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Centurion Journal of Multi-disciplinary Research is a refereed journal, which serves as a platform for exploring the current issues, challenges and linkages in the broad areas of development, technology, engineering and management. There is a special focus on skill development and education, its recognition and promotion in the country, especially with the 'Make in India' initiative by the government of India. The objective of the journal is to facilitate bringing together research based contributions in science, technology, management and skills that has direct implication for the development of under-privileged communities and empowering them. The journal links theory and practice in the above areas so as to have policy and programme implications, particularly in under-developed contexts. In addition to articles from individuals or collectives, the journal publishes book reviews.

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- Encouraging multi-disciplinary cooperation and understanding, and enhancing quality research.

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Editorial

Science is a systematic way of studying things and answer to a question based on the observations. Technology is the application of scientific understanding to a practical area. Today science and technology are focused mainly on materials and life sciences. Computational tools have boosted the research in different areas.

Earlier materials were studied in the macro scale. With the advent of various sophisticated tools such as, scanning electron microscopy or transmission electron microscope people started research on the nanoscale materials. The nanomaterials opened up a new range of properties which those materials do not show in the bulk. The surface area to volume ratio and possible appearance of some quantum mechanical effects changed the way of materials research. Coprecipitation, hydrothermal technique, ion sputtering, micro/nano emulsion, laser ablation, sol-gel, ultrasonic techniques, plasma discharge, template synthesis, biological synthesis etc. are commonly used to prepare nanomaterials. One of the major challenges in nanoparticle synthesis is the size distribution. Templates (such as protein cage, filter paper, microbes), crosslinked polymer, nano emulsion methods are gaining popularity to have a narrow size distribution. The research on nanomaterials reached the next level with the invention of carbon fiber and graphene. Today the major sources of carbon fiber are polyacrylonitrile and pitch. However, carbon fibers obtained from both the sources are very costly. Thus, research is going on to replace those materials partially by low-cost biological materials such as lignin.

Today the time to develop new materials with desired properties has reduced significantly due to the use of different computation techniques and software. Modeling, simulation, theory, and informatics are often utilized by materials science researchers. Improvement of artificial intelligence and machine learning techniques has helped researchers to predict the composition to achieve desired properties with minimum number of physical experiments. Thus, computational tools are reducing the wastage of materials, money and time.

The sustainable development goals (SDG) set by the United Nations have influenced many researchers to work in the area of life sciences. SDG 2 focuses on zero hunger. To meet the goal significant amount of research is going on in the fields of agriculture, genetics, and pisciculture. Agriculture is the major source of food. On the other hand, this area is one of the most challenged one. Various biotic and abiotic stresses cause damage to the crops. Thus, the researchers are trying to develop technologies to reduce the stresses. Intercropping and food forest are some of the techniques used to save the crops under stresses. Researchers are also using genetic modification techniques to provide the plants capacity to resist the stresses. Mutations of genes or inhibition techniques are often utilized to provide the crops stress tolerance property. Fishes are also an important part of food, especially as a major source of protein. Research is going on to improve the quantity and quality of fishes. In addition to conventional techniques IoT and sensors are playing a major role in monitoring the growth of fish.

No science and technology can be sustainable if it neglects the environment and ecosystem. Scientists have put significant effort to save the environment. They are monitoring the flora and fauna to identify probable threats. Any new species attracts the scientists to explore the reason. On the other hand, extinction of any species causes alarm and indicates where things went wrong.

Research is a continuous process to explore unknowns. It helps us know new things; at the same time, it teaches us new responsibilities. The objective of modern research should be focused on sustainability and green technologies. People need to develop new materials, new crops or new breeds without adversely affecting the environment. We all look forward towards a greener earth with all the living species protected.

Dr. Susanta Kumar Biswal

Contents

Articles

Gene expression in Eukaryotes: Regulated at multiple check-points

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Ramya Chandran[1]

Abstract

A web of events which are inter-related and highly regulated determines the fate of gene expression. Essentially, these vital events are broadly categorized into two types, namely, post-transcriptional and post-translational events. Primarily, processing mechanisms of pre-mRNA including polyadenylation, capping, splicing and modifications of RNA through changes in chromatin (siRNAs, long non-coding RNAs, miRNAs) are included under post transcriptional events. Whereas protein modifications including SUMOylation, ubiquitination, phosphorylation are some of the events which occurs post translation. Both post-transcriptional and post-translational events are considered to be constitutive and also are aggravated by endogenous and exogenous factors. Particularly, in plants, regulation of gene expression is yet to be fully understood. These molecular events ensure proper occurrence of the factor/s required which would ultimately modulate several downstream cellular processes. This review primarily focuses

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on some of the key post-transcriptional and post-translational events which are significant in deciding the fate of eukaryotic gene expression.

Keywords: Replication, messenger RNA, post-transcriptional modifications, protein modifications

Introduction

Exterior framework of an organism typically referred to as the phenotype, is generally determined by the functional proteins, though their sequence is encoded in DNA. The genetic expression is regarded as one of the elemental process which plays a vital function in the changeover of the complex genome to a substantial life. Since genetic expression process is a strongly regulated event, so any sort of misregulation may escort to distorted physical life which includes a variety of genetic diseases. Till date, it is pretty well recognized that the genetic expression is synchronized at a variety of levels and these miscellaneous mechanisms are well included as a food web (Maniatis & Reed, 2002). The regulatory mechanisms controlling gene expression is primarily divided into two main types (1) Post-transcriptional mechanism and (2) post-translational mechanism. Additionally, upstream of these two events, DNA is mostly synchronized at the transcriptional level prior to entering into the transcription event. Quality control of RNA at the post-transcriptional level is a very important concern for all organisms to ensure precise gene expression, both qualitatively and quantitatively. Transcriptional process has been expansively premeditated as compared to that of post-transcriptional and post-translational events for the reason that of scientific aspects. It is apparent that transcription is one of the essential and instinctively imperative steps within the multistep processes involved in regulation of gene expression and also the scientific methods to decode transcriptional regulation are very well recognized. Post-transcriptional regulation mechanisms engage diverse events such as messenger RNA processing which includes 5' end capping, polyadenylation and intron splicing. Export as well as localization of messenger RNA, messenger RNA decay, and translation of messenger RNA are also included. Regardless of this array of regulatory mechanisms, lone thing in general is that they eventually control where and when a messenger RNA is translated to protein. As a result, translation and its regulation are extremely fundamental to post-transcriptional regulation of gene expression. The regulatory mechanisms controlling post-translational events are known as posttranslational modification (PTM), essentially which refers to several types of covalent and enzymatic modifications of proteins occurring following to their synthesis. Post-synthesis of proteins through ribosomes, they endure PTM in order to shape the mature and functional protein product. PTMs may arise on the side chains of amino acid or else at the N- or C- terminal of proteins (Pratt 2006). Phosphorylation is quite a regular mechanism for modulating the enzymatic activity and is also most common PTM (Khoury 2011). Countless eukaryotic proteins harbor carbohydrates attached through a process called as glycosylation, which mostly induces stabilization and protein folding, thus allowing the newly synthesized proteins to perform regulatory functions. Alliance of lipids commonly recognized as lipidation, chiefly aim a specific protein or a part of it which is adhered into the cellular membrane. Additional forms of PTMs comprises of cleavage, as in the case of synthesizing a mature form of protein by processing a given pro-peptide. Occurrence of disulfide bonds, formed due to cysteine residues, also is referred to as a type of PTM (Harvey Lodish 2000). PTMs also occur as a result of oxidative stress (Dalle-Donne 2006). Protein aggregates formed post protein degradation may be referred to as carbonylation which primarily targets the newly synthesized protein. Modifications in unambiguous amino acids can thus be applied as biomarkers signifying oxidative dent (Grimsrud 2008).

RNA Processing and export

Prior to the transfer of mRNA from nucleus to the cytoplasm for getting accessible to the translational apparatus, it needs to experience a sequence of dispensation steps: firstly, at the 5' end, the messenger RNA bears a cap like structure, then, splicing event initiates leading to the splicing out of introns harboring in the pre-messenger RNA, finally a specific 3' end of the mRNA is synthesized, usually referred to as polyadenylation. Every event advance cotranscriptionally and influences each other (Proudfoot et al. 2002). Initially, m7G cap is added at the 5' end of the budding mRNA and occurs following synthesis of 20-30 nucleotides. This event primarily is a complex process and occurs in a three-step process. At first, the guanosine mono phosphate (GMP) domain from the GTP is supplemented into the foremost nucleotide present in the pre-mRNA and then, GMP is methylated specifically at location N7. For the stability of mRNA and translation process, the m7G cap is imperative. Inside the nucleus, the m7G cap gets associated along with the cap binding complex (CBC). CBC contains two subunits and after being moved into the cytoplasm, it forms a complex with the translation initiation factor 4E (eIF4E), which is essentially an indispensable tread in the initiation process of translation. Since the coding sequences (exons) of a large amount messenger RNAs incase of the higher eukaryotes are broken up by the presence of introns, thus these group of introns needs to be chopped off of the pre-messenger RNA to create functional messenger RNA. Consensus and conserved sequences are required for splicing of the mRNA, which primarily marks the exon-intron limits, and the spliceosome, commonly referred to as the catalytic complex carries out the enzymatic reactions to eliminate the introns and ultimately ligate the flanking exons. Usually, snRNPs are made up of a small nuclear RNA, commonly referred to as snRNA, and associated proteins, many of which are accessory proteins. Preferably, almost hundred of proteins are believed to be engaged as factors, primarily involved in splicing event (Jurica & Moore, 2003). Splicing reaction undergoes catalysis process and this event is reliant on RNA-RNA, protein-protein and RNA-protein interactions. Moreover, the unconventional use of exons, referred to as alternative splicing can also add to the formation of protein diversity (Matlin et al. 2005) by allowing a single gene to fabricate manifold isoforms. In higher eukaryotes, mRNAs coding for histone proteins lack poly (A) tail, but this is absent in yeast (Fahrner et al. 1980). Polyadenylation at the 3' end occurs in two steps: Firstly, the newly synthesized messenger RNA is cleaved at the site mostly where the polyadenylation is destined to initiate, and then processed for poly (A) creation. In resemblance to the splicing, the polyadenylation protein complex is required for poly (A) tail configuration and also explicit sequence-elements above the pre-messenger RNA. This hexamer (AAUAAA) is essentially associated by the cleavage and polyadenylation specificity factor (CPSF) (McLauchlan et al. 1985).The downstream elements associate with the cleavage stimulatory factor. Cleavage factor I and cleavage factor II are also obligatory. Both the poly(A) polymerase (PAP) and the cleavage and polyadenylation specificity factor are mandatory, the cleavage stimulatory factor, CstF is also indispensable for the endonucleolytic cleavage to occur, and CstF together with the CPSF are indulged for recruiting CF I and also, the CF II.The synthesis of poly (A) tail occurs in the same way both in the case of yeast and mammalian cells. The protein factors concerned largely bear orthologous components, but also explicit accessory machinery that are specifically found in any one of the species.Additionally, in case of yeast cells, the AAUAAA hexamer pattern is replaced by an erratic A-rich element and instead 3 polyadenylation complexes are present. Cleavage Polyadenylation Factor (CPF), which bears numerous factors which are homologous to CPSF and also the cleavage factor IA (CF IA), poly(A) polymerase and cleavage factor IB (CF IB). The rising poly (A) tail is associated by the poly (A)-binding protein (PAPB). The PABP is mainly thought to persuade the ultimate length of the poly (A) tail, positively by invigorating the processivity of poly (A) polymerase, and negatively by associating with the poly (A) nuclease (PAN) (Mangus et al. 2003). Moreover, PABPs are concerned with nuclear export and are also imperative for the launch of translation.The poly (A) tail is critical for quite a lot of superfluous mechanisms regulating post-transcriptional events, occurring in the cellular cytoplasm. The translational state can also be standardized via cytoplasmic polyadenylates and steadiness of a range of target messenger RNAs by manipulating the length of the poly (A) tails (Parker and Song, 2004). In recent times, poly (A) tails deadenylation has also been exposed to ensue in micro RNA-mediated regulation (Giraldez et al; Wu et al. 2006). The very last component in the expedition from the nucleus (space of transcription process) into the cytoplasm is the nuclear export of the mature messenger RNA. Export occurs through the nuclear pore complex and happens in the perspective of messenger ribonucleoprotein complexes (mRNPs). Messenger ribonucleoprotein complexes embrace messenger RNA and several associated RNA-binding proteins, which associate to the messenger RNA during the progressing steps (Aguilera 2005). These protein components (Exon Junction Complex, EJC) are imperative for the organization of the mRNP complex with the nuclear pore complex and the shuttling from nucleus into the cytoplasm, and a few of them settle, allied with the messenger RNA as it is moved out, whereas others are constrained within the nucleus. Moreover, nuclear export is an central step in quality control, as damaged or un-processed messenger RNAs are not only ineffective, but also potentially detrimental, if incase gets translated within the cytoplasm. Only physiological messenger RNAs are transferred into the cytoplasm from their site of synthesis and particularly this surveillance step is very closely united to RNA processing and the composition of mRNP.Yet again, it needs to be highlighted that, regardless of the introduction of messenger RNA transcription and other downstream chronological events occurring in the cell are well integrated among each other and are not independent in temporal and spatial perspective (Proudfoot et al. 2002; Aguilera & Moore, 2005).

