होने का कारण पाठ्यक्रम एवं सामग्री का उनकी भाषा-बोली एवं संस्कृति से भिन्न होता है। अतः आवश्यकता इस बात की है उनकी बोली को व्याकरण शब्दकोश तथा लिपि के माध्यम से व्यक्त किया जाए। उनके लोक गीत, लोक कथा दृश्यश्रव्य माध्यम से संरक्षित कर उनके समक्ष प्रस्तुत किया जाए।

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भारतीय साहित्य

विविध रूप विविध रंग



सम्पादक

डॉ. गिरजाशंकर गौतम

भारतीय साहित्य

विविध रूप, विविध रंग

डॉ. गिरजाशंकर गौतम

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अन्नपूर्णा प्रकाशन

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शोध सार :

समाज में मनुष्य की संरचना मुख्यतः लैंगिक संरचना के आधार पर ही होती है समान्यतः स्त्री और पुरुष। पर इन दोनों वर्गों से इतर, यह लैंगिक विभेदीकरण जहाँ सर्वाधिक क्रूर है वह पायदान है तीसरा वर्ग जिसे समाज ने थर्ड जेंडर, तृतीय लिंग या ट्रान्सजेंडर की संज्ञा दी है। एक ऐसा वर्ग जिसके असामान्य जीवन को समाज और अधिक क्रूर बना देता है। यह वर्ग न तो पूर्णरूपेण स्त्री है न ही पुरुष। सामाजिक सक्रियता और भागीदारी, विकासात्मक अवसरों की दृष्टि से यह वर्ग पूर्णतया बहिष्कृत या हाशिये पर रहा है। इस वर्ग की संवेदना को समझने की कोशिशों में मानवता अभी कोसों दूर खड़ी हुई है, कुछ यूँ कि वे नगण्य हो, अनुपस्थित हो। ऐसे में हिन्दी साहित्य की शीर्षस्थ महिला रचनाकार चित्रा मुद्गल का सद्य प्रकाशित उपन्यास 'पोस्ट बॉक्स नं. 203 नालासोपारा' है जो लोगों का इस विषय की ओर ध्यान आकर्षित करता है। इस उपन्यास को सन 2018 में 'साहित्य अकादमी' पुरस्कार से नवाजा गया था।

बीज शब्द : इंटरसेक्स -अन्तःलिंगी, इथनोग्राफी - नृवंशविज्ञानी,

प्रस्तावना :

लिंग का निर्धारण जीववैज्ञानिक स्थिति के अनुसार जन्म से होता है। प्राथमिक स्तर पर लिंग का निर्धारण शारीरिक संरचना अर्थात् शुक्राणु, हॉर्मोन की अवस्थिति तथा बाहरी एवं आंतरिक एनाटोमी से होता है। किसी व्यक्ति के पुरुष या स्त्री के रूप में पहचाने या परिभाषित किए जाने के लिए स्पष्ट यौनांग आवश्यक है। इसके लिए जननांग की अनियमितता महत्वपूर्ण है। ऐसे मानव हिजड़े कहे जाते हैं जो लैंगिक रूप से न नर होते हैं न मादा। नृवंशविज्ञानी (इथनोग्राफी) नन्दा अपनी प्रसिद्ध पुस्तक नाइदर मेन नॉर बुमेन (1990) में स्पष्ट कहते हैं- 'स्वयं किन्नर भी अपने आपको न तो आदमी और न ही औरत के रूप में स्वीकारते हैं बल्कि उनका मानना

है कि महिला-पुरुष द्विधारी के मध्य में कहीं न कहीं एक जमीन ईश्वर ने बनाया है, जहाँ स्त्रीत्व और पुरुषत्व की गहरी जड़ें सांस्कृतिक निर्माण के द्वारा प्रतिबंधित हैं। अधिकांश हिजड़े शारीरिक रूप से नर होते हैं या अन्तःलिंगी (इंटरसेक्स) किन्तु कुछ मादा भी होते हैं।'

मूल शोध आलेख :

हिन्दी साहित्य जगत की समकालीन महिला साहित्यकार चित्रा मुद्गल द्वारा रचित उपन्यास 'पोस्ट बॉक्स नंबर-203 नालासोपारा' किन्नर वर्ग की दास्तां बयान करता है। यह उपन्यास समाज में उपेक्षित किन्नरों की वेदना, दुश्चारियाँ और परिवार-समाज में उनके प्रति नज़रिये की अंतर्कथा है। लैंगिक विकृति से ग्रस्त शिशु का अस्तित्व परिवार के लिए अवांछनीय बोझ ही नहीं त्याज्य हो जाता है। "आज सभ्यता के सोपान में मनुष्य अपना मानवीय मूल्य खो चुका है। संवेदनहीनता, आत्मकेंद्रीयता और स्वार्थ के चलते गैर लोग ही नहीं, परिवार के सदस्य ही एक दूसरे को हिकारत की नज़र से देखते हैं। सभ्यता के विकास की विडम्बना है कि इसके मूल में दोहरे मूल्यों के बीच जीने की अभिशप्त प्रवृत्तियाँ विद्यमान हैं। आदमी के रूप में मनुष्य को गरिमा से जीने का अधिकार स्वतः ही मिल जाता है, जिसे कोई व्यवस्था, नीति, कानून नहीं छीन सकता लेकिन समाज की परम्पराएँ और समुदाय द्वारा रूढ़ियों के चलते उन्हीं के जैसा व्यक्ति अलग-थलग छोड़ दिया जाता है। रिश्ते-संबंध, जो जीवन को अर्थ, स्थिरता और मकसद प्रदान करते हैं, अवसर मिलते ही रूढ़ियों, लोकापवाद, असुरक्षा की आकांक्षा से हाशिये पर ढकेल दिये जाते हैं जिसके दंश और अपराधबोध में जलना दोनों ही पक्षों की नियति बन जाती है।"⁽¹⁾ उपन्यास का कथानक ये है कि एक मध्यवर्गीय गुजराती परिवार में विनोद शाह का जन्म होता है। तीन भाइयों में विनोद मंझला है। वह पढ़ाई में बहुत तेज़ है। अंतर्राष्ट्रीय गणितज्ञ बनने की उसमें प्रतिभा है। परंतु जब वह 11-12 साल का होता है, तब उसके व्यक्तित्व विकास में परिवर्तन दिखाई पड़ता है, उससे



यह स्पष्ट हो जाता है कि न वह पुरुष है और न ही स्त्री। पुरुष होते हुए भी उसमें स्त्रियोचित बातें विकसित हो रही हैं। विनोद के पिता एक प्रतिष्ठित गुजराती व्यापारी हैं। विनोद शाह के इस लिंग-दोष से वे काफी परेशान हैं। उनमें इतनी हिम्मत नहीं है कि वे इस सत्य को स्वीकारें। एक रोज चम्पाबाई विनोद को अपने गिरोह में शामिल करने साथ ले जाती है। परिवार वाले उसके किन्नर होने से होने वाली बदनामी से बचने के लिए दुर्घटना में उसकी मौत होने की झूठी खबर फैला देते हैं। पर विनोद की माँ एक आम भारतीय नारी है, बेटे के चले जाने का अत्यधिक दुख वह झेलती है। वह किसी भी स्थिति में यह नहीं चाहती थी कि विनोद उससे दूर हो जाए। परंतु पितृसत्तात्मक व्यवस्था में स्त्री की भावनाओं की कब कद्र की गई है?

चम्पाबाई कुछ दिन तो विनोद शाह को अपने किन्नर दल में रखती है। बाद में वह दिल्ली के सरदार को उसे बेच देती है। वहाँ के उसके जीवन से ही उपन्यास की शुरुआत होती है। उस दुर्गम जीवन को जीते हुए विनोद उर्फ बिन्नी उर्फ बिमली अपनी आर्तनाद अपनी बा को लिखकर कहता है - “कभी-कभी मैं अजीब सी अंधेरी बंद चिमगादड़ों से अटी सुरंग में स्वयं को घुटता हुआ पाता हूँ। बाहर निकलने को छटपटाता मैं मनुष्य तो हूँ न! कुछ कमी है मुझमें इसकी इतनी बड़ी सजा! ऐसी मनःस्थिति में मेरी आँखों में खारा पानी नहीं, खून टुकने लगता है बा! गालों और गले पर कत्थई लकीरें गहरी और गहरी नहरों की तरह खुद जाती हैं। जो कभी सूखती नहीं, न खाली होती हैं। जब उन्हें ऊपर दिखाना होता है, तभी दिखती हैं एहसास कराने के लिए कि अपने कत्थई गीलेपन को मेरी अँगलियाँ छू सकें। नहीं दिखना होता है तो वो गायब हो मेरे जिस्म के अधूरे हिस्से में जाकर जम जाती हैं। अंधेरा पिए हुए काली बर्फ की तरह। यह खेल स्वयं मेरी समझ में नहीं आता। यह कौन सा तिलस्म है बा! हैरत में हूँ... सबने मुझसे मुंह मोड़ लिया सपनों ने मुंह नहीं फेरा। आज भी वे मेरे पास बेरोक-टोक चले आते हैं। अंधेरा पिए हुए काली बर्फ को मंझाते।”⁽²⁾ लेखिका की लेखनी इतनी गहराई लिए हुए है कि उपन्यास को पढ़ते-पढ़ते पाठक खुद जैसे उस जीवन का हिस्सा बन जाता है। किन्नर जीवन का चित्रांकन बहुत ही गहराई से किया गया है। साथ ही बिन्नी और बा के पत्राचार से कठिन परिस्थितियों में भी रिश्तों को जोड़ कर रखने का अथक प्रयास इस उपन्यास के माध्यम से पाठकों को सीखने मिलता है।

बिन्नी किसी तरह की बेचारगी से चिपके नहीं रहना चाहता था। अतः वह दिल्ली में अपने सरदार के दोस्त जो विधायक पद पर थे से कहता है- “सर, मैं जिन तिरस्कृत स्थितियों में जी रहा हूँ, उन्हीं स्थितियों में जीते हुए, संघर्ष

करते हुए पढ़ना चाहता हूँ।”⁽³⁾ विनोद की आरंभिक पढ़ाई अँग्रेजी माध्यम से हुई थी। अँग्रेजी, गुजराती और हिन्दी पर उसका अधिकार था अतः विधायक उसे तुरंत अपने यहाँ नौकरी पर रख लेते हैं। साथ ही एन.आई.टी. बेसिक कम्प्यूटर प्रोग्राम में उसका दाखिला भी हो जाता है। बिन्नी ‘किन्नर’ शब्द से बहुत विचलित होता है। वह पत्र में लिखता है- “बस की बाट जोहते हुए मैं सोचता रहा बा। किन्नर शब्द सुनते ही अवमानना न चाहते हुए भी क्यों सुलग उठती है। सुनने में किन्नर शब्द भले गाली न लगे मगर अपने निहितार्थ में वह उतना ही क्रूर और मर्मांतक है, जितना हिजड़ा। किन्नर की सफ़ेदपोशी में लिपटा चला आता है, उसकी ध्वन्यात्मकता में रचा-बसा। कोई भूले तो कैसे भूले? सुना नहीं था जब तक यह सम्बोधन, अपने लिए कोई ग्रंथि अंकुआई ही नहीं थी। जिस दिन चम्पाबाई के सुपुर्द कर दिया गया, कसाईखाने के कपाट खुल गए। गाली हो गया मैं। हिजड़ा, हिजड़ा, हिजड़ा! गालियों की गाली। किन्नर कह देने भर से नासूर छटक जाएंगे देह से?”⁽⁴⁾ हिजड़ा... सच कहें तो समाज में यह शब्द गाली की भांति इस्तेमाल किया जाता है। हिजड़ा शब्द का क्या अर्थ है। हिजड़ा शब्द मूलतः उर्दू का शब्द है। यह अरबी भाषा के ‘हिजर’ से आया हुआ है। हिजर का अर्थ है जिसने अपना वर्ग छोड़ दिया हो या जिसे उसके वर्ग से बाहर निकाल दिया गया है, अर्थात् स्त्री-पुरुष से अलग होकर समाज में स्वयं को स्वतंत्र रूप से जीने वाला वर्ग किन्नर कहलाता है। उपन्यास में बिन्नी अपने किन्नर होने के सकारात्मक पहलुओं पर दृष्टि डालते हुए कहता भी है- “जननांग विकलांगता बहुत बड़ा दोष है लेकिन इतना बड़ा भी नहीं कि तुम मान लो कि तुम धड़ का मात्र वही निचला हिस्सा भर हो। मस्तिष्क नहीं हो, दिल नहीं हो, धड़कन नहीं हो, आँख नहीं हो। तुम्हारे हाथ-पैर नहीं हैं। हैं, हैं, हैं... सब वैसा ही है, जैसे औरों के हैं। यौन सुख लेने देने से वंचित हो तुम, वात्सल्य सुख से नहीं! सोचो। बच्चे तुम पैदा नहीं कर सकते मगर पिता नहीं बन सकते, यह किसने नहीं समझने दिया तुम्हें? सुनो-पहचानो उन्हें। अपने श्रम पर जीओ। मनोरंजन की दक्षिणा पर नहीं। हिकारत की दक्षिणा ज़हर है ज़हर। तुम्हें मारने का ज़हर। तुम्हें समाज से बाहर करने का ज़हर।”⁽⁵⁾ वह किन्नर गिरोहों से नफरत करता है जो ढूँढ-ढूँढकर नए किन्नरों को अपनी जमात में लेते हैं और अपने जैसों का एक दल बनाकर उन्हें किन्नरों के वही पुराने नाच-गाने के काम करने पर मजबूर कर रहे हैं। वह कहता है- “कोसता मैं उन लोगों को भी हूँ बा, जिन्होंने मुझे हाशिये के इस नरक में बिताभर जगह टिकने के लिए मुहैया