Significance of translational regulation

A varied number of reasonable benefits do occur since the translational regulation is perfectly fitted. Most importantly, the translational regulation happens as an immediate retort without the requirement of undergoing the several processes involved in regulating gene expression such as transcription, processing of messenger RNA or even export of messenger RNA. Moreover, the regulatory mechanism of translation is a reversible in nature since it involves quite a lot of reversible protein structure alterations like, the phosphorylation of several initiation factors. Control of translational machinery is very much inevitable, particularly in the systems where transcriptional regulation is not promising like in the case of reticulocytes, they lack nucleus, RNA viruses or oocytes. Most importantly, the translational regulation is primarily, spatial control of gene expression inside the cell (St Johnston 2005). The significance of dedicated translational regulation is realized especially for localized protein assembly within neurons or else throughout the development process, since transcriptional regulation is limited to the cellular nucleus (Schuman et al. 2006). For regulating gene expression, translational regulation is a superior alternative owing to its flexible nature. There are numerous molecular targets for regulation of translational process, which ultimately affects the efficiency of translational event for numerous or a few messenger RNAs. Most remarkably, for fine tuning of gene expression cells regulate the translational machinery, as there are several number of genes such as GADD45á or TNF-á which are regulated at the transcriptional and translational level (Saklatvala et al. 2003; Lal et al. 2006).

Effectors for regulation of translation: Initiation factors, messenger RNA (mRNA) and the ribosome

Translational control is well regulated at a comprehensive level as well as in a messenger RNA specific manner (Gebauer & Hentze, 2004). Primarily, large-scale regulation affects the effectiveness of translation machinery of many messenger RNAs through a common switch-on and switch-off of translation process. The translation of a subset of mRNA is affected by mRNA-specific regulation. Mainly, translational regulation allows or forbids the union of the messenger RNA with that of the translational apparatus. A fundamental target in several regulatory mechanisms is the cap binding protein, eIF4E which binds to many inhibitory proteins, resulting in the unavailability of the messenger RNA. Comprehensive regulation of translation is universally mediated through such modifications, especially of the translation initiation factors. An additional target for translational regulation is the messenger RNA itself. The cis-regulatory elements associate with trans-acting factors. The cis-regulatory elements present on the messenger RNA could be present anywhere along the messenger RNA, but typically for the translational regulatory factors, these vital elements are present in the 5' UTR or 3' UTR. Translational regulatory events mediated by messenger RNA, occurs mostly by numerous regulatory proteins, which primarily bind to the cis-regulatory elements of a given messenger RNA.

The ribosome itself may also become one of the targets of translational regulation. Quite a lot of its protein constituents undergo post-translational modifications. An exemplar is the phosphorylation process of ribosomal protein S6 mediated by ribosomal S6. It has been reported that the phosphorylation of ribosomal protein S6 fallout in an augment in translation initiation. Ribosomal proteins also undergo a post-translational modification, ubiquitination (Spence et al. 2000) and methylation. Many studies points towards the heterogeneity of ribosomes; the cell is able to construct a range of different kinds of ribosomes (Bachand & Silver, 2004; Swiercz et al. 2005), which essentially differs in terms of paralogue composition and post-translational modifications, and many a times dedicated ribosomes could also play a role in the translational regulation of specific subsets of messenger RNAs.

Novel components in translational control: Processing bodies and micro RNAs

Recently, two novel ways to direct messenger RNA turnover at the posttranscriptional level have gripped a immense deal of consideration. The discovery of processing bodies localized in the cytoplasm of a cell, which were originally considered as foci inside the cell with a high concentration of enzymes meant for messenger RNA decay (Bashkirov et al. 1997), has been a significant outreach in the scientific field. The added detection is that of small RNAs, which may amend the permanence and translation of targeted messenger RNAs (Bartel 2004). Processing bodies are most likely a site of messenger RNA decay. Processing bodies were first characterized by several groups using several scientific techniques such as microscopy, as factors involved for the perishing of messenger RNA decay and other factors like LSM, XRN1, DCP1 and DCP2 accumulate in the foci (Bashkirov et al. 1997). The messenger RNA decay in case of eukaryotes is mainly controlled in diverse ways mostly by exonucleolytic or endonuleolytic pathways. Degradation occurring through exonucleolytic pathway is typically initiated by deadenylation of the poly (A) tail of the messenger RNA. Then the transcripts will be tarnished from their 52 ends mostly by the exonuclease such as XRN1, subsequent elimination of the 5' cap, known as decapping. On the other hand, the exosome complex can debase transcripts from their 32 ends prior to decapping. Factors involved in the nonsense-mediated decay process, which are responsible for the hasty dilapidation of messenger RNAs with a untimely stop codon are also found in mammalian processing bodies (Conti and Izaurralde 2005).

Nonsense-mediated messenger RNAdecay (NMD), which is possibly the best-known translation-dependent regulatory mechanism specifically in eukaryotes, selectively destroys messenger RNAs as a means of post-transcriptional gene control. NMD occurs by the association of three core protein factors, UPF1, UPF2 and UPF3 (Kim et al. 2009). Control can be for the purpose of ensuring the quality of gene expression.The relation between the processing bodies and messenger RNA turnover rate is still captivating.The precise mechanism how messenger RNAs shuttle into the processing bodies and become repressed from translation is not yet clearly deciphered. Small RNAs are mostly rib regulators that have significant roles in most of the eukaryotes. They inhibit the gene expression by acting either on DNA to direct sequence abolition and chromatin remodeling, or on the RNA to direct cleavage and eventually regulate the translation expression (Hervé Vaucheret 2006). Micro RNAs (miRNAs) and short interfering RNAs (siRNAs) are the two categories of small RNA molecules that appeared as regulating factors of messenger RNA stability and translation. Both the miRNAs and siRNAs are short RNAs ranging around 20-27 nucleotides and are differentiated based on their biogenesis (Kim 2005; Jackson & Standart, 2007). miRNAs are principally derived from longer precursors that mostly comprise of a ~75 nucleotide improperly based hairpin segment. siRNAs are of comparable length but are derivative of complementary RNA precursors. During RNA interference (RNAi), siRNAs which are exogenously introduced target messenger RNAs for cleavage in an endonucleolytic manner (Tomari & Zamore 2005). In case of animal cells, a large amount miRNA are only partly complementary to their target messenger RNAs and the down-regulation of translational product of the target is typically greater than the down-regulation of its messenger RNA profusion, which suggests regulation at the stage of translation (Jackson & Standart, 2007).

Posttranslational modifications of proteins

Posttranslational modifications (PTMs) of proteins largely involve covalent alterations that occur subsequent to the translation process. The newly synthesized nascent proteins are eventually exposed to a string of specific enzyme-catalyzed alterations located on their backbones or side chains. Two extensive types of protein posttranslational modifications occur. The first type includes every enzyme-catalyzed addition of a few kinds of chemical groups, typically an electrophilic part of a substrate, towards the side chain residue of a protein.This modified side chain is generally electron rich and act as a nucleophile in the transfer process.The second type of PTMs is covalent cleavage of the peptide backbones in proteins. It occurs either by protease action or less commonly mediated by autocatalytic cleavage.A lot of diversifications can be seen in the side chains of amino acids (Walsh et al. 2005).

Covalent modification of Proteins

Fundamentally, there are five most frequent types of covalent additions occurring to proteins. They are acylation, phosphorylation, alkylation, oxidation and glycosylation, which are generally catalyzed by dedicated posttranslational modification enzymes. Thus, the protein products obtained in this mode result into making up subsets of the complete proteome of an organism commonly referred to as the acyl proteome, the phosphoproteome, the alkyl proteome, the oxidized proteome and the glycoproteome. Most remarkably, every sub proteomes add to extensive diversity (Walsh et al. 2005).

Posttranslational Modification: Reversible and Irreversible

Because of the cellular requirement of a meticulous covalent modification occurring in a protein, reversibility and irreversibility of the specific protein modification is critical. The epitome of reversible modification is mainly the protein phosphorylation, reliable with its advancement to the foremost role in protein-based signaling in eukaryotes. All PTMs apart from alkylation have committed enzymes. Mostly, large enzyme families mediate the amputation of several covalent modifications. The enzymes which are involved in acylation, reverse phosphorylation and glycosylation are mostly specific hydrolases, while cleavage of disulfide bonds is mediated by reductases (Walsh et al. 2005).

Conclusion

The self-fidelity and unswerving post-transcriptional and post-translational mechanisms make sure of a safe and sound pathway for the genetic makeup, primarily the DNA of an organism and carries out the critical changeover of the DNA into a functional protein which eventually results into an healthy physiological environment within the cell. This interrelationship and interdependence prevailing among different molecular events similar to a spider's web provides the foundation for a fault free "Central Dogma" of molecular life.A number of events occurring within a cell irrespective of the nature of product to be formed, whether RNA or protein, surveillance mechanisms ensures the fidelity.These molecular events are essentially very critical for maintaining the homeostasis within the cell. For instance, maximum number of immune related genes, both in plants and animals, are tightly regulated by the quality control mechanism, NMD. NMD ensures that during normal and healthy conditions (pathogen unchallenged condition); these immune genes do not synthesize their protein counterparts. This regulation critically saves a lot of energy for the organism by not synthesizing unwanted protein factors. Whereas, the same NMD process shuts off when the organism is challenged with any sort of pathogen and allows the expression of protein factors responsible for defense mechanism. In a nutshell, understanding and deciphering the role of different posttranscriptional and posttranslational events would be critical for future benefits.

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Age and Growth Analysis of *Puntius ticto* relative to other common carps

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Sanjoy Louha[1] and Binit Kumar Sahu[1,2]

Abstract

Age and growth study provide detail information on the life history, ecology of fish and habitat which is important to manage the water body for fish production and optimize of harvestable size. Scale based age and growth of Indian major crap (*Labeo rohita*, *Cirrhinus mrigala and Puntius ticto*) was studied. There is no significance occurs in between the species. Such studies are helpful in describing the present status of fish population along with the future course of the fishery.

Keywords: Scale, age determination, *Labeo rohita, Cirrhinus mrigala, Puntius ticto*

Introduction

Determination of age and growth is an age old practice. Age and growth studies are important for the problem associated with management of fisheries. Age determination of fish from scale, vertebrate fins, spines, fin rays and other structure are usually performed (Secor et al., 1996).

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The age of fish can be estimated indirectly the length frequency distribution. From which it can obtain the mean length of each age group or directly by counting and analysis of the annual growth marks in calcified structure such as scale, otolith, opercular bone and fin rays of each specimen (Bhatt & Jahan, 2015). Some authors describe the length weight relationship in various fish scale and age (Summerfelt & Hall, 1987; Naeem et al. 1992). Age determination in fish is fundamental for the management of fisheries (Hilborn and Walters 2013). Age determination of fish is useful for understanding fish life history and their population dynamics (Beddington & Kirkwood 2005). The many body parts of fish that is scales, opercula, vertebrae, spines, fin rays and otoliths (Casselman 1983) are available for ageing fish and these structure are used for comparative purposes (Vilizzi and Walker 1999: khan and khan 2009). In India 31 species of *Labeo rohita* were found. (Talwar & jhingran 1991). Labeorohita (Hamilton, 1882) commonly known as Rohu is the one of the most commercially important fresh water fishes. It belongs to the family Cyprinidae and order Cypriniformes. It is found in all tanks and ponds (Beavan 1877; Jhingran 1991). *Labeo rohita* are typically full scaled and silvery, black grey, olive green or yellow-brownish coloured (Kirpichnikov 1967, Balon 1995, Lintermans 2007; Begenal, 1974; Mills & Beamish, 1980 and Panfili. et al. 2002). The fish is covered with cyclod scale (Hamilton,1882). *Cirrhinus mrigala* (Hamilton, 1882) commonly known as Mrigala is a carp native to the river of Indo-Gangetic plains of India and Pakistan. It belongs to the family Cyprinidae and order Cypriniforms (Hamilton, 1882; Kirpichnikov, 1967; Balon 1995; Linterman 2007). In natural environment it grows in 99cm, and weight is 12.7kg. It is a detritus and bottom feeder (Talwar and Jhingran 1991). The body is covered with cyclod scale (Hamilton, 1882). *Puntius ticto* (Hamilton 1882) is a small indigenous fresh water and brackish water fish species. It is commonly known as 'ticto' and 'two-spot barb' (Islam 2007; Rahman, 2005 & Rahman, 1989). The body is covered with cycloid scale (Hamilton 1882).

Materials and Methods

The fresh water fishes *Labeo rohita*, *Cirrihinus mrigala* and *Puntius ticto* were purchased from local fish market (Jagatsinghpur) Odisha and total length of each fish was measured. The fish scales were scrubbed from the lateral side of the fish in the region directly below the dorsal fin and above the lateral line. Ten and twelve scales were taken from each fish and kept separated. Isolated scale were first washed in water and the scrubbed gently between finger tips to remove the mucus and other extraneous matter attached to the scale then they were cleared with tissue paper. To make scale more clear and soft, they were dipped in weak 1% of KOH solution for about 5min then washed with tap water and dried in air. The scales were place in 30%, 50% and 70% alcohol respectively for about 5min to dehydrate. Then they were stained with Eosin and washed with 70% alcohol. Again, the scale was dehydrated with 90% alcohol for 5 minute. Finally the scales were placed over the slide. Covered with cover slips and observed under trinocular microscope (10x) and taken the photo of scale using both 10x and 5x lens. The number of complete annuli and rings were counted and noted down properly.

Results and Discussion

Labeo rohita, Cirrhinus mrigala and Puntius ticto (n=5) were collected from the local areas of Jagatsinghpur, Odisha. Their measurements were taken in cm, then mean and standard deviation of each species parameter were calculated and noted in the form of Table 1.

Table 1: Calculated length, mean and standard deviation of *Labeo rohita*

Measurement	*Labeo rohita*-1 (in cm)	*Labeo rohita*-2 (in cm)	*Labeo rohita*-3 (in cm)	*Labeo rohita*-4 (in cm)	*Labeo rohita*-5 (in cm)	Mean	Standard deviation
Total length	38.1	40.2	30.1	42.2	35.2	37.16	± 4.224
Standard length	30.5	32.4	24.3	34.0	28.3	29.9	±3.386
Fork length	32.8	35.2	25.9	36.3	30.3	32.1	±3.726
Head length	7.8	8.23	6.16	8.64	7.21	7.60	±0.865
Pre-pelvic length	15	15.8	11.8	16.6	13.8	14.6	±1.678
Pre-dorsal length	14	14.7	11.0	15.5	12.9	13.6	±1.563
Dorsal fin base length	6	6.33	4.74	6.64	5.54	5.85	±0.664
Caudal depth	9	9.50	7.11	9.97	8.32	8.78	±0.998
Body depth	10	10.55	7.9	11.07	9.23	9.73	±1.107

Measurement	*Labeo rohita*-1 (in cm)	*Labeo rohita*-2 (in cm)	*Labeo rohita*-3 (in cm)	*Labeo rohita*-4 (in cm)	*Labeo rohita*-5 (in cm)	Mean	Standard deviation
Peduncle length	4	4.22	3.16	4.43	3.69	3.9	±0.443
Pre orbital length	2.5	2.64	1.97	2.74	2.30	2.43	±0.273
Eye diameter	10.1	10.6	7.98	11.19	9.46	9.8	±1.101
Post orbital length	6	6.33	4.74	6.64	5.54	5.85	±0.664
Pectoral length	5.8	6.12	4.58	6.43	5.36	5.6	±1.317
Pelvic fin base length	6	6.33	4.74	6.64	5.54	5.85	±0.664
Anal fin base length	5.8	6.12	4.58	6.43	5.36	5.6	±0.645

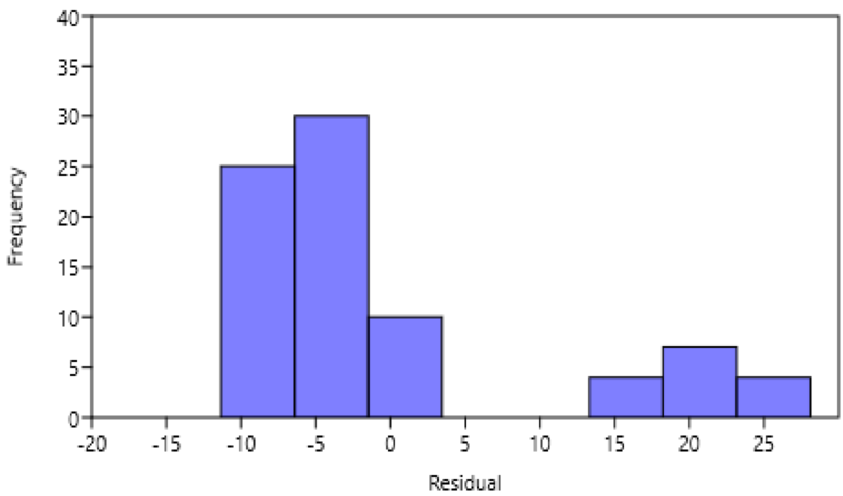


Fig.1. Histogram of residuals of *Labeo rohita*

Cirrhinus mrigala

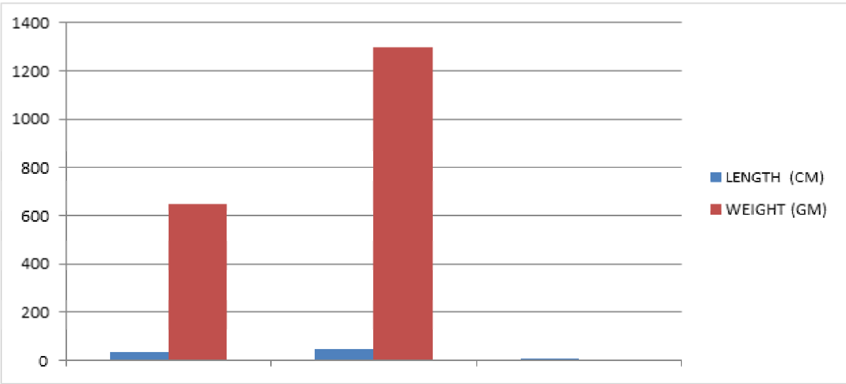
The measurement of *Cirrhinus mrigala* were taken in cm, then mean and standard deviation of each species parameter were calculated and noted in the form of table (2).There is no significance in between the species of *C.mrigala*.

Table 2: Calculated length, mean and standard deviation of *C.mrigala*

Measurements	*Cirrhinus mrigala*-1 (in cm)	*Cirrhinus mrigala*-2 (in cm)	*Cirrhinus mrigala*-3 (in cm)	*Cirrhinus mrigala*-4 (in cm)	*Cirrhinus mrigala*-5 (in cm)	Mean	Standard deviation
Total length	48	43	46.2	32.1	30.5	39.96	±7.267
Standard length	41	36.7	39.4	27.4	26.0	34.1	±6.212
Fork length	41.2	31.6	39.8	27.6	26.2	33.28	±0.746
Head length	8.8	7.88	8.47	5.88	5.59	7.3	±1.333
Pre-pelvic length	22	19.7	21.1	14.7	13.9	18.28	±3.340
Pre-dorsal length	19.3	17.3	18.6	12.9	12.2	16.06	±2.945
Dorsal fin base length	8	7.16	7.7	5.35	5.08	6.65	±1.211
Caudal depth	5	4.47	4.81	3.34	2.10	3.94	±1.086
Body depth	11.6	10.4	11.1	7.77	7.38	9.65	±1.740
Peduncle length	5.3	4.75	5.10	3.54	3.55	4.44	±0.758
Pre orbital length	4	3.58	3.85	2.67	2.54	3.32	±0.606
Eye diameter	1	0	0.9	0.6	0.6	0.62	±0.348
Post orbital length	5	4.47	4.81	3.34	3.17	4.15	±0.758
Pectoral length	7.6	6.81	7.32	5.08	4.83	6.32	±1.152
Pelvic fin base length	1.5	1.34	1.29	1.0	0.9	1.2	±0.222
Anal fin base lengths	3.3	2.9	3.18	2.21	2.10	2.73	±0.494

Table 3: Age and Weight relationship of *C.mrigala*

SPECIES	WEIGHT(g)	AGE
Cirrhinus mrigala-1	1300	Below 1 year
Cirrhinnus mrigala-2	1100	Below 1 year
Cirrhiinus mrihgala-3	1150	Below 1 year
Cirrhinus mrigala-4	750	Below 1 year
Cirrihinus mrigala-5	600	Below 1 year
mean	890	



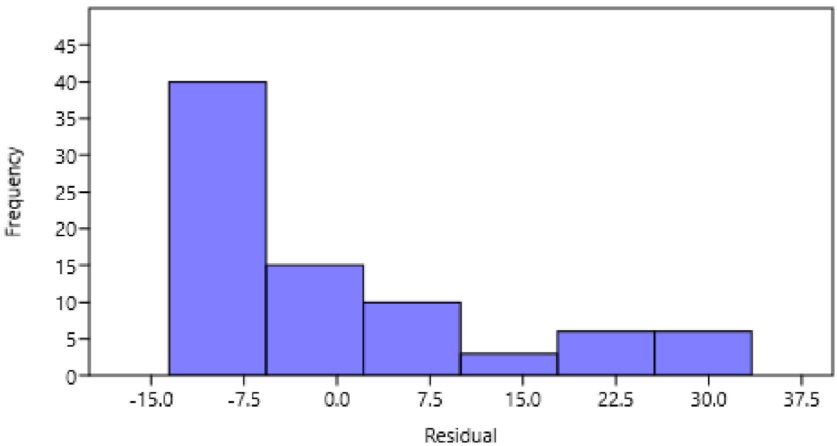


Fig.2. Histogram of residuals of *Cirrhinus mrigala*

Puntius ticto

The measurement of *puntius ticto* were taken in cm, the mean and standard deviation of each parameter were calculated and noted in the form of table (4).