की है लेकिन इस सच से भी मुँह कैसे मोड़ लूँ और मोड़ भी नहीं पाता कि मेरी इस दुर्गति के पीछे उन्हीं का हाथ है। यह भीतर से खोखले और डरे हुए लोगों की जमाते हैं। ये चाहते हैं, जिस विशेष परिभाषा से उन्हें मंडित किया गया है, उसी रूप में ही सही, उनकी भी एक संगठित उपस्थिति समाज में बने। उनकी ताकत में इजाफा हो। दूँढते फिरते हैं जनाएंगी विकलांगों को, इसीलिए। कहीं से कोई टोह मिल जाए। गुरु परंपरा से दीक्षित कर बनाए रखना चाहते हैं उस एकता को जो उन्हें आपस में जोड़े रहे।”⁽⁶⁾ बिन्नी अपने सरदार के कभी पाँव नहीं पड़ता। उसका मानना था कि असामाजिक तत्वों के हाथ की कठपुतली बनने में जितनी भूमिका किन्नरों के संदर्भ में सामाजिक बहिष्कार-तिरस्कार की रही है, उससे कम उनके पथभ्रष्ट निरंकुश सरदारों और गुरुओं की नहीं। ऊपर से विकल्पहीनता की कुंठा ने उन्हें आँधी का तिनका बना दिया।

यह सर्वविदित है कि राजनीति और राजनैतिक लोग हाथी का आचरण अपनाते हैं। दिखाने के दाँत और खाने के दाँत और विनोद की प्रतिभा, भाषा पर उसका अधिकार, स्पष्टवादिता, विनम्रता आदि से प्रभावित होकर विधायक उसे किन्नरों का संगठन करने के लिए उकसाते हैं या यूँ कहें कि विनोद उर्फ बिन्नी का अपनी राजनीति के लिए, अपनी पार्टी के लिए उपयोग करना चाहते हैं। बिन्नी इस चुनौती को स्वीकारता है। चंडीगढ़ में किन्नरों की एक बड़ी सभा आयोजित की जाती है। वहाँ बिन्नी पार्टी के एजेंडा से हटकर किन्नरों के माँ-बाप को उन्हें घर वापस बुलाने की अपने मन की बात सभा से कहता है। वह कहता है- “मैं सरकार से अपील करता हूँ इस सभागार में, लिंग बिरादरी की घर वापसी को वह सुनिश्चित करे। कानून बनाए। बाध्य करे अभिभावकों को। घर से बहिष्कृत बच्चों को वह जिस भी उम्र के पड़ाव में हों, अपने साथ रखें। प्रचार करे, अखबारों, चैनलों और आकाशवाणी पर विज्ञापनों के माध्यम से। उनकी चेतना को झकझोरे, ताकि भविष्य में कोई माता-पिता लोकपवाद के भय से लिंग दोषी औलाद को दर-दर की ठोकरें खाने के लिए घूरे पर न फेंके।”⁽⁷⁾ बिन्नी को लिंग-दोषी समुदाय का ताली पीट-पीटकर भीख मांगना नागवार लगता है। बिन्नी अपने ही समुदाय की किन्नर पूनम जो उससे कहीं-न-कहीं प्रेम करती है से भी कहता है- “किसी नुक्कड़ पर आलू के पराठों का ठेला लगाकर खड़ी हो जाओ। धुआंधार बिक्री होगी तुम्हारी। लाइन लग जाएगी मोहन बाबा नगर तक ग्राहकों की। ढेरों कमाओगी गिनते नहीं बनेगा तुमसे। एक और काम करना। समय निर्धारित कर लेना। सुबह नाश्ते का समय सात से नौ, रात्रि भोजन सात से दस। देखना, कामकाजी कुंआरों का ही भला नहीं होगा, गृहस्थ भी अपने बाल बच्चों

समेत आकर खाएँगे, बंधवाकर ले जाएंगे। तुम्हारी ख्याति दिग-दिगंत तक फैलेगी। प्रेस और इलेक्ट्रॉनिक मीडिया वाले आकर तस्वीरें लेंगे। बेरोजगारों को आत्मनिर्भरता का पाठ पढ़ाएंगे। अपना काम करने में शर्म कैसी। शर्म तो... शर्म तो सड़क पर ताली पीट-पीटकर भीख मांगने पर आनी चाहिए।”⁽⁸⁾ बिन्नी के कहने पर ही उसने अपने जुबान पर हर समय होती गालियों का प्रयोग करना छोड़ दिया। बिन्नी भी उसके सकारात्मक स्वभाव का मुरीद है। वह उसमें किन्नरों की मनःस्थिति को खुद अपने में बदलने की कोशिश को परिलक्षित होते हुए देखता है। वह कभी-कभी अचंभित भी होता है कि त्रिशंकु अवस्था में जीने से इंकार कर पूनम ने स्वयं अपना लिंग अपनी मर्जी से निर्धारित कर लिया है। अपनी बा से वह कहता है- “मुझे तो लगता है बा! ईश्वर ने उसे बालिका भ्रूण के रूप में ही उसकी माँ की कोख में स्थापित किया होगा। बस चूक हो गई उससे, उसकी योनि गढ़ने में।”⁽⁹⁾ विधायक का भतीजा न्यूजसी से अपना जन्मदिन मनाने दिल्ली आ रहा था और अपने सभी सहपाठियों से मिलने को इच्छुक था। अतः विधायक जी की इच्छा थी कि होने वाले कार्यक्रम में बच्चों के मन-मुताबिक डीजे-शो तो रहे ही मगर आधे-पौने घंटे के लिए कुछ शास्त्रीय नृत्य-गायन का भी रंगारंग कार्यक्रम हो, ताकि देश की किशोर और युवा पीढ़ी अपनी संस्कृति की शास्त्रीयता से परिचित हो सके। अतः बिन्नी के तारीफ करने पर कथक नृत्य के लिए पूनम को बुलाया जाता है। नृत्य के बाद जब वह कपड़े बदलने जाती है तब विधायक का भतीजा और उसके चार दोस्त उसे अपनी दिल देहला देने वाली वासना का शिकार बनाते हैं और वह मौत के बेहद निकट चले जाती है।

बिन्नी ने चंडीगढ़ के किन्नरों के अधिवेशन में जो घर-वापसी का आह्वान किया था, उसका प्रसारण सभी राष्ट्रीय-चैनलों पर हो जाता है। इधर मुंबई में बिन्नी की माँ जीवन की अंतिम घड़ियाँ गिन रही हैं। वह अंतिम समय में बिन्नी से मिलने की इच्छा प्रकट करती है। बिन्नी हवाई जहाज से निकल जाता है। “17वीं चिड्डी तक उपरोक्त सम्पूर्ण कथा विकसित होती जाती है। यह चिड्डी खत्म होते ही लेखिका उपस्थित हो जाती है और पाठकों से निवेदन करती है कि वे 17.12.2011 के ‘टाइम्स ऑफ इंडिया’ इस अंग्रेजी अखबार के प्रथम पृष्ठ पर छपे समाचार को पढ़ें। समाचार 1 के अंतर्गत विनोद शाह की माँ वंदनाबेन शाह का एक वक्तव्य छपा है जिसमें वो विनोद को घर वापसी का आग्रह करती हैं और यह जानकारी भी देती हैं कि उसके पिता हरीश शाह ने अपनी समूची संपत्ति को अपने तीनों बेटों में समान रूप से बाँट दिया है। बा ने अपने इस अंतिम पत्र में यह इच्छा भी



व्यक्त की है कि उसके तीनों बेटे उसकी मृत्योपरांत उसे मुखाग्रि दें।⁽¹⁰⁾ ये वही बा है जो कभी बिन्नी को एक 'महान गणितज्ञ' के रूप में देखने के सपने देखा करती थी। अपनी चुप्पी के लिए स्वयं को कोसती थी। वह कहती है- 'कैसे कहूँ दीकरा कि मेरा सपना कहाँ अस्त हो गया। क्यों नहीं रोक पाई मैं उस सपने को अस्त होने से। जटिल प्रश्नों को हल करने की इजाज़त मुझे नहीं है। किसी के भी सामने। शपथ नहीं दी गई है। मानकर ही चला जाता है, झूठ को सच मानकर स्वीकार करना होगा। स्वीकार करती चली आई हूँ। अब वह विवशता नहीं लगती। प्रकृति का हिस्सा बन गया है मेरी। फिर द्वंद्व को भी मन के अदेखे कोने-अंतरों में उठने की इजाज़त नहीं होनी चाहिए। उठ भी आते हैं तो क्या! किसी नतीजे से जुड़ पाने का साहस कहाँ जुटा पाते हैं। इसलिए कि स्त्री के अंतर्प्रकोष्ठों का वातावरण औरों की भंगिमाओं और भृकुटियों से निर्मित होता है। संज्ञाविहीन होती है, स्त्री। उसके नाम नहीं होते। मुखौटे होते हैं। गुहारने और हस्ताक्षर करने भर के लिए। यह सच होते हुए भी उसके तलछट का सत्य कुछ और है। स्त्री खुद भ्रम में है। उसके पास अपनी संज्ञा है। उसकी काया के भीतर जो एक अदद कोख है, वही उसकी संज्ञा है। बा, शब्द का है कोई पर्याय? उससे बड़ा वजनी। किसी तराजू पर न तुलने वाला। तुझे मरा हुआ करार दे दिया गया। तू सबके लिए मर गया। मेरे लिए भी मर गया? अपनी कोख की संज्ञा से मैंने पलायन करने की हिमाकत की। आखिर क्यों?'⁽¹¹⁾ बिन्नी की माँ आखिर में अपने किए का प्रायश्चित करती है और एक अविस्मरणीय कदम उठाते हुए अपने किन्नर बेटे की चिट्ठियों के दर्द, टूटन, जटिल जीवन के लिए उससे माफी मांगती है। अब उसे न समाज का डर है, न रिशतेदारों का। वह अपने बेटे को घर वापस बुला रही है। वही घर जिसने उसे मरा हुआ करार दिया था। लेकिन नियति की लेखनी मनुष्य की सोच से भी परे होता है। 27 दिसम्बर के ही दिन इटाइम्स ऑफ इंडियाफ में एक और समाचार छपता है। मुंबई में कुर्ला कालीन कॉम्प्लेक्स से लगी हुई मीठी नदी में पुलिस ने एक किन्नर की फूली हुई लाश बरामद होती है। शव की शिनाख्त नहीं हो पाई है। सिर बुरी तरह से कुचला हुआ है। बिन्नी अपनी माँ को मुखाग्रि नहीं दे पाता। चंडीगढ़ के बिन्नी के भाषण से किन्नरों का पारंपरिक व्यवसाय खतरे में आ जाता है। किन्नर शायद घर लौटेंगे। इसलिए किन्नरों का व्यापार करने वाले सरदार लोग सकते में आ जाते हैं। आपसी रंजिश के चलते हत्या का संबंध इन दिनों अंडरवर्ल्ड में सक्रिय 'मुन्नाभाई' किन्नर गिरोह से होने का अनुमान है।