Table 4: Calculated length, mean and standard deviation of *P.ticto*

Measurements	*Puntius ticto*-1 (in cm)	*Puntius ticto*-2 (in cm)	*Puntius ticto*-3 (in cm)	*Puntius ticto*-4 (in cm)	*Puntius ticto*-5 (in cm)	Mean	Standard deviation
Total length	6.6	5.2	5.9	6.2	5.0	5.78	±0.601
Standard length	6	4.7	5.3	5.6	4.5	5.22	±0.556
Fork length	5.3	4.1	5.0	5.1	4.1	4.72	±0.515
Head length	1.2	0.9	1.0	1.1	0.9	1.02	±0.116
Pre-pelvic length	2.7	2.1	2.4	2.5	2.0	2.34	±0.257
Pre-dorsal length	2.7	2.1	2.4	2.5	2.0	2.34	±0.257
Dorsal fin base length	0.5	0.3	0.4	0.4	0.3	0.38	±0.074
Caudal depth	0.7	0.5	0.6	1.6	0.5	0.78	±0.416
Body depth	1.7	1.3	1.5	1.5	1.3	1.46	±0.149
Peduncle length	0.5	0.3	0.4	0.4	0.3	0.38	±0.074
Pre orbital length	0.2	0.1	0.1	0.1	0.1	0.18	±0.046
Eye diameter	0.2	0.1	0.1	0.1	3.8	0.86	±1.470
Post orbital length	0.5	0.3	0.2	0.4	0.3	0.34	±0.101
Pectoral length	0.7	0.5	0.4	0.6	0.5	0.54	±0.101
Pelvic fin base length	0.3	0.2	0.1	0.2	0.2	0.2	±0.063
Anal fin base length	0.5	0.3	0.2	0.1	0.3	0.28	±0.132

Table 5: Age and Weight relationship of *P.ticto*

SPECIES	WEIGHT(g)	AGE
Puntius ticto-1	3.75	Below 1 year
Puntius ticto-2	3.60	Below 1 year
Puntius ticto-3	2.70	Below 1 year
Puntius ticto-4	2.00	Below 1 year
Puntius ticto-5	3.55	Below 1 year
Mean	3.12	

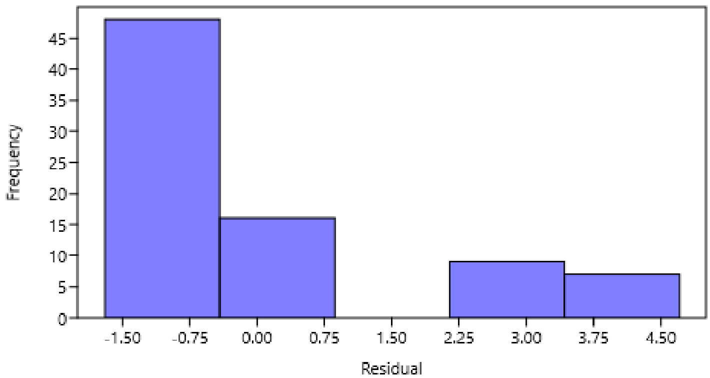


Fig.3.Histogram table of residuals of *Puntius ticto*

Table 6: Comparative morphometric data of *Labeo rohita, Cirrhinus mrigala and Puntius ticto*

Measurements	*Labeorohita*	*Cirrhinusmrigala*	*Puntiusticto*	Mean
Total length	37.16	39.96	5.78	±27.63
Standard length	29.9	34.1	5.22	±23.07
Fork length	32.1	33.28	4.72	±23.36
Head length	7.60	7.3	1.02	±5.30
Pre-pelvic length	14.6	18.28	2.34	±11.74
Pre-dorsal length	13.6	16.06	2.34	±10.66
Dorsal fin base length	5.85	6.65	0.38	±4.29
Caudal depth	8.78	3.94	0.78	±4.5
Body depth	9.73	9.65	1.46	±6.94
Peduncle length	3.9	4.44	0.38	±6.90
Pre orbital length	2.43	3.32	0.18	±1.97
Eye diameter	9.8	0.62	0.86	±3.76
Post orbital length	5.85	4.15	0.34	±3.43
Pectoral length	5.6	6.32	0.54	±4.15
Pelvic fin base length	5.85	1.2	0.2	±2.41
Anal fin base length	5.6	2.73	0.28	±2.87

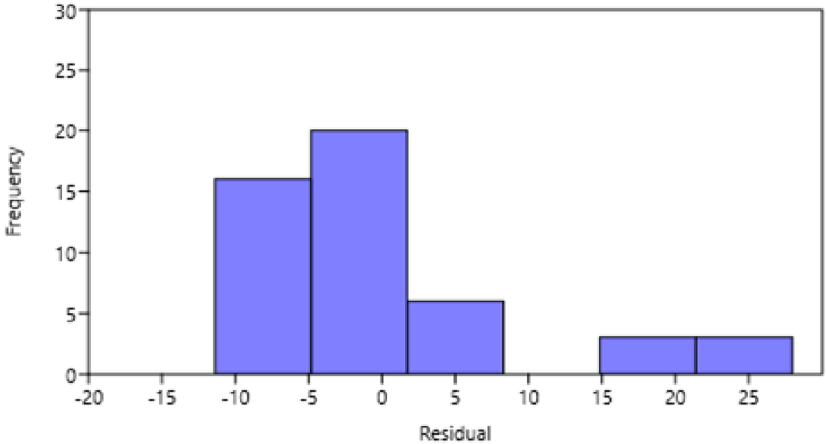


Fig.4 Histogram of residuals of 3 fish species

Fig. 4 *Labeo rohita* length 38.1cm; weight 650gm

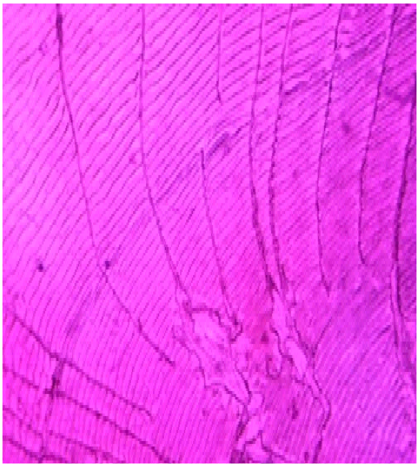


Fig.5 Scale of *Labeo rohita*

Fig.6 *Puntius ticto* length6.6cm; weight 3.75gm

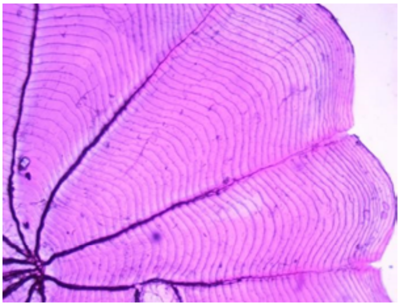


Fig.7 Scale of *puntius ticto*

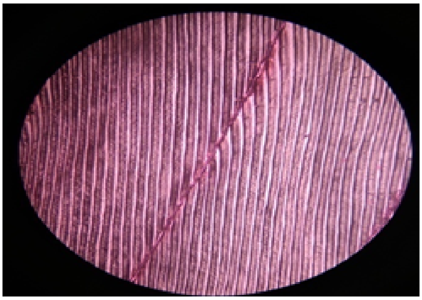


Fig.8 Scale of *Cirrhinus mrigala*

Fig.9 *Cirrhinus mrigala*length 48cm; weight 1300 gm

Conclusion

The overall results indicates that *Labeo rohita, Cirrihinus mrigala, Puntius ticto* showed almost an isomeric pattern of growth. Scale analysis method is the simplest method for estimation of age in fishes. The present findings on age and growth analysis will be useful in fishery management. Fisheries management including uplifting of the status of community ponds can widely be impacted by studying different kinds of common edible carps with respect to their growth and age by simple morphometric protocols.

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Comparative Study of Age and Growth in Selected Freshwater Fishes

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Abstract

The age of Indian major carp *Catla catla*, minor carp *Cirrihinus reba* and snakehead *Ophiocephalus striatus* was determined by scale analysis method. Different length parameters were measured and length-weight comparison was also done. Scale analysis method was found to be the most suitable method for estimating age. Growth rate of *Catla catla* was found to be faster than that of *Cirrihinus reba*. The age group was divided as 0+ and 1+ for below 1yr of age and more than 1yr of age respectively. No significant variation was seen, rather the samples were found similar with each other. No adverse environmental impact was found on any species. The intra-specific and inter-specific correlation and ANOVA results indicate a +ve relationship among the species.

Keywords: Age determination, scale, *Catla catla*, *Cirrihinus reba*, *Ophiocephalus striatus.*

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Introduction

Age determination of fish provides vital information on sexual maturity, spawning time, catchable size, growth rate and lifespan (Ujjania, 2012). These parameters are very essential in fishery. There are four main methods of determining age and growth in fishes: i. Peterson's method of length-frequency analysis, ii. Analysis of scale and other hard parts, iii. Rearing of fish in captivity and observing their growth rate along with analysis of scale, otolith etc., iv. Tagging live fishes in their natural condition after noting essential data and re-examine those fishes after particular interval to observe the changes (Seshappa 1999). However, the last method is not that much easy as only few tagged fishes get recovered. Scale analysis is mostly preferred because it is affordable and quick (Das 2012). Scales can be used without sacrificing the fish. Therefore, this study is highly significant for fishery management and conservation (Bhatt 2016). In case of trees, age can be estimated by counting the annual rings in the cross section of trunk. Similarly counting the number of annuli of fish scale provides its age. These annuli or lines of growth usually develop once a year. Age and growth studies are essential in understanding the dynamics of fish population and annual variation. It also represents the effect of various biotic and abiotic factors on the organism (Mayank 2015). *Catla catla* (Hamilton 1822) is the fastest growing carp species (Mitra 1942). *Cirrihinus reba* (Hamilton 1822) is a common Indian minor carp like *Labeo bata*. *Ophiocephalus striatus* (Bloch, 1793) is also called as snakehead which is highly rich in nutrients. All these three freshwater fishes have high consumer preference. Several authors have studied on the age and growth of fish on the basis of scale analysis. Johal and Tandon have concluded that the riverine *Catla catla* have better growth rate than those of reservoirs. Prakash and Gupta have studied the growth rate in all the three major carp species and found out that their growth rate is faster during the first five years of life and then becomes slower. The present study is based on estimating the age and growth rate in *Catlacatla, Cirrihinusreba*and *Ophiocephalusstriatus* which will be helpful in various fishery aspects.

Materials and methods

Freshwater fishes *Catlacatla*, *Cirrihinusreba* and *Ophiocephalusstriatus* were collected from the local areas of Bhubaneswar. All the experiments were done inside the laboratory of Department of Zoology, Centurion University of Technology and Management, Bhubaneswar. Measurements were taken with the help of a measuring tape. Weight and sex were also recorded. Scales from each fish were removed from the region below the dorsal fin and above the lateral line. A number of (10-12) scales were taken from each fish and kept separated. Isolated scales were washed in tap water and scrubbed gently between fingertips to remove mucus and dust particles. Then they were dried on a tissue paper. To make scales more clear and soft, they were kept inside the weak solution of KOH for 5mins; then again washed with tap water and dried. Scales were then placed in 30%, 50% and 70% alcohol for about 5mins to dehydrate. After that they were stained with Eosin and washed with 70% alcohol to remove excess stain. Again, the scales were dehydrated with 90% alcohol for 5mins. Finally the scales were placed over slide, covered with cover slip and observed under compound microscope (10x). The number of complete annuli or rings were counted and noted down properly.

Results

Catla catla, *Cirrihinus reba* and *Ophiocephalus striatus* (n=5) samples were collected having the mean length of 38.86±3.61cm, 34.18±1.98cm and 39.9±3.55cm respectively. Besides the total length, other measurements were also noted down such as: the fork length, standard length, head length, pre-pelvic length, pre-dorsal length, dorsal fin base length, caudal peduncle length, body depth, peduncle depth, pre-orbital length, eye diameter, post-orbital length, pectoral length, pelvic fin base length and anal fin base length. All the morphometric data were tabulated. Then the mean and standard deviation of each parameter were calculated. The mean weight of *Catla catla* samples was 686gm, *Cirrihinus reba* was 446gm and *Ophicephalus striatus* was 762gm. The male-female ratio was 2:3 in *Catlacatla*, 1:4 in *Cirrihinu sreba* and 2:3 in *Ophiocephalus striatus*.

One of the *Catla catla* females and both the *Ophiocephalus striatus* males were found to be more than 1yr of age but all the *Cirrihinus reba* samples were below 1yr age.

Fig.1 *Catla catla*

Fig.2 *Cirrihinus reba*

Fig.3 *Ophiocephalus striatus*

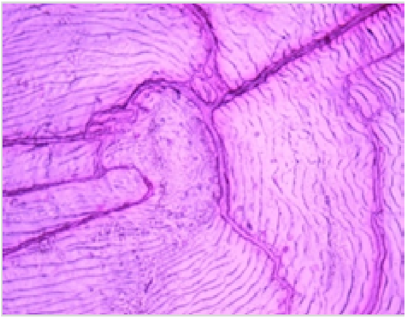


Fig.4 Scale of *C. catla* showing focus (0+ age group)

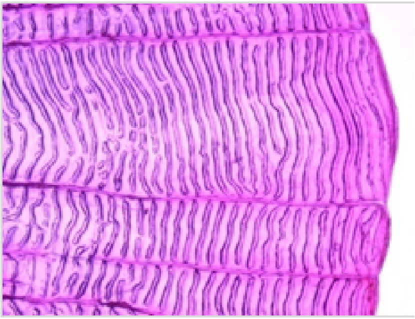


Fig.5 Scale of *C. catla* showing margin (0+ age group)

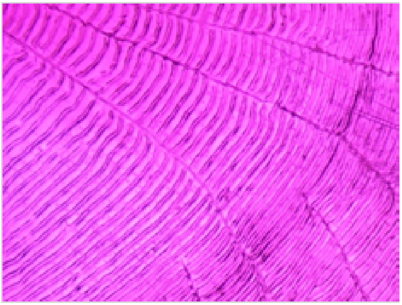


Fig.6 Scale of *C. catla* showing annual ring (1+ age group)

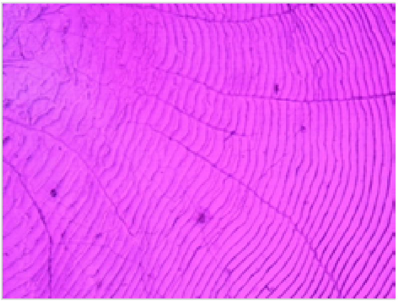


Fig.7 Scale of *C. reba* (0+ age group)

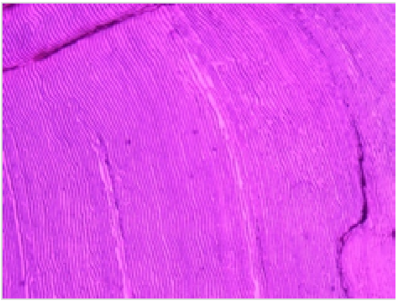


Fig.8 Scale of *O. striatus* showing annual ring (1+ age group)

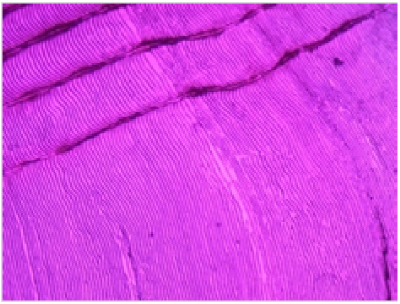
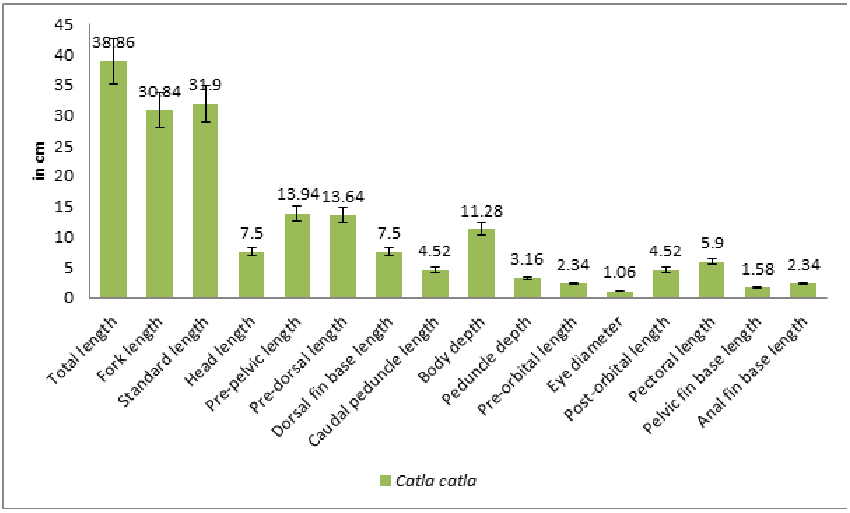
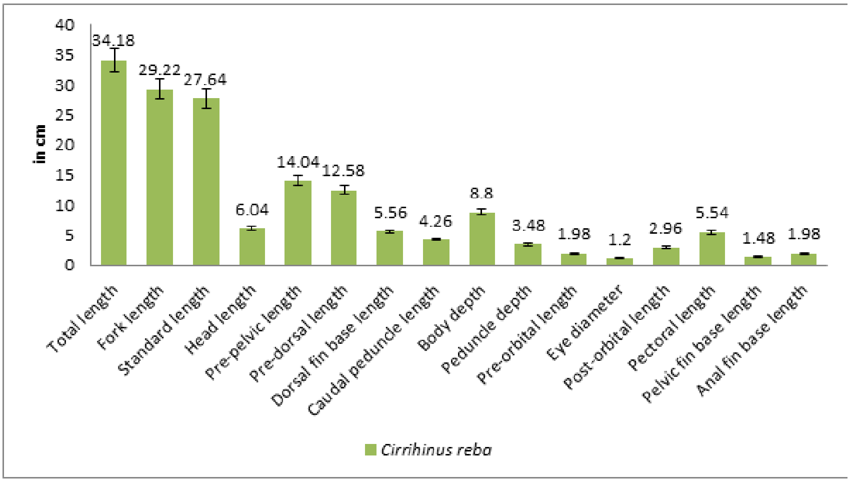


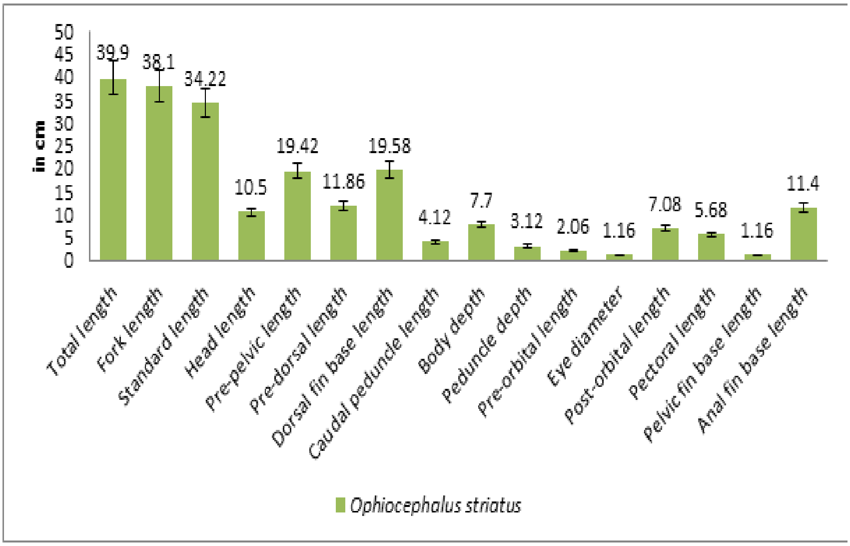
Fig.9 Scale of *O. striatus* showing annual ring (1+ age group)



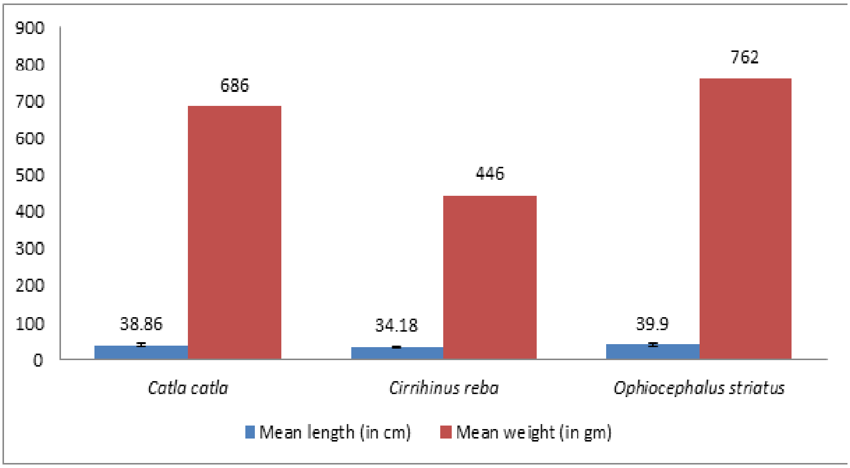
(Morphometric graph of *Catla catla* representing the mean values)



(Morphometric graph of *Cirrihinus reba* representing the mean values)



(Morphometric graph of Ophiocephalus striatusre presenting the mean values)



(Comparative graph of mean values of length and weight in *Catla catla, Cirrihinus reba* and *Ophiocephalus striatus*)

Discussion

The scales of all these three species are cycloid. Focus, radii, true ring and false ring were distinguished properly. Circuli were very clearer. The age group was categorized as 0+ for below 1yr age and 1+ for more than 1yr of age. One *Catla catla* sample and two *Ophiocephalus striatus* samples showed 1 complete ring formation on their scales. So they were placed under 1+ age group. Those samples which didn't show any annual ring formation were placed under 0+ age group. Under 0+ age group, *Catla catla*s howed better growth rate than *Cirrihinus reba* which justifies that *Catla catla* is the fastest growing carp species(Mitra, 1942).From the correlation table it can be seen that there is no significant deviation among the samples. It indicates that there is no adverse environmental effect on them. From ANOVA it was observed that in all the three species, the degree of freedom (df) between groups is 4 and within groups is 75. The value of p between groups is 0.97 in *Catla catla,* 0.99 in *Cirrihinus reba* and 0.97 in *Ophiocephalus striatus*. Similarly, the value of F between groups is 0.12 in *Catla catla*, 0.05 in *Cirrihinus reba* and 0.13 in *Ophiocephalus striatus*.