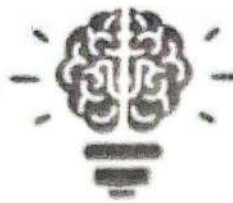
निकर्ष :

जो चेहरा सामने आकर किन्नरों की पारंपरिक व्यवस्था-तंत्र को बदलने की हिम्मत करता है, उसकी हत्या कर दी जाती है। एक ज़बान जो किन्नरों के हक के लिए खुल रही थी उसपर हमेशा के लिए ताला लगा दिया जाता है। प्रश्न यह उठता है कि जब मूक, बधीर, दृष्टिबाधित या दूसरी विकलांगताएँ समाज में सद्य है तो कमर से नीचे की विकृति क्यों त्याज्य मान ली जाती है? उपन्यास विनोद उर्फ बिन्नी के माध्यम से समाज में लंबे समय से चली आ रही प्रतिष्ठा के थोथे चलन का प्रतिरोध करता है, जिसके कारण मनुष्य का उपहास, उसकी उपेक्षा उसकी दैहिक विकृति के लिए किया जाता है। उपन्यास में समाज की निस्संगता, अमानवीयता पर गंभीर रूप से विचार किया गया है कि मनुष्य की चिंताएँ इतनी आत्मकेंद्रित क्यों हो गई है? उपन्यास का प्राप्य यही है कि वह पाठक को अपने व्यक्तित्व की सीमाओं से बाहर निकलकर अनुभूति के वृहत्तर संसार से जोड़ता है। किन्नरों के एक अंग नहीं होने से उन्हें मनुष्य ही नहीं समझना गलत है। वह भी प्रकृति द्वारा निर्मित एक मनुष्य है जिसके पास एक अदद मस्तिष्क है, भावनाएँ हैं जो उसे समाज में बाकी वर्गों की तरह समान रूप से जीवन जीने का हक दिलाता है और दिलाता रहेगा।

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**साहित्य में वसंत का औषात्य
एवं प्रकृति का वैविध्य**

प्रो. डॉ. अनुसुइया अग्रवाल

1

इस पुस्तक के सर्वाधिकार सुरक्षित हैं। प्रकाशक की लिखित अनुमति के बिना इस पुस्तक या इसके किसी भी अंश का किसी भी माध्यम से अथवा ज्ञान के संग्रहण एवं पुनर्प्रयोग की प्रणाली द्वारा, किसी भी रूप में, पुनरुत्पादित अथवा संचारित-प्रसारित नहीं किया जा सकता, इसे संक्षिप्त, परिष्कृत कर प्रकाशित करना कानूनी अपराध है।

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सारांश - स्वातंत्र्योत्तर साहित्य में जीवन - मूल्य में तेजी से बदलाव आया है। परंपरा से आधुनिकता का सफर तय कर रही पीढ़ी के नैतिकता, धर्म, प्रेम, आस्था आदि मानवीय मूल्य के मानदंडों में परिवर्तन दिखाई देता है। महिला साहित्यकारों ने नारी मन के कोनो को परत-दर-परत खोला है, जिसमें उनकी समस्याओं, वेदनाओं व यातनाओं के साथ-साथ कोमल मनोवृत्तियों का भी विश्लेषण कर प्रस्तुत किया है। इन कोमल मनोवृत्ति में सर्वप्रमुख है- 'प्रेम'। प्रेम - निरूपण साहित्य में प्राचीन काल से ही दिखाई देता है। जो साहित्य की प्रत्येक विधा में दृष्टिगोचर होता है। कुसुम अंसल के उपन्यास 'एक और पंचवटी' के केंद्र में है- वासंती रंग। यह वसंत का औदात्य ही था कि साध्वी का विक्रम के प्रति प्रेम परिणति तक पहुंच जाता है, यहां से कथा नया मोड़ लेती है और प्रेम की पराकाष्ठा का एक नया समीकरण इस उपन्यास में मिलता है।

*** विषय प्रवेश*** - कुसुम अंसल मनुष्य की ऐकांतिक अनुभूति की साधक है। व्यक्ति व समाज के यथार्थ का चित्र व्यक्ति के अंतर्निहित संवेदना की आधार भूमि पर रखते हुए आगे बढ़ती हैं। संवेदनशीलता को परिवेश की, रचना की जरूरत निर्मित करते हुए कल्पना में यथार्थ का समन्वय करती हैं। कुसुम अंसल के उपन्यास में आधुनिकता के आयाम दिखाई देते हैं, परंतु 'एक और पंचवटी' में वासंती रंग की अभिव्यक्ति हुई है। वसंत का रंग अर्थात् प्रेम का रंग। इसके संबंध में राजकिशोर का कहना है "और, दुनिया के सभी हिस्सों के लिए वसंत का संदेश एक जैसा ही है। हिंदू धर्म के नये प्रेमियों की क्लास लगाकर विद्यानिवास मिश्र और राममूर्ति त्रिपाठी जैसे विद्वानों को यह समझाना ही चाहिए कि प्राचीन भारत के लोकप्रिय उत्सवों में एक मदनोत्सव भी था और यह वसंत के ही महीने में मनाया जाता था संभवत यह उत्सव होली तक चलता था।" वसंत यही है जब संपूर्ण धरा स्वर्ण शस्य का शृंगार करें, फूलों का गजरा लगाए, आम के चौर की खुशबू चारों ओर महके और पलाश की अलख कजरा अपनी आंखों में लगाते हुए दिखे। इस समय सरसों कुछ यूँ खिले की धरा के मन की बात अभिव्यक्त करें, यह रंग संयम, नियम, वैराग्य को किताबी बातें सिद्ध करती हैं और मन की बात को उजागर करती हैं। इस समय लता पवन के संग मानो नई कहानी गढ़ती है, कहानी है प्रेम की।

मनुष्य के जीवन में प्रेम का सर्वोच्च स्थान है। किसी मनोरम व्यक्ति, सुरम्य वृक्ष व सुंदर वस्तु के प्रति आकृष्ट होना और उससे रागात्मक संबंध बनाना ही प्रेम है। लैंगिक समानता के लिए प्रेम विषय पर अपनी अवधारणा प्रस्तुत करते हुए लेखिका सुजाता कहती है - "प्रेम एक का दूसरे में विलय नहीं है, बल्कि पारस्परिक विनिमय है स्व का। इसलिए प्यार में पड़ना नहीं होता (यह कोई जाल नहीं) इसके काबिल बनना होता है।" आधुनिक समय में व्यक्ति का जीवन दुर्बोध व जटिल है, अतः आज के प्रेम का स्वरूप ही वैविध्यपूर्ण दिखाई देता है।

प्रेम की विडंबना प्रेमी ही जानता है। यह कितना सार्थक है यह सिद्ध नहीं किया जा सकता। इस संबंध में खलील जिब्रान ने कहा है - "प्रेम का मतलब एक कप से, लेकिन अलग स्ट्रॉ से पीना। एक-दूसरे की वैयक्तिकता को बचाते हुए ही नहीं, समृद्ध करते हुए। जिस संबंध की शुरुआत ही गैर बराबरी से होती है, उसमें प्रेम अंततः जेंडर स्टीरियोटाइप का निर्वाह भर ही रह जाता है।" इसे कुछ मान्यतानुसार यूँ समझ सकते हैं कि सर्वमान्य तथ्य है प्रणय के रिश्ते स्वर्ग में बनते हैं परंतु प्रश्न यह भी है कि किसी का साथ पाकर दो व्यक्ति पूर्ण हो जाए, क्या रिश्ते इसलिए बनाए जाते हैं! या फिर अपनी पूर्णता दो व्यक्ति साझा कर सकें, इसलिए रिश्ते बनते हैं! परंतु 'एक और पंचवटी' की नायिका साध्वी के साथ ऐसा कुछ नहीं हो सका। उसका विवाह यतीन से हुआ था परंतु स्वयं को साध्वी से कमतर जानकर पुरुष अहं वशीभूत उस पर अत्याचार करता था और उसे कभी समझने की कोशिश ही नहीं किया। वह बहुमुखी प्रतिभा की धनी साध्वी की काबिलियत से वाकिफ था परंतु उसकी प्रशंसा ना कर स्वयं हीन भावना से ग्रस्त था अतः दोनों में मतभेद बढ़ते गए और अंततः साध्वी ने घर छोड़ मायके जाने का निश्चय कर लिया। उसे मायके छोड़ने के लिए विक्रम तैयार हो जाता है। यह वही विक्रम है जिसे कॉलेज में मुख्य अतिथि बनाया गया था और साध्वी को उसने उस दिन पुरस्कार दिया था तब से साध्वी के मन में विक्रम के प्रति कोमल मनोभाव (प्रेम) उत्पन्न हो चुका था। "गरीब परिवार की साध्वी एक अच्छी विद्यार्थी, तैराक, चित्रकार, शालीन आदि कई गुणों से संयुक्त है। विद्यालय के एक आयोजन में निर्णायक बनकर आये एक उद्योगपति विक्रम का सुदर्शन व्यक्तित्व उसे आकर्षित करता है- साध्वी के कुँवारेपन का यह पहला प्यार था।" 4

यतीन, विक्रम का ही भाई है परंतु विक्रम उससे स्वभाव में भिन्न है। विक्रम को रिश्ते की खूबसूरती को पहचानना और उसे उसी खूबसूरती से निभाना आता है। वह व्यस्त तो था परंतु जितना भी समय उसने साध्वी को दिया उसमें जिंदगी के मायने बुनता गया। "साध्वी, तुम मुझे बहुत पसंद हो... तुममें जो भी है उसका मैं आवर करता हू... शायद इसलिए भी कि वह सब मुझे अपने लिए चाहिए था और जो मुझे प्राप्त नहीं हुआ था कभी... मैंने यतीन के नाम तुम्हें क्रय करके सोचा था- इस घर में तुम्हारी उपस्थिति मुझे संतोष देगी... परंतु ऐसा हुआ कब ...?" 5 विक्रम ने थोड़ा समय और थोड़ा ख्याल

रखकर साध्वी के मन पर पड़ी उसकी छवि ने चमक से भर दिया। इस चमक में वासंती
प्रेम का रंग था।