Conclusion

The results indicate that all the samples were in good health condition and showed optimum growth in their habitat. They were found to be devoid of any adverse environmental effect. It can be concluded that the scale analysis method is the simplest method for estimation of age in fishes. The correlation and ANOVA results indicate the +ve relationship among the species. The present findings on age and growth analysis will be useful in fishery management.

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A Review on Constrains and Strategies of Pulse Production in Rice Fallows

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Abstract

In South Asia, rice-fallows are currently being targeted for agricultural intensification. Due to lack of irrigation facilities and the farmers' poor socio-economic situation, rice-fallows under a rainfed mono-cropping system remain fallow after rice. Nonetheless, with good moisture conservation methods, it is possible to include biologically resilient winter crops under water-limited rice-fallow environments. Rice fallow, a rainfed lowland agro-ecology, is currently gaining a lot of interest in South Asia for sustainable cropping intensification. Cropping intensification of rice-fallow lands are however hampered by lack of irrigation, farmers' poor financial situation, and soil limits. Fundamental impediment to planting a crop in succession in rice fallows is the rapid

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loss of soil residual moisture.After the rice harvest, around 11.7 million hectares of India's 43.95 million hectares of rice-growing land remain fallow. In these places, a multitude of abiotic, biotic, and socioeconomic variables hinder the production of crops other than rice. Low soil moisture content after rice harvest, rapid reduction in water table as crop season progresses, and mid- and terminal-drought at blooming and pod filling phases are the key obstacles for crop growth in rice fallow. Pulses such as lentil, chickpea, urdbean, mungbean, and lathyrus are good candidates for rice fallow since they survive better under surface planting and rainfed conditions. Due to soil disruption, inadequate aeration, and mechanical impedance in the seed zone, rice fallow soil physical and biological restrictions impact pulses seed germination, seedling emergence, and crop establishment.

Key words: Rice fallow, pulses, tillage, crop establishment, relay cropping

1. Introduction

Rice is grown in India across the country, with a total cultivation area of 43.86 million hectares (DAC 2016). Under various cropping strategies, the crop is grown in both irrigated and rainfed agro-ecosystems. In irrigated areas, rice-wheat, rice-rice, rice-sugarcane, rice-groundnut, rice-vegetables, and rice-maize are predominate; in rainfed areas, rice-pulses, rice-sunflower, rice-sesame, and rice-fallow predominate. According to estimates, roughly 11.695 million hectares of rain-fed rice fallow land in India is kept vacant during the *rabi* and summer after the *kharif* rice harvest (Gumma et al. 2016).The mentioned rice fallow regions are largely concentrated in eastern India (approximately 80%), which includes Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal, and the North-eastern states (Singh et al. 2016). The remaining 20% of rice fallow regions are covered by the southern states of Tamil Nadu, Karnataka, and Andhra Pradesh. (Subbarao et al. 2001). Despite the fact that these rice fallow regions have enormous potential for profitable crop production using current agro-techniques and scientific methodologies for utilizing residual soil moisture (Huke 1982), yet these rice fallow systems did not invite adequate interest during the past few decades. As a result, a large amount of food, feed, and fodder output is lost over time. Rice fallow areas are unsuitable for growing rice again during *rabi* because of their high-water requirements. However, they are suitable for short-season, low-water-requiring grain legumes and oilseeds such as chickpea, green gram, black gram, sunflower, and mustard (Sharma & Pandey 2001). As a result, cropping system intensification including two crops could help smallholder farmers earn more money, enhance human health through protein supplementation, and soil health through nitrogen-fixing legume crops and also, addressing food security concerns and challenges of increasing population without expanding croplands (Gumma et al. 2016). So with proper agronomic approaches towards the sustainable intensification of these rice fallow areas can help in short duration grain crops. This review will help grow crops under stressed conditions and thus will help provide food to people and meet SDG 2 goal.

2. Constrains of crop production in rice fallows

2.1 Abiotic constrains

Physical stress, which is most often associated with soil moisture stress, marginal soils with poor fertility status, difficult soils, and unpredictable environmental circumstances existing at the time of sowing, are all examples of abiotic restrictions (Varade 1990). These are important abiotic restrictions that have resulted in reduced pulse output in rice fallow areas in recent years. Furthermore, drought and heat stress during the flowering and pod filling stages have a negative impact on pulse production, reducing output by up to 50% of possible yields. Soil salinity and alkalinity limit pulses root and shoot growth in difficult soils. Due to a lack of nutrients, inadequate microbial (rhizobium) activity, and reduced root growth, the situation worsens, resulting in a decrease in pulse growth and yield (Satyanarayana et al. 1988). Due to disruption in soil structure, soil water deficiency, poor aeration, and mechanical impedance at the rhizospheric zone, this land also impairs pulses seed germination and seedling emergence and establishment, in addition to the intrinsic limits associated with rice agriculture (Rotter & Van de Geijn 1999). Soil hardiness is the most limiting factor among these physical restrictions, followed by low organic matter concentration in the soil. In puddled rice fields, soil hardiness degrades soil hydraulic characteristics, affecting soil moisture distribution and root growth of deep tap-rooted pulses (Pande et al. 2009). If tillage is used after rice harvest to remove stubbles, *rabi* pulses sowing will be delayed, and germination would be affected due to the creation of big clods.

2.2 Biotic constrains

Many organisms, including rhizobia, could not grow in such an environment due to the prevalent anaerobic conditions in rice cultivation. Even if the crop is planted on schedule and grows well, it is frequently plagued by insect pests and illnesses. Although there haven't been many extensive research on the dynamics of disease pests in pulses under rice fallow areas, these biotic agents thrive in such conditions and cause noticeable damage (Maruthupandi et al. 2015). Powdery mildew, mung bean yellow mosaic virus (MYMV) infections and numerous dry/wet rots and wilts among others, are considered major issues. Due to higher relative humidity in coastal belts, powdery mildew is another major disease of *rabi* planted urd bean and mung bean. Rust and Fusarium wilt are also common in lentils. Urd bean and mung bean are susceptible to MYMV, powdery mildew, cercospora leaf spot, and leaf curl virus in India's peninsular rice fallow areas (Kumar et al. 2016). Root-knot nematodes are among the most important nematodes in terms of spreading and crop damage in rice fallow regions (Ramanathan 2000). Many times, in portions of rice fallow areas, particularly in Odisha and West Bengal, as well as areas of Bihar, Chhattisgarh, and Jharkhand, there is a lack of resistance varieties and specific awareness. Pesticides not being available in sufficient quantities or at the proper time is another major impediment to profitable pulse growing. Weeds, like insect pests, are a threat to pulse cultivation in rice fallows, causing up to 50% crop loss if left unchecked (Ghosh et al. 2016). Ratooning of rice after harvest is another important issue in the rice fallow relay cropping system in many regions of the country, resulting in insect resurgence, uncontrollable weeds, and deteriorating soil physic-chemical conditions that necessitate specific attention.

2.3 Socio economic constrains

For out-scaling the production potential of pulses in rice fallow areas, the effectiveness of public extension programs for efficiently distributing technology, awareness about inputs, and the most up-to-date information to farmers is critical(Kumar et al. 2016). Some socio-economic institutional barriers in pulses production include a lack of scientific information, a lack of better type of seeds, and lack of technical expertise, while others include a lack of seed storage, lifesaving/ supplementary irrigation, and poor marketing support (Praharaj et al. 2016). In most parts of the country, increasing farmers access to information about crops and cultivation practices is critical to the successful implementation of rice fallow areas. It is assumed that, most of the rice fallow areas in eastern India are populated by farmers from lower socioeconomic status, and that socio-economic considerations for their welfare play a critical part in tangible crop husbandry development (Layek et al., 2014). During the seeding and intercultural activities of pulses attention changes to timely harvesting and threshing of rice, scarcity and diversion of labour is the main drawbac (Mishra et al., 2016). Because soil moisture is rapidly diminishing, there is limited time to seed the following crop in the rotation or through paira cropping.

2.4 Production constraints of rice fallows

2.4.1 Lack of improved varieties and quality seeds

Since crop varieties specifically suitable for rice fallows in various places have yet to be produced, varieties with comparative benefit should be recommended from among the current types. Farmers are forced to sow low-yielding local varieties due to a severe shortage of quality seeds of approved types (Sharma & Pandey 2001).

2.4.2 Poor plant stand

Under relay (utera) cropping, Plant population is frequently low due to poor seedling emergence caused by compact soil, poor seed-to-soil contact, and low surface-layer soil moisture. Seed rotting due to high wetness has also been recorded in some regions (Singh et al., 2016).

2.4.3 Weed menace

Due to the lack of land preparation, weeds are a severe concern for utera cultivation. Due to the rapid drying of the soil surface, hand weeding is difficult. Cuscuta infestation is also linked to urd bean and mung bean in various regions (Satyanarayana et al. 1997). It is not possible to use pre-emergence or pre-plant herbicides under these conditions.

2.4.4 No use of fertilizers

Because no manure or fertilizer is placed in rice fallows due to the no-tillage approach used in relay planting, the crops suffer from nutrient stress. Furthermore, because of the transplanted puddled rice, the physical state of the soil is poor, nutrient mobilization is limited. Rhizobial populations are greatly reduced as a result of puddling for rice transplanting and anaerobic conditions, limiting biological N_2 fixation. Furthermore, mono cropped rice agriculture results in nutritional imbalances in the soil.

2.4.5 Terminal drought

Terminal drought has a significant impact on crop productivity since *rabi* crops are produced on residual soil moisture under rainfed circumstances. Drought causes leaf senescence to increase, as well as a reduction in net photosynthesis and translocation from leaf to growing grains. Furthermore, low biomass accumulation frequently does not support grain filling during reproductive stages. In the tropics, terminal drought and heat stress cause forced maturity and can reduce seed output by 50%.Winter rains are unlikely to fall in the central and eastern plains.

3. Scientific strategies and approaches for crop production in rice fallows

Ghosh et al. (2016) recommended holistic crop-management approaches, viz. no-till cropping, relay cropping, residue retention, mulching, seed-priming, farm-pond establishment for life-saving irrigation and micronutrient application for substantially improving the survival and performance of pulses in rice-fallows. Rampal (2017) proposed the policy measures pertaining to production, consumption and price policy to ensure pulse security (40 g per day) in India. Production policy aims at increasing domestic production to make up for the 4 million tonnes deficit, considering demand-supply gap in pulses.

3.1 Suitable crops

Pulses and oil seeds have been recommended by the majority of workers as the best crops to grow in rice fallow areas throughout the winter. Kar et al. (2008) highlighted the potential for growing post-rainy season crops such as groundnut, green gram, and profitably in rainfed shallow lowland rice-fallow with the use of residual soil moisture and soil upward flux in Dhenkanal district, which is in Odisha's mid-central Under water shortage conditions. Reddy and Reddy (2010) discovered lentil based cropping techniques to be effective for unexploited rice-fallows in various states. *Rabi* pulses are being grown on lowland rice fallows in India's north-eastern plains, promising to boost pulse production without the dangers of high-input agriculture (Biswas & Bhowmick 2015). Ali et al. (2015) listed pulses, such as lentil, lathyrus, chickpea, pea, green gram, black gram, cluster bean, lablab bean and oilseeds. Low-input-demanding pulses were reported to be the most preferred solution among the candidate crops for intensification of rice–fallow production systems by Ghosh et al. (2016). Singh et al. (2016) recommended lentil, chickpea, lathyrus, green gram, and black gram for rice-fallows since they require little water and require little input. Singh et al. (2017) claimed that pulses were only grown in a 0.5-million-hectare area in India's rice fallow belt, despite the feasibility of producing such crops in an additional 2–3-million-hectare area. Yadav et al. (2015) recommended rice–garden pea, rice– field pea and rice–lentil systems for rice-fallow lands of eastern India due to low energy requirement, high energy and system productivity and low global warming potential.

3.2 Varietal suitability

Under rice fallow areas, the second crop grows in decreasing soil moisture circumstances. Short-duration types should be chosen so that they can successfully finish their life cycle while utilizing the available resources. Under the difficult conditions, the types should have a robust, deep, and penetrating root system to tap water and nutrients. They should be resistant to biotic (weed, disease, insect-pest) and abiotic (nutrient deficiency) challenges (mostly water scarcity). Lathyrus is a promising pulse for West Bengal's rice fallow areas. Because of the existence of endogenous neurotoxic nonprotein aminoacids, its use is restricted. Early flow ering, short duration, rapid biomass buildup, deep root-system, high water-use efficiency (WUE), and high root proliferation have been discovered to be desirable features in pulses to avoid abiotic pressures before the onset of terminal drought and heat (Basu et al. 2016).

3.3 Crop establishment

Without any tillage operations or sequence cropping by zero-minimum or conventional-tillage, rice-fallow pulses and oilseeds are cultivated under the utera cropping technique. For growth and development, the winter crop relies on residual soil moisture and fertility. RIFA cropping systems (paira, relay, and sequence) have been described by Singh et al. (2016). Many researchers have documented good direct impacts of green manure, FYM, and chemical nutrients (macro and micro nutrients) applied to rice on rice, as well as residual effects on subsequent crops in rice-fallow areas. Before planting rice, acid soils should be reclaimed with low-cost liming products. With the application of 30 kg S and 6 kg zn/ha to rice, Singh et al. (2013) reported the highest grain production of both rice and the subsequent lentil, results an additional net return from the system. According to Joshi et al. (2002), the energy-use efficiency trend is utera system > zero-tillage > zero-tillage + mulch.

3.4 Reduced tillage

One or two ploughings are used to sow the seed in decreased tillage. With reduced tillage treatment, Kar and Kumar (2009) found maximum grain yields of 580, 630, 605 and 525 kg/ha from lathyrus, black gram, pea, and green gram, respectively. Conventional tillage, on the other hand, resulted in 34–4 percent lower yields than reduced tillage. Under rainfed conditions of Mirzapur in eastern Uttar Pradesh, Singh et al. (2014) observed greater yields of Indian mustard with reduced till practice and application of water hyacinth mulch @ 2 t/ha. Capillary rise is inhibited by reduced tillage because the ploughed furrow slice acts as a soil or dust mulch. As a result, soil moisture is preserved. Rice–linseed systems yielded higher seed yield, rice-equivalent yield, and net return in shallow lowland rice fallows in Assam and rice–lentil and rice–

rapeseed systems yielded higher seed output, rice-equivalent yield, and net returns.

3.5 Conventional tillage

Crops are seeded following repeated tillage operations to prepare a friable, ploughed, and levelled seed bed in a conventional tillage system. Mishra and Singh (2011) found that conventional tillage yielded higher yields of Indian mustard, lentil, and chickpea, while zero tillage yielded higher yields of field pea. Under zero and conventional tillage, field pea and Indian mustard proved to be the most environmentally friendly. Under rainfed conditions, Bhowmick et al. (2013) showed better seed yield of conventionally tilled chickpea with closer spacing (30 cm) than broader spacing (45 cm). Singh et al. (2015) discovered a cultivar response to crop establishment strategy in lentils, he suggested the lentil variety 'Pusa Vaibhav' for both zero and conventional tillage after unpuddled transplanted rice, as well as the cv. 'Mallika' for zero till age following puddled transplanted rice. Due to a higher loss of stored soil moisture during conventional tillage, Kar and Kumar (2009) reported 34–44 percent poorer pulse yields as compared to reduced tillage. The physic-chemical and biological characteristics of soil are deteriorated by conventional tillage.

3.6 Seed priming

Seed priming is a technique for increasing the pace and consistency of germination. The seed's physiological progress is aided by the process. It's a low-cost hydration technique in which seeds are partially moistened until pre-germination metabolic processes begin without actual germination, and then re-dried till near to the original dry weight (Singh et al., 2015). A seed primer can be used in conjunction with other seed treatments (fungicides, insecticides, and herbicides), making it a practical aspect of everyday farming. Seed priming, also known as imbibing, takes only a few minutes and is therefore both time and cost-effective. The crops are sown in rice-fallows under unfavourable soil moisture conditions. As a result, priming is beneficial. Nawaz et al. (2013) reviewed the research on various types of seed priming and summarized the benefits as improved crop germination, earlier seedling emergence, better stand establishment and weed competition, higher drought tolerance, avoidance of time and capital-intensive re-sowing, and ultimately higher crop yield under stress conditions.

3.7 Nutrient management

Due to insufficient stored moisture, nutrient mobility in the soil and uptake by plants in pulses and oilseeds cultivated after rice in rice fallow areas is extremely difficult. As a result, rice fallow areas can be thought of as hungry and thirsty in the winter. After sowing, there is no way to separate the fertilizer dose for top-dressing or side-dressing. Green-manuring/application of organic manure to preceding rice, application of pulse/ oilseed fertilizer needs as diammonium phosphate in terminal stage of rice, seed-nutrient priming, basal application, and foliar feeding meet crop nutrient demand. Nutrient priming is effective because it places nutrients inside the seed in the same way that fertilization does, which is a very efficient process. The process of nutrient absorption ensures that nutrients are absorbed quickly, consistently, and effectively. The research found that basal application of a recommended fertilizer dose, foliar sprays of urea, DAP, micronutrients, and growth-regulators, as well as foliar sprays of urea, DAP, micronutrients, and growth-regulators, were effective in increasing yield of pulses and oilseeds grown under residual soil moisture conditions.

3.8 Soil-moisture management

Moisture is defined as the presence of a liquid, most commonly water, in small amounts. Unlike free water, soil moisture is retained under strain or tension. *Rabi* crops in rice-fallow rely heavily on stored soil moisture and/or additional irrigation due to a shortage of post-monsoon rainfall. Due to the cold temperatures, the evapo-transpiration demand is minimal during this time. Green gram, cowpea, and groundnut yields were higher with protective irrigation than with residual soil moisture, according to Monjappa and Koppad (2002). To fulfil the expanding demand for pulses in the country, moisture-conservation technology should be developed and pushed to make it easier to cultivate pulse crops in the hostile environment of rice-fallows (Ali et al., 2014). After deploying two life-saving irrigations in rice-fallows, Singh et al. (2014)

reported a yield increase of 20, 34, and 40% in groundnut, lentil, and rapeseed, respectively. In eastern India, Bandyopadhyay et al. (2015) calculated climatic, AESR, and soil-wise water requirements met by residual soil moisture, as well as the feasibility of producing crops without irrigation and with 1 or 2 irrigations. Pulses and oilseed crops such as green gram, black gram, sesame and Indian mustard can be cultivated well on residual soil moisture content in most AESRs in eastern India. Bandyopadhyay et al. (2016) found that relay lentils with long (20 cm) rice stubbles of 10-20 cm height had 1–4% increased soil water content.

4. Conclusion

Abiotic (water, temperature, and soil) constraints, biotic (crop management), and socio-economic constraints all exist in rice-fallow locations. Climate, soil, and the duration of the growing season influence crop/cropping system selection. Rice-fallow crops such as pulses and oilseeds are ideal. Under rice fallow conditions, proper seed priming would ensure germination and crop establishment. For efficient use of available resources, a system strategy combining both rice and subsequent pulses/ oilseeds for tillage, nutrient, water, and weed control must be used. Productivity and profitability of pulses and oilseeds in rice-fallow areas can be maximized by constraint analysis, identification of promising interventions for strategic planning and suitable policy measurers.

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Properties Study of Ether Sulfone and Styrene Mixture using Biovia Material Studio

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Abstract

The compatibility of Ether sulfone and Styrene were studied to form a miscible blend using Biovia Materials Studio. On the basis of free energy of mixing, chi parameter, phase diagram and mixing energy, the compatibility of the two components were analyzed. From the results it was deduced that the pair can become compatible at both low and high temperature. The phase diagram showed that a single phase can be obtained above 387.5K which was the critical temperature. The mechanical properties of the composite were studied based on bulk modulus, shear modulus, Young' modulus. The results indicated that the values of all the properties changes with change in mass fraction of styrene.

Keywords: Blend, In silico, polyether sulfone, styrene

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1. Introduction

Now a day's polymer has become the backbone of modern society. Everything around us is made up of polymers starting from a pen to complex things like plastic etc. Polymers are basically a chemical compound bonded together to form along chain formed from monomers joined by covalent bond or hydrogen bonding or electrostatic interaction [1-4]. Polymers are generally divided into two types. i.e., man-made & naturally. Natural polymers are found on plants, animals etc.The common natural polymer in the world is cellulose found generally in the cell wall of plants. Another example is Rubber which has been used for several ages.Artificial polymers or synthetic polymers are generally produced in the laboratory. For example, PVC, STRYNES etc. These are being used for producing synthetic polymer which is vastly used is the polythene. Because of their resistance, brittleness, ductility, translucence, durability these are highly being exploited & there has been dramatic increase in the demand. By method of polymerization synthetic are being prepared by combining small monomer molecule into long repeated chains held together by strong covalent bonds. Most polymers referred to thermo plastic or plastic generally consists of molecular chains that can be broken & recycled whereas cross linked polymers don't rebounding after the bond is broken. Then have higher strength, hardness, and thermal properties [5-7].

Polymer blends or composite are materials generally a mixture formed from two or more copolymers of different chemical & physical; properties to produce a third material of significant chemical and physical properties different from the individual components. The individual components retain their identity in the composite differentiating composite from mixture and solid solution.The main objective of making composite is to reduce the weight of individual component without affecting the other properties like strength, durability, ductility etc. The main force driving it is the variety of option it provides for marketing purpose for low carbon fiber for their light weight and strength. Blending provide a wide attractive opportunity for 3R i.e., recycle, reuse, reduce thereby decreasing its negative impact on the environment.The limitation of polymer is their non-degradability properties thus polluting and the environment [7-10].