यह वासंती रंग का ही एहसास है कि जब साध्वी विक्रम से मानसिक व
भावनात्मक रूप से जुड़ी तो उसके वह दो दिन यादगार दिन बन गए। मायके जाते समय
विक्रम का वह गेस्ट हाउस साध्वी के सपनों का घर बन जाता है और वह उसे पंचवटी
नाम देती है, वहां की प्रकृति को निहारते हुए साध्वी मन ही मन सोच रही है - "चारों ओर
आम के वृक्ष थे... जैसे आम के बाग के बीचों बीच किसी ने यह घर बना लिया हो। मार्च
का अंतिम सप्ताह था और अधिकतर वृक्ष बौर से लदे थे, खूब फूला हुआ नन्ही- नन्ही
आमियों में परिवर्तन हो रहा था। सारे वातावरण में एक सुगंध थी, मीठी-सी भी और तुर्श
तोड़ी खरास से मिली जुली। वहां की हवा भी तो भिन्न- सी लग रही थी, जो मुझे
एन्द्रेक रूप से वातावरण तथा प्रकृति में घोल रही थी। आकस्मिक परिस्थितियों से
घिरकर मैं यहां इस निर्जन स्थान पर आ पहुंची थी। पता नहीं किस अभिप्रेत प्रयोजन के
लिए यहां इस बंधन मुक्त स्थल पर वस्तु-चेतना की अन्वेषण कर रही थी मेरी आत्मा ?
चारों ओर असीम शांति थी जैसे कोई उपवन हो। सहसा मुझे लगा मैं अपने पूर्व
परावर्तित परिवेश को त्याग कर पंचवटी में आ गई हूँ।" ⁶ यहां बसंत की मादक प्रकृति
साध्वी में विक्रम के प्रति अव्यक्त प्रेम के भाव अभिव्यक्ति में सहायक हो रही थी। एक
सत्य ही प्रतीत हो रहा था कि विक्रम, मैं और पंचवटी का यह सूना निर्जन कोना है।
साध्वी विचार शून्य स्थिति में पहुंच गई थी और भावाद्रेक में उसने आम के बौर के
गुच्छे तोड़ लिए, उसकी सुगंध को अपने में समाहित करती वह गेस्ट हाउस में गई और
रानी - सा एहसास अपने अस्तित्व से जोड़ कर तैयार होने लगी- -" बड़े प्रयास से तैयार
हो पाई, हल्की हरी साड़ी पर लंबी मोतियों और मानक की माला पहन ली, बाल जैसे ही
बिखरे रहने दिए पर एक आम्र मंजरी के भार से झुकी एक डाली बन जाना चाहती थी कि
मेरे सौरभ से मत मेरा वह भंवरा मुझसे दूर ना जा सके बस मुझ में ही डूब जाये।"

बसंत का सम्मोहन साध्वी के मन के भावों को उद्दिग्ध कर जाता है। बौर की
मिठास पर घुलती खुशबू प्रेम जगा जाती है। होठों पर अनकही बात फिर से निकल आती
है जैसे वसंत मन की चोरी को सबके सामने खोल रहा हो। गेस्ट हाउस के चारों ओर की
प्रकृति उसके मन में वासंती रंग फैला सारे भावों को खोलने का काम कर रही थी।
साध्वी उस प्रकृति से पुनः जुड़ जाती है - "आम्र मंजरियों का निमंत्रण हवाओं द्वारा मुझ
तक पहुंच गया था। बाहर आकर देखा दूर तक आमों के वृक्षों की कतारें थीं और मैं उन्हीं
की परछाइयों में अपनी छाया मिलाती चलती गई। एक नीची- सी डाल धरती के निकट,
धरती के समानांतर फैला आई थी। उसी पर मैं पीठ टिका बैठ गई थी। मेरी चेतना में
जगत का अस्तित्व धूमिल हो रहा था, जैसे मेरी अभिव्यक्ति वह आम्र-मंजरी कर रही थी,
उसकी तुर्श सुवास से मैं अभिभूत थी। हवा के झोंके से बौर का चूरा भुरभुरा कर मुझ पर
गिर रहा था- पराग के वह अणु मेरा स्वागत कर रहे थे। एक अप्रत्याशित सुख मेरे भीतर
झर रहा था।" ⁸ साध्वी ने अपने अस्तित्व की तलाश की और प्रकृति में खुद को घोल

दिया। उसे वहाँ के वृक्षों के आसपास घूमना उन्हें निहारना और उनसे ही ठिठोली करना सुखकर लग रहा था। तभी नौकर ने आवाज लगाई कि साहब अभी नहीं आएँगे, साध्वी गेस्ट हाउस की भीतर जाकर लेट गई और न जाने कब उसकी आंखें लग गईं। तभी अचानक उसे चेत आया जब उसके माथे पर विक्रम ने अपने जलते हुए होंठ रख दिए और साध्वी ने अपनी बाहें फैला दी। पंचवटी का मादक सौंदर्य भरा वासंती वातावरण उसके प्रेम को परिणति तक पहुँचा देता है। साध्वी सोच में पड़ जाती है- "संवेग तथा भीतर का उत्ताप अनिवार्य हो उठा मैंने बाहें फैला दी थीं वह पूर्ण रूप से मुझमें एकाकार हो गया था। मेरे भीतर जन्म-जन्मांतर की प्यास लपट- लपट जल उठी थी। विशुद्ध तथ्य यह था कि स्वयं ऋतुराज वसंत आया था। गदराएँ बौर के फूल एक सम्भाव्य संवेग से प्रेरित - अपने आप को उसके चरणों में बिखेर कर उसका स्वागत करने को आतुर थीं। मेरी बोध क्षमता क्षीण हो चुकी थी बस उसके बंधन में कसमसाकर टूट जाने की इच्छा बलवती हो रही थी।" इस तरह वसंत का प्रभाव साध्वी और विक्रम के प्रेम के स्वप्न को यथार्थ में परिणत कर देता है। प्रेम को परिभाषित करते हुए साध्वी अन्वेषण करती है - "प्रेम सूत्र है-मन के भीतर एक वीणा को झंकृत करके संगीतपूर्ण बनाता है - शायद वैसा ही एक अनुपम संगीत मेरे भीतर मूर्त हो रहा था। यह प्रेम मेरे रोम-रोम में प्रार्थना का-सा संकल्प बो रहा था। एक शब्दातीत अनुभव जो मेरे लिए सचमुच नया था। यह क्षण वैसे भी तो कुछ कहने सुनने के लिए नहीं थे।" ¹⁰

प्रेम को परिभाषित करना उसके बारे में सब कुछ बता पाना दुरुह है क्योंकि यह अनुभूति और अभिव्यक्ति की भाषा है। सर्वविदित है इसके लिए ज्ञान नहीं जीवनानुभूति की अनिवार्यता है। जब दो व्यक्ति विवाह के बंधन में बंधते हैं तो एक-दूसरे के प्रति प्रेम, आदर-सम्मान, समर्पण का भाव होना अनिवार्य है। एक-दूसरे के गुण-अवगुण को स्वीकार करते हुए अपना आवश्यक होता है अन्यथा विवाह मजबूरी बन जाती है, जिसे बेमन से ढोना पड़ता है। साध्वी को विवाह मजबूरी की तरह ढोते रहना स्वीकार नहीं था। वह विक्रम के साथ बंध जाती है और यह बंधन उसे आजाद करता है। लेखिका सुजाता का यह कथन साध्वी और विक्रम के संबंध में सटीक बैठता है- "अपने सहज स्वरूप में प्रेम स्त्री को आजाद करता है, मुक्ति का उत्सव है स्त्री के लिए प्रेम। उत्सव अकेले नहीं मनाया जाता। एक पुरुष को भी यह उतना ही आजाद करता है। यह बने बनाए जीवन सिद्धांतों, परंपरागत नियमों और स्थापित संस्थाओं को ताक पर रखता है, अपने रास्ते और मंजिलें खुद तय करता है, दोनों में से किसी एक को झुकाए बिना। इस तरह प्रेम आजादी की तरफ बढ़ा कदम होता है, लेकिन सिर्फ एक कदम, क्योंकि आगे वह लगातार एक साझा संघर्ष है, बराबरी के लिए।" ¹¹

प्रेम अत्यंत उदात्त है, इसकी पराकाष्ठा है कि स्व से पर की यात्रा करना और फिर दोनों का एकात्म हो जाना। यह सूक्ष्म से सूक्ष्म, अनंत से - अनंतरम स्वरूप में विद्यमान है। मनुष्य जिस से प्रेम करता है, उस से लगाव रखता है और वह उसके लिए

बेशकीमती हो जाता है। रिश्ता हो या व्यक्ति वह कीमती है और उसके प्रेम में आत्मसमर्पण करना स्वाभाविक है। साध्वी इस प्रेम में परिपूर्णता को प्राप्त करती है और मन-ही-मन सोचती है - "मैंने सोच लिया था कि उनकी तर्क-पद्धति अब जो भी हो मुझे स्वीकार होगी। हां, यह भी सच था कि पहली बार मेरी आत्मा उस सच को जी कर अनिवार्य रूप से निरपेक्ष ज्ञान बनकर मुझे प्राप्त हुई थी। ऐसा अपूर्व अनुभव पहले कभी नहीं हुआ ... इतना मनोबल प्राप्त था मुझे कि लगता था संसार का कोई भी कष्ट मैं अब हंसकर झेल जाऊंगी-विक्रम का दिया यह विश्वास मेरे जीवन की ढाल बन जाएगा।"¹²

प्रेम में व्यक्ति खूबी - खामी दोनों को समग्रता से स्वीकार करता है। उसे विश्वास है कि जब उसे उसकी जरूरत हो तो वह एक पुकार में अपने होने का एहसास कराए। साध्वी को विक्रम के होने का एहसास हमेशा बना रहा और गेस्ट हाउस के बसंती रंग में डूबे वे दो दिन वह अपने साथ ले गई। विक्रम का अंश उसके शरीर में पल रहा था, जिसकी खबर ना विक्रम को थी और ना ही उसके ससुराल में किसी को। जब मायके से सात महीने बाद अपने पेंटिंग की प्रदर्शनी के लिए वापस ससुराल जाना चाहती है तो विक्रम इसके लिए गाड़ी भिजवाता है और फिर से वह गेस्ट हाउस आती है। पंचवटी में सैर कराते हुए ! साध्वी अपने मन की अभिव्यक्ति देते हुए कहती हैं- "जब पिछली बार यहां आई थी तो इस स्थान को मैंने एक नाम दिया था... पंचवटी। है न पागलपन? पर जाने क्यों वैसा ही लगा था, उस समय अमराई पर बौर लदा था। कैसा मोहक था उस समय का ये उपवन। मैं एकाकिनी यहां निर्जन में बैठी सोचती रही जैसे मैं वनवासिनी हूं और यहां रहने आई हूं। तब इस पंचवटी ने कच्चे पीले बौर के ढेर सारे फूल बरसाकर मेरा स्वागत किया था और जब यह स्थल मेरे लिए पूज्य है, अनुपम है स्वर्ग है। मैं भी तो घर त्याग कर आई थी इतना दूर, कभी न लौटने के लिए, एक तरह का वनवास ही तो है जो मैं जी रही हूं।"¹³ विक्रम ने कहा कि तुम्हारे जीवन बर्बाद होने में और दुविधा में डालने में मैं जिम्मेदार हूं। इस पर साध्वी का कहना था कि जो हुआ वह मेरी नियति है और अप्रत्याशित सुख, अदृश्य सूत्र मुझे यहां आप से जुड़ने ले आया। प्रेम के लिए किसी को दोष भी नहीं देती। यहां विक्रम उसके रूप को देखकर, सच्चाई जान कर आश्चर्यचकित हो जाता है। अपने अपराध बोध को प्रकट करता है और उससे पूछता है कि अब मैं तुम्हारे लिए क्या करूं? तुम कहो तो मैं नीरा को छोड़कर तुम्हें अपना लूंगा। परंतु साध्वी विक्रम को बदनाम नहीं करना चाहती थी, वह विक्रम को बताती है कि अब वह गोरखपुर में एक कॉलेज में नौकरी कर रही है। बच्चे होने पर उसे बड़ा कर लेगी, पढ़ा लेगी और जैसा वह कहेंगे, बच्चे को वही बनाने का प्रयास करेगी। उसका प्रेम उसकी शक्ति का पर्याय बन जाता है। वह प्रेम का प्रतिफल भी नहीं चाहती और किसी पर कोई जिम्मेदारी नहीं डालती। इस प्रकार उसका स्वावलंबी रूप निखर कर सामने आता है।

साध्वी ने बेबाकी से अपनी सच्चाई यतीन को बतायी और प्रेम की परिभाषा देते हुए कहती है- "प्रेम वह मानवीय अवस्था है जिसकी पूर्णता तक पहुंचने के लिए कोई भी पथ की बाधा, रुकावट नहीं बनती, चाहे वह अपनी शादी का बंधन क्यों न हो और

प्रेम को भावनात्मक स्तर पर पूर्ण रूप से पा लेने के बाद जो सुख अनुभव होता है वह अनुपम है, अपूर्व है, अनुभवातीत है। उसको पूर्णरूप से आत्मसात कर लेने पर सांसारिक कोई भी दुख नहीं रह जाता। चेतना में इंद्रियातीत अपनत्व या ईगो जैसा कुछ नहीं बचा रहता, सभी कुछ पिघलकर सुख हो जाता है - बस सुख। मेरे अभिप्राय रहित जीवन को उस प्रेम ने एक राह दी है, एक अस्तित्व प्रदान किया है। मैं हंसकर उस राह पर चलती चली जाऊंगी.... क्योंकि इस राह पर यह मानवीय तत्व, उग्र, प्रतिष्ठा या मान अपमान जैसा कुछ नहीं दिखाई पड़ता। मेरा प्रेम किसी के जीवन को तहस-नहस नहीं करता यतीन, न तुम्हें न ही नीरा भाभी को। मेरे मन में तुम्हारे प्रति आदर था, और नीरा भाभी के लिए बड़ी बहन -सी श्रद्धा- वह मेरे मन में आज भी वैसी ही सुरक्षित है। मैंने आप लोगों के परिवार से एक नहीं -सी जल की बूंद पाई है... पूरा समंदर आपका है। मैं उस नहीं सी जलकण से यदि प्यास बुझा लेती हूँ तो आपका क्या घट जाता है, कुछ भी तो नहीं मैं किसी की भी अपराधिनी नहीं हूँ यतीन... अतः क्षमा भी किसी से नहीं मांगूंगी।" ¹⁴

साधवी का प्रेम सपने दिखाता है और स्वर्गीय सुख का अनुभव कराता है, उसके जीवन को परिपूर्णता तक पहुँचाता है। श्रीराम दवे ने कुसुम अंसल के 'एक और पंचवटी' के इस प्रेम प्रसंग पर अपने विचार प्रस्तुत करते हुए लिखा है "लेखिका ने साधवी और विक्रम के इन अंतरंग क्षणों को इतनी कुशलता से उकेरा है कि कहीं कुछ अश्लील प्रतीत नहीं होता है बल्कि पाठक को लगता है जो भी हो रहा है वह ठीक हो रहा है।" ¹⁵ उपन्यास के अंतिम पड़ाव में विक्रम का प्लेन क्रैश हो जाता है। साधवी को दो पुत्र होते हैं, जिसे वह लवकुश नाम देती है। यतीन साधवी के प्रेम को अब समझता है, उसका हृदय परिवर्तन हो चुका है और वह साधवी से कहता है कि विक्रम भैया ने तुम्हारा उत्तरदायित्व मुझे सौंपा था, अब मैं उसे जीवन भर निभाऊंगा। विक्रम की मौत पर उसकी मां रोती है तो तीन कहता है कि भाई के रूप में यह दो बच्चे आ गए हैं और बच्चों को गोद में उठाकर नर्स से उन्हें पालने की ट्रेनिंग लेने की बात कहता है। इस तरह उपन्यास का सुखांत होता है।

निष्कर्ष - प्रेम प्यास को बढ़ाता नहीं तृप्ति का एहसास है। तो क्या साधवी की बनी इस पंचवटी में उसका प्रेम संतुष्टि को प्राप्त नहीं! विवाह पश्चात इस तरह अन्य के साथ अंतरंग संबंध धर्म, नैतिकता व सामाजिक नियम के विरुद्ध हैं जिसे समाज स्वीकार नहीं कर सकता परंतु परिवेश की मांग को दर्शाते हुए कुसुम अंसल ने इसे न्यायसंगत उद्वारया। स्त्री और पुरुष के बीच प्रेम की नई परिभाषाएं कुसुम अंसल ने इसमें गढ़ी हैं। धर्म, नैतिकता और मर्यादा की सीमाओं के बीच भी बसंतोत्सव या यूँ कहें मदनोत्सव की तरह साधवी ने प्रेम के उत्सव को मना लिया। विक्रम और साधवी का यह संबंध समाज, धर्म, नैतिकता को स्वीकार न होने के बावजूद भी कुसुम अंसल ने उपन्यास के माध्यम से संबंधों में बिखराव क्यों आता है, इस विषय को बेहतर ढंग से उठाया है, साथ ही वासंती

रंग के माध्यम से जीवन में प्रेम के रंग की अभिव्यक्ति को दर्शाया है। साधवी का प्रेम उसकी स्वतंत्रता की उद्धोषणा ही नहीं करता, उसके आत्मपरिचय के लिए भी सहायक होता है। प्रेम को नए रूप में परिभाषित करने का खतरा कुसुम अंसल ने एक और पंचवटी में उठाया है। इस तरह यहाँ कोमल भावनाओं की अभिव्यक्ति के साथ-साथ संवेदना के नए संस्करण को अभिव्यक्त किया गया है।

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हिंदी अनुशीलन

त्रैमासिक

जनवरी-मार्च 2024

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नियति अग्रवाल
डॉ. गिरजाशंकर गौतम

आवां विस्तृत फलक का उपन्यास है जो दो दिशाओं—नारी-चेतना और श्रमिक आंदोलन में जूझता हुआ विकसित होता है। कथा नौकरी के लिए नमिता के संघर्ष से शुरू होती है जिसमें उसके पिता की बीमारी और आर्थिक संकट के कारण उसकी पढ़ाई बीच में ही रुक जाती है। परिश्रम और संघर्ष के सहारे पिता और परिवार की भरसक सेवा-सहायता करते हुए वह अपने भविष्य को दृढ़ती है। इस संघर्ष के बीच ही उसे यह आभास हो जाता है कि स्त्री की मुक्ति कोई स्वयं की इच्छा न होकर वृहत्तर सामाजिक मुक्ति का ही एक हिस्सा है। इसे पुरुष के विरोध में खड़े होकर नहीं, उसके साथ खड़े होकर एक संपूर्ण लड़ाई के रूप में लड़ा जा सकता है। आँच से दहकते इस आवां का फलक बड़ा ही व्यापक है। इसके भीतर से जो ज्वालाएँ उठती हैं, उनमें भाँति-भाँति प्रकार की सामग्री हवन हुई है।

बीज शब्द : स्त्री, आवां, बाजारवाद, असंतुलन, असंतुष्ट, परिवर्तनकामी, स्वाभिमान, बाध्यता, स्वच्छंदता, संघर्षशील, जड़, अतिक्रमण, पूंजीपति, आधुनिकता।

हिंदी साहित्य में स्त्री की समस्याओं की पहचान से लेकर स्त्री चेतना के प्रश्न, मानवाधिकार को साधन बनाकर स्त्री को एक मानव के रूप में स्थापित करने के प्रयत्न, भोगशील वस्तु से स्त्री के गरिमामयी स्थान को प्राप्त कराने हेतु स्त्री-अस्मिता के लिए संघर्ष आदि के द्वारा विमर्श के केंद्र में स्त्री को लाने का कार्य स्त्री लेखन के द्वारा किया गया है। समकालीन हिंदी कथासाहित्य के कथाकारों में किसी एक महिला कथाकार का नाम लेना हो जो अपने लेखन से एक भारतीय स्त्री की संपूर्ण गरिमा का प्रतिनिधित्व करती हो, जो लेखन के स्तर पर चेतनासंपन्न, जागरूक, मुखर और सक्रिय हो, तो निस्संदेह चित्रा मुद्गल का नाम सर्वोपरि होगा। उपन्यास का शीर्षक मौलिक और गंभीर अर्थ को दर्शाता है। कहा जाता है—‘माँ की कोख, कुम्हार का आवां।’ जिस प्रकार माँ की कोख में एक शिशु जीवन पाता है, उसके अंगों का विकास होता है, उसे उस कोख में एक पक्की कद-काठी मिलती है जिससे वह एक पोषक जीव बनकर दुनिया के दर्शन करता है, उसी प्रकार होता है ‘कुम्हार का आवां।’ आवां उस गढ़े को कहते हैं जिसमें कुम्हार मिट्टी के बर्तन पकाते हैं। कुम्हार चाक पर मिट्टी से खूबसूरत खिलौने, नक्काशीदार सुराही, सुंदर-सुंदर चिड़िया, कौवा, हाथी, घोड़ा, मोर, बंदर, मिट्टी के कलात्मक बर्तन बनाता है। लेकिन अगर इन कलात्मक, खूबसूरत और नक्काशीदार सुराही को आवें में पूरी सावधानी से पकाया न जाए तो जब आवां खोला जाता है तो सारी खूबसूरत

वस्तुएँ जलकर काली हो सकती हैं। ऐसे में बर्तन टूट-फूट जाते हैं। उपन्यास में हम 'बाजारवाद' के आवें की बात कर रहे हैं। इस आवें में जल रहा है पसीना बहाने वाला मजदूर, देश की आधी आबादी और गिरवी होता देश का स्वाभिमान।

उपन्यास में लेखिका ने समय के मायाजाल में फंसी एक लड़की 'नमिता' की जीवन-यात्रा बताई है। नमिता के अलावा उपन्यास में और भी स्त्री-पात्र हैं जैसे नमिता की माँ, स्मिता, सुनंदा, किशोरी बाई, गौतमी आदि जिनकी भी अपनी दारुण-कथा है। मजदूर आंदोलन के नेता देवीशंकर पांडे के लकवाग्रस्त होने पर घर का आर्थिक भार नमिता पर आ गया। उसका संघर्ष लोकल ट्रेन में यात्रा करने से ही शुरू हो जाता, "लोकल में यात्रा करना और प्लेटफार्म की वैतरणी पार करना उसके लिए सीता मैया की कलयुगी अग्नि-परीक्षा हो उठती। मगर किराए में लगभग ढाई गुने का अंतर घर के एकदम निकट से शुरू होने वाली डबल डेकर बसों के पायदान पर उसे पाँव ही न रखने देता।" ट्रेन के डिब्बे आज भी स्त्रियों को उनकी अस्मिता को शर्मनाक करने के लिए सटीक जगह होते— "भीड़ से उसकी मुलाकात जब भी होती, उसके घड़ से उसे सिर गायब मिलता और उसके संभलते, न संभलते वह धड़ अचानक कोंचती कुहनियों, सरसराती उँगलियों, लोलुप कनखियों, सिसकारी भरती छुअन में तब्दील हो अपने करीब दबोचते-चाँपते संभोग को उद्दीप्त होने लगता। मुक्ति की छटपटाहट उसकी धरती रंधों से रिसती परनालों-सी उफनने लगती और वह पाती कि उसके देह पर चढ़े कपड़े अचानक देह की चमड़ी हो गए हैं।" स्त्री का बाहरी जीवन आत्मनिर्भरता को तो दर्शाता है पर समाज में उसके साथ नीच हरकतें नहीं होती ऐसा कदापि नहीं है। पढ़ाई छोड़ नमिता घर की घरेलू व्यवस्था में भी महत्वपूर्ण पात्र थीं। लकवाग्रस्त पिता की परिचर्या का भार भी उसके जिम्मे ही था। माँ ने शुरुआत में यह जिम्मेदारी निभाई थी पर फिर उन्होंने कोताही बरतना शुरू कर दिया। इस वजह से उसे अपनी पढ़ाई छोड़नी पड़ी। माँ कहती— "कहाँ-कहाँ मरूँ और क्या-क्या करूँ? जिसे देखो डिप्टी कलेक्टर बनने में अधिया रहा। मूँड़ने को बच गई मैं अनपढ़-गंवार. ... जरखरीदी बाँदी!" इंसान बाहर की पराई दुनिया से तो लड़ सकता है पर घर के अंदर जब घर के सदस्य ही मानसिक तनाव देने लगे तो वह इंसान पूरी तरह से टूट जाता है। नमिता की माँ उसे अपनी प्रतिद्वंद्वी औरत मानने लगी थीं "जिसके बढ़ते कद को सहन कर पाना उनके डाह के बूते का नहीं, जो उन्हें अप्राप्य रहा, वह उसे क्यों हासिल हो!" बेटियाँ जब बड़ी होती हैं तो माँ-बेटी एक-दूसरे की सबसे खास दोस्त बन जाती हैं। पर अगर वही माँ अपनी ही बेटी की दुश्मन बन जाए तो घर नरक-सदृश होने लगता है। नमिता के घर की हालत भी कुछ ऐसी ही थी। पत्नी की इस मनोदशा पर दुखी होते हुए देवीशंकर पांडे ने एक रोज़ नमिता को स्लेट में लिख माँ के इस व्यवहार के बारे में उसे समझाया— "तुम्हारी कम पढ़ी-लिखी माँ को समय अपनी कसौटी पर कस रहा है, अपनी हाजिरी दर्ज करते हुए। वरना पड़ोसियों के घर अचार-खटाई, पापड़, बड़ी-मुंगौड़ी बेलने-तोड़ने और बहन कुंती के घर मुल्ला की दौड़ मस्जिद सदृश सीमित रहने वाली कभी घर से बाहर काम-काज खातिर निकलती? अंतर यह है तो मात्र इतना कि वह अल्पज्ञ अपने समक्ष छोटे-छोटे अवसरों का रूप धर आ खड़े हुए समय से परिचित होना नहीं चाहती, बल्कि उसकी अवमानना करती है। उपेक्षा करती है। दुखी है। संकटों के पहाड़ तले दबी हुई। ग्रंथियों की मारी कोई आज से नहीं है वह। बड़े चाव और निष्ठा से पोस रही है उन्हें। उसके खून में रच-बस गई उसका स्वभाव और व्यवहार हो गई है ग्रंथि। उन्हें बदलने की कोशिश करना या उम्मीद करना कोई सकारात्मक

परिणाम नहीं देगा। बल्कि उसके धड़ से उसका चेहरा छीन लेगा। जी नहीं पाएगी वह अपने इस चेहरे के बिना। दुख होता है उसे देखकर। क्षोभ नहीं होता। यही सोचकर कभी मैंने उससे छिननी नहीं चाही। अपने को ढाल लिया। दरअसल, समस्या वह तुम लोगों के लिए नहीं, स्वयं अपने लिए है। निपट अकेली। असंतुलित, असंतुष्ट, रुग्ण....।”⁵ ऐसा नहीं था कि नमिता माँ के बारे में सोचती नहीं थी पर वह स्वयं भी घर को संभालने में अपना जाँगर चला रही थी जो माँ कभी देखना नहीं चाहती थी।

माँ के लगातार बोलने से कामगार आघाड़ी के नेता अन्ना साहब नमिता को देवीशंकर की जगह युवा कार्यकर्ता के रूप में काम पे लगा लेते हैं। पर वह यह ज़रूर जानना चाहते हैं- “ट्रेड-यूनियन के क्रिया-कलाप में नमिता की कोई रुचि है भी या नहीं? श्रमिकोत्थान के आंदोलन में वह सक्रिय भाग लेना चाहेगी या नहीं। हमने निर्णय ले ज़रूर लिया है, लेकिन उसके अंतर्भावों से परिचित हुए बिना निर्णय पर अंतिम मुहर लगानी संभव नहीं। बाध्यता से व्यक्ति का उन्मेष कुंठित होता है। स्वाभाविक प्रक्रिया है। प्रत्येक युवा हृदय के कुछ सपने होते हैं। एक आवां होता है आंच से दहकता। जिसकी पकावट से वह आकांक्षा की भित्ति उठाता है। छाजन छाता है। मैं नहीं चाहता कि ट्रेड-यूनियन में आने का निर्णय वह विकल्पहीनता से आक्रांत होकर करे। समाजसेवा का संकल्प मरुभूमि की तपित पीठ है। सामान्य व्यक्ति उसे अपनी शुष्क संवेदना के पायों पर नहीं झेल सकता। वही झेल सकता है, जो मनुष्य के लिए चिंतित और मौजूदा व्यवस्था से असंतुष्ट हो। परिवर्तनकामी हो।”⁶ यह संदर्भ हमें अन्ना साहब की समाज के प्रति गहरी संवेदनशीलता को दर्शाता है। उपन्यास में श्रमजीवी संस्था की मुखिया शाहबेन जिनके यहाँ नमिता और उसकी माँ दोनों ही पापड़ बेलने जातीं के द्वारा हमारे देश के राष्ट्रपिता महात्मा गाँधी जी का संदेश भी पाठकों को ऊर्जा प्रदान करता है— “जीवन में कोई अकेला नहीं होता, अकेला वही होता है जिसे अपने ऊपर भरोसा नहीं होता।”⁷

नमिता कामगार आघाड़ी में अपना काम तो शुरू कर देती है। पर उसे क्या पता था कि पुरुष किसी भी रिश्ते से ऊपर एक पुरुष होता है और फिर अन्ना साहब तो मात्र उसके पिता के दोस्त थे। नमिता तब हतप्रभ हो उठती है जब वह कहते हैं—“देखो, दोस्त की बेटी हो तुम, बेटी नहीं हो मेरी। पिता समान हूँ मैं तुम्हारे, पिता नहीं हूँ। रिश्ते की इस गहन अंतर्सूक्ष्मता को महसूस कर लोगी तो संबंध से स्वयं को शोषित अनुभव नहीं करोगी।”⁸ नमिता अन्ना साहब का अनैतिक चरित्र देखती है। वह जानती है कि तनखाह के रूप में ग्यारह सौ रुपये उसके लिए बहुत मायने रखते हैं। पर बीमार पड़े बाबूजी की पंजर छाती पर अपना सर टिकाकर उसने रुदन के साथ पूछा—“बाबूजी! अगर मैं बिना कारण बताए आपसे कह दूँ कि कल सुबह से मैं ‘कामगार आघाड़ी’ की नौकरी करने नहीं जा रही, तो आप समझ जाएंगे न, मैं ऐसा क्यों कर रही हूँ? गैरजिम्मेदार मैं नहीं हूँ बाबूजी! जानते हैं आप जानते हैं न?”⁹ अतः हम ये कह सकते हैं कि कठिन परिस्थितियों में नौकरी का लोभ छोड़ पाना स्वाभिमानी व्यक्ति के बूते की ही बात है। नमिता के बारे में चित्रा मुद्गल अपने एक साक्षात्कार में कहती हैं— “ट्रेड यूनियन के एक बड़े नेता की बेटी के रूप में मैंने उसे इस तरह से गढ़ा है कि एक लड़की, जो अपने पिता के प्रभा मंडल के नीचे चिराग तले अंधेरे के रूप में पलती है और उन अभावों को जीती है जो एक ईमानदार ट्रेड यूनियन लीडर जीता है। उसे जीना भी चाहिए। मुंबई जैसे शहर में रहते हुए भी नमिता ऐसे संघर्ष करती है जैसे कोई निम्न मध्यवर्गीय लड़की करती है। मैं चाहती थी कि नमिता अपने अनुभव से अपने आप को गढ़े। संघर्षों के बीच,

उनसे लड़ते-टकराते अपनी पारिवारिक जिम्मेदारियों को निभाते वह स्वयं को स्वयं में अन्वेषित करे।”¹⁰

नमिता कामगार आघाड़ी का काम छोड़ती है और फँस जाती है पूंजीपति वर्ग के षड्यंत्र में। मैडम अंजना वासवानी बहुत ही चालाकी से नमिता की सादगी का फायदा उठाती है और उसे सौंप देती है हीरा व्यापारी संजय कनोई के हाथों में। संजय कनोई धीरे-धीरे नमिता के नज़दीक जाता है। वह अपने बाप बनने की अधूरी इच्छा को पूरा करने के लिए नमिता की जानकारी के बिना उसकी कोख का सौदा करता है। वह प्रेम का झूठा नाटक रचता है। पत्नी निर्मला से नफरत करने का झूठा स्वाँग रच वह कहता है—“मैं नहीं चाहता, मेरी और तुम्हारी परस्परता के बीच निर्मला उपस्थित हो। निर्मला, निर्मला, निर्मला... सिर चढ़े प्रेत-सी खूँदती रहती है वह प्रतिपल मेरे दिमाग को, दिल को। घृणा है मुझे उससे। उसकी परछाई से। जानती हो तुम। बता चुका हूँ सब। फिर क्यों चर्चा कर रही हो उसकी? भाग्य ने बीवी की जगह कुटनी बाँध दी मेरे गले। मुक्त होना चाहता हूँ मैं उस कुटनी से।”¹¹ नमिता उससे प्रेम करने लगती है। वह संजय की बातों से इस कदर सहमत हो जाती है कि कोई अगर उसके बारे में कुछ बोले तो नमिता तत्परता से कह उठती है—“शादीशुदा आदमी इंसान नहीं होता? ब्याह-शादी का समीकरण जीवन में गलत बैठ जाए तो उसके पीछे गले में पत्थर बाँध आदमी को नदी में छलांग लगा देनी चाहिए? सारी हर्षा! निर्मला कनोई से मुझे गहरी सहानुभूति थी, अब नहीं। वास्तविकता से अपरिचय मेरी सीमा थी। उस सीमा का अब अतिक्रमण हुआ है। उन पक्षों से अवगत हुई हूँ जो किसी भी सामान्य व्यक्ति को विकसित करने के लिए पर्याप्त हैं।”¹² संजय नमिता के साथ शारीरिक संबंध बनाता है। वह उसे हैदराबाद पत्थरगट्टी भेज देता है प्रशिक्षण लेने के बहाने ताकि वह स्वच्छंद तरीके से नमिता से मिल सके और अपने षड्यंत्र में कामयाब हो सके। नमिता गर्भवती हो जाती है। जब पाँचवाँ महिना आरंभ हो जाता है तब उसे पता चलता है कि वह माँ बनने वाली है। वह तब भी यह गर्भ नहीं चाहती। वह कहती भी है—“मैं वैसी आधुनिका नहीं हूँ कि बिना ब्याह के अवैध संतान पैदा कर छद्मक्रांति जिऊँ। मेरे लिए संतान सामाजिक जिम्मेदारी है। उंगली नहीं उठा सकता वह मेरी ओर कि मैंने उसे इस तरह क्यों पैदा किया, जिस तरह से वो जन्मना नहीं चाहता था।”¹³ मगर संजय बात काटते हुए चेतावनी भरे स्वर में कहता है—“तुम मेरे बच्चे को हाथ नहीं लगाओगी। तेरह साल बाद ...तेरह साल बाद मैं बाप बना हूँ। किसी मर्द के लिए बाप बनना क्या होता है...सात जन्म लेकर भी तुम महसूस नहीं कर पाओगी।”¹⁴ जब अन्ना साहब की हत्या की खबर सुनकर नमिता का अनजाने ही गर्भपात होता है तब संजय कनोई की हकीकत पता चलती है। आवेश में वह कह उठता है—“जानती हो? बाप बनने के लिए मैंने तुम्हारे ऊपर कितना खर्च किया? उस मामूली औरत अंजना वासवानी की औकात है कि तुम्हारे ऊपर पैसा पानी की तरह बहा सके? उसका जिम्मा सिर्फ इतना भर था कि वह मेरे पिता बनने में मेरी मदद करे और सौदे के मुताबिक अपना कमीशन खाए। वह ऐसी पचासों लड़कियों को परोस सकती थी, जो मुझसे यौन-संबंध कायमकर केवल पचहत्तर हजार में मुझे बाप बना सकती थीं...मैं रंडियों से बाप नहीं बनना चाहता था, जिनके लिए बच्चा पैदा करना महज सौदा-भर हो और जो अनेकों से सौदा कर चुकी हों...मुझे नहीं गवारा थी ऐसी किराए की कोख।”¹⁵ नमिता यह सच्चाई जानकर पूरी तरह से टूट जाती है। आखिर यह कैसी आधुनिकता है जिसमें किसी स्त्री की पवित्र कोख का भी उसकी अनभिज्ञता में सौदा हो रहा हो? संजय कनोई का भौंडा रूप देखकर नमिता

वापस लौट जाती है लेकिन इस बार अपनी माँ के पास नहीं बल्कि मजदूर बस्ती में। उपन्यास की समीक्षा करते हुए लेखक मधुरेश कहते हैं—“दुनिया को काफी कुछ अपने ढंग से देख लेने के बाद अपने अंतिम निर्णय में वह फिर अपनी उन्हीं छूटी जड़ों की ओर लौटती है। उसमें अपने लिए अपनी दृष्टि से दुनिया देखने का हौसला है। अपनी जड़ों की ओर उसकी वापसी का संघर्ष ही वस्तुतः वह ‘आवां’ है जो उसे गढ़ता और पकाता है और राह के चुनाव का विवेक देता है।”¹⁶

निष्कर्ष : उपन्यास की स्त्री-पात्र संघर्षशील है। वह निरंतर अपनी लड़ाई लड़ती है। वह आखिर में महसूस करती है कि दूसरों की नज़र से देखी हुई दुनिया अपना सच नहीं होती, न अपना अनुभव। अपने अनुभव के बिना कोई परिष्करण संभव नहीं है। सदियों से चली आ रही पितृसत्तात्मक चुनौतियाँ आज भी 21वीं सदी में ज्यों की त्यों विद्यमान हैं क्योंकि पितृसत्ता से मुक्त होने का ताल्लुक मर्दों के मानसिक अनुकूलन से है। अपने मानसिक अनुकूलन से मुक्त हो परिवर्तित समय में पितृसत्ता अपने को कितना बदल पा रही है यह सोचने वाली बात है क्योंकि कुँवारी कन्या को अपनी यौन-इच्छा के लिए, प्रथम अवसर को अपनी मर्दानगी के लिए प्रतिष्ठा का प्रश्न मानने वाली पितृसत्ता की सोच से, इक्कीसवीं सदी में भी पुरुष-वर्ग मुक्त नहीं हो पाया है।

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विकलांगता और सामाजिक सरोकार

ओंकार प्रसाद
डॉ. गिरजा शंकर गौतम

विकलांगता और मानव जीवन के बीच गहरा संबंध है। विकलांगता न केवल व्यक्ति को प्रभावित करती है बल्कि उसके सामाजिक, आर्थिक और पारिवारिक संबंध में भी गहरा प्रभाव पड़ता है। यह प्रभाव सभ्यता और संस्कृति के विकास पर महत्वपूर्ण रहा है। सभ्यता और समाज के उद्भव एवं विकास के साथ समाज ने विकलांगता को समझने और समाहित करने के लिए नए तरीके विकसित किए हैं। विकलांगता के विषय में इतिहास में कई ऐसे संदर्भ मिलते हैं, जो अनुभव और प्राचीन जीवन शैली से संबंधित हैं। विशेष कर प्राचीन काल में जंगली प्राणियों के साथ मुठभेड़ में घायल होने का जो उल्लेख मिलता है। सामाजिक और पर्यावरण परिस्थितियों पर ध्यान देना जो उस समय मौजूद थी। प्राकृतिक आपदाओं, युद्धों और दुर्घटनाओं के परिणाम स्वरूप विकलांग हो जाते थे। यह एक विशिष्ट परिस्थितियों में से एक है। इस शोध लेख के माध्यम से विकलांगता के हर एक पहलुओं पर दृष्टिपात करते हुए उसकी सामाजिक सहभागिता पर भी बल दिया गया है, ताकि समाज में विकलांग जीवन के संघर्ष, चुनौतियाँ एवं समस्याओं की विस्तृत व्याख्या की जा सके तथा समाज को अपने विचार और धारणाओं पर पुनः विचार करने के लिए प्रेरित किया जा सकता है, जिससे समाज में विकलांगता के प्रति सहानुभूति न बढ़ कर, समानानुभूति बढ़ सके।

बीज शब्द : विकलांग-विमर्श, चुनौतियाँ, समस्याएँ, सामाजिक समानता, सरोकार, मानव जीवन, समरसता

समाज में अनेक प्रकार के विमर्श एवं आंदोलन चल रहे हैं, इन्हीं में से वर्तमान दौर का एक विकलांग विमर्श है। आजकल, समाज में 'विकलांग विमर्श' को एक नियमित आंदोलन के रूप में स्थापित करने का अभियान शुरुआत किया गया है। 'विकलांग विमर्श' की बात करने से पहले हमें विमर्श को जानना व समझना होगा। यद्यपि विमर्श : (वि+ मृश्+धञ्) 'विमर्श' संस्कृत का शब्द है। जिसका शाब्दिक अर्थ—'समीक्षा', 'विचार' व 'तालीम' है। इस शब्द का उपयोग किसी विषय की गहन छानबीन, विचारों का मूल्यांकन और अध्ययन के संदर्भ में किया जाता है। तथापि यह 'वि' का अर्थ विचार, 'मर्श' का अर्थ उपदेश देना है।

साहित्य समाज के विभिन्न पहलुओं को समझने में मदद करता है अर्थात् साहित्य समाज को एक समग्र दृष्टि प्रदान करता है। आज के समय में विभिन्न विमर्शों के माध्यम से हाशिये के लोगों को केंद्र की मुख्य धारा से जोड़ने का प्रयत्न किया जा रहा है। आज हमारे समाज

का एक बड़ा हिस्सा किसी न किसी तरह की विकलांगता का दंश झेल रही है। शासन ने विकलांगों के सशक्तिकरण के लिए कई योजनाओं का संचालन शुरू किया है। वर्तमान में प्रमुख योजनाएँ संचालित हैं। इनमें दिव्यांग भरण-पोषण अनुदान (दिव्यांग पेंशन) योजना, कृत्रिम अंग/सहायक उपकरण योजना, दुकान निर्माण/संचालन ऋण योजना, विवाह-प्रोत्साहन योजना, दिव्यांगता निवारण हेतु शल्य-चिकित्सा के लिए अनुदान योजना है। परंतु समाज के रवैये एवं धारणाओं में बदलाव न होने की वजह से दिव्यांगों को कई समस्याओं का सामना करना पड़ता है। ऐसे में साहित्य में दिव्यांग विमर्श की आवश्यकता महसूस होती है। दिव्यांगजन समाज की अर्थव्यवस्था और सामाजिक व्यवस्था की मुख्य धारा से कोसों दूर हैं। गैर-विकलांग लोगों के साथ जीवन में कई चुनौतियाँ होती हैं, उन्हें समाज के साथ सामाजिक और आर्थिक रूप से अधिक समस्या झेलनी पड़ती है। ऐसे में दिव्यांग विमर्श साहित्य के माध्यम से समाज में धारणी विकास को बढ़ावा देने की महत्वपूर्ण पहल हो सकती है। इसके माध्यम से समाज में समरसता और सामाजिक न्याय की दिशा में सुधार किया जा सकता है, दिव्यांगों के जीवन के प्रेरक प्रसंग द्वारा अन्य दिव्यांगों के अंतर्निहित ज्ञान का उत्साहवर्धन किया जा सकता है।

मानव मानव एक समान कहने वाले समाज की वास्तविक स्थिति देखी जाए तो कई वर्ग हाशिये पर नजर आते हैं। उनमें से एक विकलांग वर्ग भी है। विकलांग व्यक्तियों में आज भी चुनौतियाँ और संघर्ष हैं। समाज की परिधि से विलग होने का दर्द जो विकलांग वर्ग को झेलना पड़ता है, वह उन्हें सभ्य समाज की धुरी से विलग करता है। प्राचीन काल से लेकर आज तक समाज में उपेक्षित, तिरस्कृत, अपमानित होते चले आ रहे हैं विकलांग वर्ग।

महर्षि अष्टावक्र की कथा त्रेता युग की है। महर्षि अष्टावक्र की कथा महाभारत के वन पर्व के अध्याय 132-134 में वर्णित है। अष्टावक्र बालक आठों अंगों से टेढ़ा पैदा हुआ, इसीलिए उसका नाम अष्टावक्र रखा गया। वह एक महान ऋषि हुए, जो शारीरिक रूप से विकलांग थे, परंतु आत्मा और ज्ञान से महान् थे। अष्टावक्र जब अपनी माँ की गर्भ में था, तो उसी समय अकाल पड़ा था, तभी पिता ऋषि कहोड़ धनार्जन के लिए राजा जनक के दरबार में गए थे, वहाँ राजपंडित बंदी नाम के विद्वान ने उन्हें शास्त्रार्थ में परास्त कर दिया और शर्त के मुताबिक ऋषि कहोड़ को जल समाधि लेनी पड़ी। जब अष्टावक्र 12 वर्ष का हुआ तो पिता की मृत्यु की बात माता के मुख से प्राप्त हुई। वे अपने मामा श्वेत केतु को लेकर राजा जनक के पास पहुँचा। द्वारपाल ने बालक समझकर उसे प्रवेश नहीं दिया। तब द्वारपाल को उन्होंने उत्तर दिया, “अधिक उम्र से, न बाल पकने से, न धर्म और न अधिक भाई-बंधु रहने से कोई बड़ा होता। जो अंगों सहित संपूर्ण वेदों का स्वाध्याय करने वाला तथा वक्ता है वही बड़ा है।”¹¹

ऐसे कई उदाहरण हैं; जिनमें विकलांग वर्गों को सामान्य व्यक्ति समझकर उन्हें उनके अधिकारों से वंचित कर दिया जाता था। राजपुत्रों में पिता की संपत्ति और उसके राज्य का एकमात्र अधिकार ज्येष्ठ पुत्र को प्राप्त होता है। पांडवों में ज्येष्ठ होने की वजह से युधिष्ठिर को राजा बनाया गया परंतु हरेक परिस्थिति में यह नियम लागू नहीं था। हालाँकि भाईयों में ज्येष्ठ पुत्र धृतराष्ट्र थे लेकिन दृष्टिबाधित होने की वजह से राजा नहीं बनाए गए। अधिकतर देखा गया है कि मानसिक रूप से विकलांग वर्ग के व्यक्तियों को परिवार की संपत्ति से बेदखल कर दिया जाता है। श्रीमती चटर्जी जी ने कहा है कि “पूरे ब्रह्माण्ड का रवैया विकलांगों के प्रति उपेक्षात्मक है, जिसे बदलना ही होगा। एक राजनेता से लेकर एक आम नागरिक तक को अपना नजरिया इस परिप्रेक्ष्य में बदलना होगा और इसकी शुरुआत हो चुकी है।”¹²

मानव समाज में विकलांग हित के प्रति जागरूकता और समर्थन का वातावरण धीरे-धीरे बढ़ रहा है। प्रधानमंत्री नरेंद्र मोदी ने रेडियो पर 'मन की बात' कार्यक्रम में शारीरिक रूप से अक्षम लोगों को नया नाम दिया। मोदी जी ने कहा कि विकलांग को दिव्यांग शब्द से संबोधित किया जाना है, इसलिए कि उनके पास एक अतिरिक्त शक्ति है। "शब्दों का अपना महत्व होता है... परमात्मा ने जिसको शरीर में कुछ कमी दी है, हम उसे विकलांग कहते हैं। कभी-कभी हम जब उनसे मिलते हैं तो पता चलता है कि हमें आँखों से उनकी यह कमी दिखती है, लेकिन ईश्वर ने उन्हें कुछ एक्स्ट्रा पॉवर दिया होता है। एक अलग शक्ति का उनके अंदर परमात्मा ने निरूपण किया होता है। मेरे मन में विचार आया कि क्यों न हम देश में विकलांग की जगह पर दिव्यांग शब्द का प्रयोग करें। ये वे लोग हैं, जिनके पास एक ऐसा अंग है या एक से अधिक अंग हैं, जिनमें दिव्यता है।" यह एक सामाजिक सकारात्मक बदलाव है, समाज में सामाजिक समरसता और सहानुभूति की दिशा में मदद मिल रही है। विकलांगों को समाज में समावेशन एवं उनके अधिकारों के सशक्तिकरण में महत्वपूर्ण भूमिका रही है, जिससे समृद्धि एवं सामाजिक समानता की दिशा में सुधार हो रहा है। समाज में विकलांगों के सहयोग के लिए कई आश्रम और अस्पताल बनने लगे हैं। देश-विदेश में जहाँ विकलांगों को बोझ समझा जाता था, वहीं उनके उत्थान के लिए शिक्षा और जागरूकता का प्रचार-प्रसार किये जाने लगा है। दृष्टि बाधित और मुख बधिर के लिए विशेष विद्यालय की स्थापना की जा रही है जिससे उनकी शिक्षा का प्रबंध अच्छे से किया जा सके। "विकलांग-विमर्श इस पर भी चिंतन करता है कि सामंती सोच के स्थान पर समाजवादी सोच के ढंग से साहित्य को निरखा-परखा जाए और आधुनिक संदर्भ में उसकी प्रासंगिकता को उचित ढंग से प्रस्तुत किया जाए।" 12

प्रगतिशीलता की परिभाषा को समझना एवं बदलना हमारे दृष्टिकोण और कृतियों में महत्वपूर्ण बदलाव ला सकते हैं। इस तरह हम नये सोच-विचार के साथ समस्या का हल खोज सकते हैं। विषय-विमर्श से हम नये-नये दृष्टिकोण प्राप्त कर सकते हैं, समस्याओं के समाधान के लिए नये रास्ते खोजे जा सकते हैं। विचारशीलता और विचारों के परिपूर्णता में आगे होना महत्वपूर्ण है परंतु ध्यान देने योग्य बात है कि वह विचार-विमर्श, केवल और केवल पुस्तकों, पुस्तकालयों की शोभा बनकर ही न रह जाये, इस पर विमर्श होना जरूरी है। हमारा विमर्श प्रयोगवादी नहीं होगा तब तक, मानव का कल्याण संभव नहीं है।

हम संक्षिप्त रूप में अभी एक विषय के विमर्श की बात करेंगे। प्रेम एक गहरा और व्यापक भाव है, जिसमें आस्था, निष्ठा, दया आदि शामिल होती है। यह हमारे जीवन में महत्वपूर्ण होता है और समाज में सामाजिक संवादिता एवं सहयोग को बढ़ावा देता है। ये भाव कैसे आएँ? यह विचारणीय हैं, जब तक एक-दूसरे के प्रति प्रेम, दया, निष्ठा नहीं होगी तब तक हम एक-दूसरे से नहीं जुड़ पायेंगे अर्थात् हाशिये के लोगों तक कभी नहीं पहुँच पायेंगे।

वर्तमान में विमर्श करके हम विषय की गंभीरता की व्याख्या तो करते हैं, परंतु हमारे बीच इसका नतीजा कैसे हो? इस पर भी विचार होना चाहिए, आज किसी को न पुस्तक पढ़ने का शौक है और न समय है। इसमें गिने-चुने लोग ही रुचि रखते हैं। शोध परक सामग्री की तलाश में शोधार्थी भी इसका अध्ययन करते हैं परंतु जो कार्य आज हो रहा है, वह निश्चित रूप से भविष्य के लिए रास्ता खोलेगा।

विकलांगों के प्रति हमारे अंदर सेवा का भाव तब आएगा जब उनके दुःख-दर्द और पीड़ा को समझेंगे, सांसारिक दुःख और दर्द का कारक भूत और भविष्य की चिंता ही है, जो हमें

आगे बढ़ने में बाधक है इसलिए अनेक कोशिशों के बावजूद भी हम एक स्थान पर खड़े नजर आते हैं, जहाँ पर बरसों पहले खड़े हुए थे। विकास को हमने रुपयों-पैसों, पहनने-ओढ़ने, मान-अपमान से जोड़कर रखा है। विचारों को विकसित करने का कभी विचार विमर्श ही नहीं किया। जबकि विचार शक्ति ही जीवन की दशा और दिशा प्रदान करने वाली सच्ची ताकत है।

दुःख का भोक्ता कोई किसी का नहीं बन सकता। सिर्फ मन को समझाने के लिए शब्द जाल बुना जा सकता है। जिस ईश्वर ने हम सबको इस संसार में भेजा है, किस काम के लिए भेजा है, यह सब उसका विधान है। हमें कोशिश करनी चाहिए कि विधाता के लिखे विधान का एक हिस्सा बन जाएँ। हमारा चिंतन-मनन उसी के बताए रास्ते पर चले, तब कहीं जाकर इस भवसागर को पार करने का साहस मिलेगा और सुख-दुःख साथ होगा। विषय विमर्श ही इस धारा चिंतन का प्रकाश है, जब यह प्रकाशित होने लगता है तो विभिन्न दिशाओं के रास्ते दिखने लगते हैं। हम उस रास्ते पर चल रहे हैं जहाँ उन असहाय प्राणियों में ईश्वर ने अपने गुण-अवगुण का दर्शन कराया है, एक-दूसरे की इंद्रियाँ कार्य करने लगती हैं। यही ईश्वर कृपा का दर्शन है, इस दिशा में किये जा रहे कार्य, लोक कल्याणकारी हैं। जिसमें से विकलांगों के लिए किये जा रहे कार्य, लोक कल्याणकारी हैं।

विकलांगता, समाज का एक अभिन्न एवं महत्वपूर्ण हिस्सा है। समाज में समानता और समरसता का हक प्राप्त है, इनके उत्थान के लिए सरकार और समाज सेवा संगठन विकलांगों के लिए नैतिक और कानूनी समस्या को सुनिश्चित करने के लिए अनेक योजना बना रहे हैं, इसे नकारा नहीं जा सकता। यह एक विचार विमर्श का विषय है। मानव एक विवेकशील प्राणी है। मानव अपनी विवेकशीलता से समाज के विकास की ओर अग्रसर होता है। वह समाज में साझा काम करता है, समाज में रहकर, समाज के प्रति नैतिक और सामाजिक नियमों का पालन करता है, अपने आस-पास के वातावरण को सुधारने के लिए उपाय ढूँढ़ता है फिर वह विकलांग हो या सकलांग। समाज में असामान्यता, वैविध्यता सर्वमान्य एवं सर्वव्यापी है। समय के अनुरूप विकलांगता का विषय भी इससे अछूता नहीं रहना चाहिए। किसी भी प्राणी को देखकर हमारा हृदय, उसके प्रति सहानुभूति एवं स्नेह से भर उठता है। डॉ. संगीता परमानंद के अनुसार, “विकल स्वयं ही अपनी विकलांगता को लेकर हताश-निराश एवं सतत संघर्षमय रहता है। उस पर समाज का ऐसा उपेक्षापूर्ण व्यवहार उसे सामाजिकता के लिए सदैव से भिन्न कर देता है। इस वर्ग की इसी भिन्नता को अभिन्नता में परिवर्तित कर समाज में उसे उसका यथायोग्य स्थान प्राप्त करने में सहयोग ही सामाजिक पुनर्वास है।”⁵

विकलांगता या अपंगता किसी के जीवन को नष्ट नहीं करती और ना ही अभिशाप है। यह एक व्यक्ति के द्वारा समाज में किए जाने वाले सामाजिक, व्यक्तिगत और पेशेवर सफलता के मायने में किसी भी तरह की बाधा नहीं होती है। समाज में ऐसे भी अपंग हैं जो अपनी विकलांगता को, अपनी विशिष्टता बना लेते हैं और जीवन में आगे बढ़ जाते हैं जिनसे हम अनवरत प्रेरित होते हैं।

विकलांग साहित्य और कला के माध्यम से हमें विकलांग समुदाय के प्रति समझदारी और सहानुभूति का दृष्टिकोण प्राप्त होता है। इससे समाज में साहस और न्याय की भावना विकलांग वर्ग व्यक्त करते हैं। कुछ लोगों में विकलांगों के प्रति गलत धारणाएँ और अंधविश्वास के भाव के प्रवृत्त होते हैं। ऐसे में अंधविश्वास और गलत धारणाएँ विकलांग वर्ग को और

भी समस्या में डाल देती है और उन्हें समाज में समरसता की ओर बढ़ने में अवरोध पैदा करती हैं। कुछ लोग विकलांगता को पूर्वजन्म के कर्मों का फल मानते हैं। समाज में विकलांग हमेशा प्रताड़ना के अधिकारी माने जा रहे हैं। सकलांग लोगों की तरह विकलांग वर्ग भी जीवन जीना चाहते हैं परंतु जी नहीं पाते। उनका जीवन उपेक्षाओं का सामना करते-करते यूँ ही बीत जाता है। शारीरिक रूप से विकलांग व्यक्ति में से कुछ अपनी बुद्धिमत्ता की वजह से इतिहास प्रसिद्ध हो गए हैं। आम व्यक्ति को जो अधिकार है वह विकलांग वर्ग को भी है। विकलांगजनों के द्वारा समाज के प्रति आदर्श एवं सम्मान का भाव है तथा विकलांग समाज चाहता है कि वह सकलांग समाज के साथ आर्थिक, सामाजिक और राजनैतिक आदि प्रत्येक कार्य में कंधे से कंधा मिलाकर चले व समाज में सामान्यजन की तरह अच्छा स्थान प्राप्त करे। वे इतने आगे आ गए हैं कि संसार के प्रत्येक कार्यों में अपना अहम योगदान दे सकें।

जन्मजात, नैसर्गिक अथवा अन्य दुर्घटना के कारण से शरीर के किसी अंग की अक्षमता वस्तुतः विकलांगता है। “कुदरत की दी हुई शारीरिक, मानसिक दुर्बलता, न्यूनता या विरूपण ही विकलांगता है।”⁶ यह एक अनापेक्षित, अनामंत्रित घटना है, जिसके लिए किसी एक कारण को दोषी ठहराना सरासर नाइंसाफी होगी। उम्र, जाति, वर्ण, संप्रदाय, वर्ग, धर्म, लिंग की सीमाओं से परे कोई भी इसका शिकार हो सकता है।

समाज में अनेक लोग निवास करते हैं, कोई प्रकृति को ईश्वर मानकर प्रकृति प्रदत्त सभी चीजों को ‘दिव्य’ मानता है तो कोई इसे नकारते हुए ‘विकलांग’ भी कहता है। वास्तव में ईश्वर या प्रकृति प्रदत्त दिव्यांगता को न देख सकने वाला व्यक्ति, समाज मानसिक रूप से विकलांग है, यही विकृत मानसिकता वाले लोग विकलांग की श्रेणी में आते हैं। ऐसे अनेक उदाहरण हम देख सकते हैं। जो सकलांग समाज को पीछे छोड़ते हुए दिव्यांग वर्ग के लोग आगे निकल आते हैं विनय कुमार पाठक के अनुसार, “सुविधाभोगी विकलांग के पास आँख है पर दृष्टि नहीं, हाथ है पर कर्म नहीं, पाँव है पर प्रचलन नहीं, एयरकंडीशन है पर शीतल-मंद सुगंध-समीकरण नहीं, लजीज व्यंजन है पर पाचन शक्ति नहीं, इनलप बैड है पर आँखों में नींद नहीं, बंगला है पर घर नहीं, परिवार है पर प्यार नहीं, समाज है पर जुड़ाव नहीं। वस्तुतः यही व्यक्ति वास्तविक विकलांग है जिसके लिए उपयुक्त उपचार होने से चिकित्सा भी लाचार है।”⁷

निष्कर्ष

विकलांगता का दंश झेल रहे वर्गों का आज समाज में संघर्ष व चुनौतियाँ तो कम नहीं हैं परंतु दया का पात्र बनाने की जगह उन्हें सामनानुभूति, सामर्थ्य, साहस, सशक्त और स्वाधीनता की दिशा में प्रोत्साहित करना आवश्यक है। विकलांगों को समाज सहित मिलकर उनके पूर्ण सशक्तता को बढ़ावा देने का समर्थन करना चाहिए। समाज में सबको विकलांगों के उत्थान व कल्याण के लिए अपनी सामर्थ्य, दक्षता और प्रखरता का साथी बनाना बहुत जरूरी है, ताकि वह समाज के साथ सजग और आत्मनिर्भर बन सकें और आत्म सम्मान की जिंदगी जी सकें।

हमारा कर्तव्य है कि ऐसा रास्ता अपनाएँ जिससे विकलांग वर्ग हताशा, दिशाहीनता की दुर्भाग्यपूर्ण स्थिति से उबर सके। अपनी ऊर्जा का सदुपयोग कर सके। समाज में बुद्धिजीवी वर्ग को सामने आकर विकलांगों को ऐसा मंच देना होगा। जहाँ वे वैचारिक आदान-प्रदान कर सकें, उन्हें सही विचारधारा, सकारात्मक सोच व उचित दिशा-निर्देश प्राप्त हो सकें।

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