The main reason of shifting from micro to nano particles leads to change in its physical and chemical properties. As a result, nanoparticles of size less than 100nm are being used in polymer technology. Modification of nanomaterials to get the desired product of required properties opened various ways to multi-functional materials. The common type of nanomaterials used is nanotubes, fibres, fullerenes etc. Natural fiber composite is derived from renewable and carbon dioxide such as wood, plants. There are two types of natural fibres sources- one obtained from plants like cotton, jute, hemp and the other obtained from animal origins like silk, wool, hair etc. Typically, composite materials used in the field of work are reinforced concrete, composite woods such as plywood, reinforced plastic such as fiber reinforced plastic or fiberglass, composite containing ceramic and metal matrix. These are generally used for buildings, bridges, swimming pool panels, bath tubs, sink, aircraft etc. Fiber reinforced composite materials made of matrix of desired polymer and fibres. Fibres generally include glass (fiberglass), carbon (in carbon fiber reinforced polymer) etc. These are thin, flexible plastic panels made of strong polystyrene reinforced with fiberglass. The main advantage in its high strength to weight ratio i.e., they are light in weight bout of high strength. It has a vast range of mechanical properties including tensile, compressive strength. Carbon reinforced fiber is basically used for describing a fiber reinforced composite material that uses carbon fiber as its base component. It generally contains 70% fiber weight and generally light in weight. It is generally used in manufacturing racing cars, motor bikes, sports equipment, etc [6-10].

2. Theoretical studies details

2.1. Software used

For analysing the compatibility of blend, Materials studio module of Biovia software (Dassault Systems of France) was used. To predict the level of interaction, the software uses machine learning techniques and standard algorithms.

2.2. Methodology

The structure of Ether sulfone and Styrene were prepared using the build menu of Materials Studio. First go to build menu then select built polymer then choose homopolymer. A list of desired polymers was obtained and from them sulfone was choose and then ether sulfone was selected. The procedure was repeated for another polymer group vinyl and styrene was selected. Under blends-> calculation menu of Materials studio, the structure of the components was optimized. Styrene was used as the base (the component taken in high quantity) and Ether sulfone was used as screen (the component taken in small quantity). After calculation of the blends is over blend-> analysis menu of Materials studio was used to generate various data like chi parameter, free energy of mixing, mixing energy. The data were then studied and the compatibility of the components to form a suitable blend was analysed.

The structures of Ether sulfone and Styrene obtained from earlier were fed to the synthia menu of Materials Studio. Then it was run for different weight fractions of the components. Different properties of the composite were displayed in a tabular form. The values were pasted to excel sheet and different graphs based on the numerical values obtained from earlier were plotted to identify the effect of weight fraction of styrene on the mechanical properties of the composite.

3. Results and discussion

By using Biovia Materials Studio, the use of Ether sulfone and Styrene as potential components of a blend was analysed. In this work the use of polyether sulfone and poly styrene as potential components of a composite was analysed using. BIOVIA Materials Studio Synthia uses pre-defined correlations (advanced quantitative structure-property relationships) to evaluate a wide range of polymer properties. Group additive methods were used for many years to predict the properties of polymers as well as small molecules. These methods are accelerated and convenient to use. Consequently, they are of greatest utility when a rapid estimate of a property is required even though detailed understanding of the atomistic interactions is not known. But the limitation of these methods is their dependence upon a database of group contributions. So, if the group contribution of a group in a polymer is not known, then the property of that polymer cannot be calculated.

To overcome this limitation, Synthia uses topological information about polymers in the predictive correlations. The connectivity indices derived from graph theory are employed. No database of group contributions is required. So, for any polymer composed of any combination of the following nine elements: carbon, hydrogen, nitrogen, oxygen, silicon, sulphur, fluorine, chlorine, bromine properties may be predicted.

3.1. Free energy of mixing

If a blend is homogenous then it is said to be miscible. For a blend to be homogenous, a negative value of free energy of mixing is required indicating that mixing is spontaneous. Thermodynamic analysis suggests that

$$\Delta G_m = \Delta H_m - T\Delta S_m \qquad (1)$$

Where $\Delta G_m = Gibb's free energy of mixing$

$\Delta H_m = Enthalpy of mixing$

$\Delta S_m = Entropy of mixing$

$T = Absolute temperature$

In case of a blend the value of $T\Delta S_m$ is always positive since there is an increase in the entropy on mixing. Therefore, the sign of ΔG_m always depends on the value of the enthalpy of mixing ΔH_m. For the components to form a miscible blend, the entropic contribution to free energy should exceed the enthalpy contribution, i.e.

$$\Delta H_m < T\Delta S_m \qquad (2)$$

Figure I shows that the free energy involved in mixing is always negative or less than zero for the temperatures studied. The free energy decreases with increase in temperature (up to 275 K) as evident from Eq. I and free energy increases with increase in temperature.

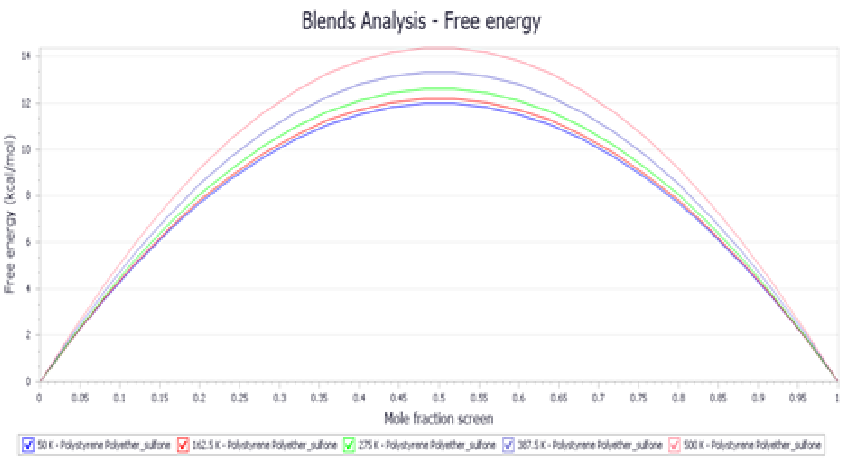


Figure I: Change in free energy value

From the results it was observed that the blend will form a homogenous mixture for the temperature range studied (50 to 500 K). The trend shows a very good compatibility between polyether sulfone and polystyrene with negative value of mixing energy, which may form a particular shape with significantly high effort. Figure I. shows the graph of free energy change with mole fraction of polystyrene at different temperatures.

3.2. Chi parameter

The excess free energy of mixing and phase behaviour for polymer blends and block copolymers can be explained by Flory–Huggins ÷ parameter. For polymers which are not chemically similar, a significant mismatch in cohesive energy density leads to a high ÷ value and, hence, a greater driving force for phase separation. For chemically dissimilar polymers, a high value of ÷ indicates poor mixing. For chemically similar polymers with small cohesive energy difference, small ÷ value is expected. However, a chance of demising for sufficiently long chains is observed. The architectural and geometric differences between the components prevent from occupying the same configurations them in a mixture experienced in the pure phase. From polymer field theory, we can predict that a mismatch in chain stiffness for chemically similar components may lead to a high positive value of ÷ (chi).

Figure 2 shows that the value of ÷ high from temperature ranging from 50Kto 500K. From the graph it was observed that the ÷ values decreases exponentially with increase in temperature. It consents with the free energy of mixing for the blend

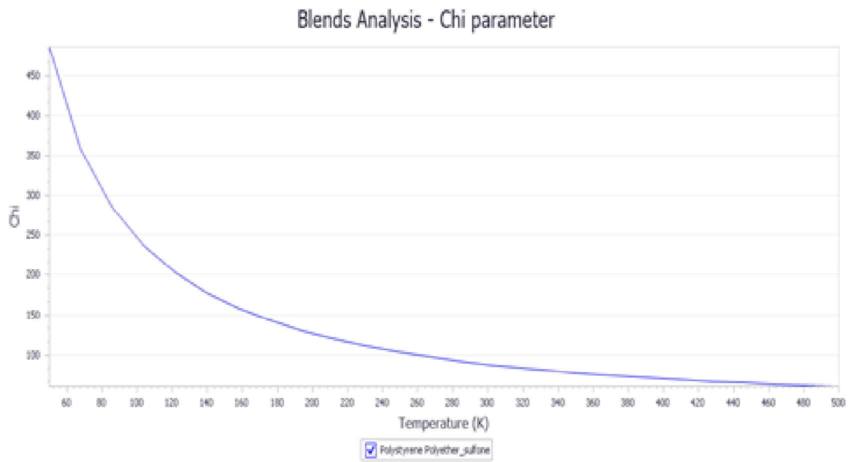


Figure 2: Change in ÷ (chi) value with temperature

3.3. Phase diagram

The compatibility of binary mixtures can be visualized by phase diagrams. Figure 3 indicate the phase diagram for the two components of the blend. The degree of miscibility can be observed over three different regions:

a of around 750 K. This value supported the fact that a single-phase blend can be formed at a high temperature (higher than 750 K).

b. Fragmented metastable regions existed between binodals and spinodals, and

c. The two-phase separated regions of immiscibility are bordered by the spinodals.

The binodals separated miscible (one-phase) and metastable region, while the spinodals separated the metastable and two-phase region.

The phase separation of the system while entering from single-phase region to the metastable region occurs by the mechanism of resembling crystallization. On the other hand, when the system jumps from a single-phase into the spinodal region of immiscibility the phases separate spontaneously by a mechanism called spinodal decomposition.

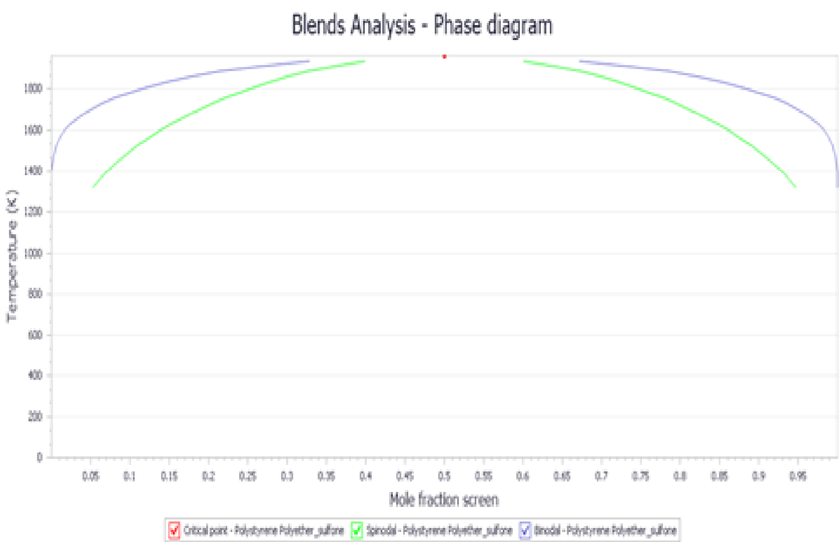


Figure 3. Phase diagram

3.4. Mixing energy

A small value of mixing energy can favour the mixing process. Thus, for mixing, the temperature at which the mixing energy is low can be chosen. Figure 4 display that the mixing energy for the system was small for the temperature range studied.The graph manifest that at first with increase in temperature the mixing energy increases to a highest value after that with further increase in temperature the mixing energy decreases and again increases with further increase in temperature. The temperature varies from 50K to 500K. For the varying of mixing energy. It is very much possible to mix the two components at any feasible temperature with least mixing energy value.

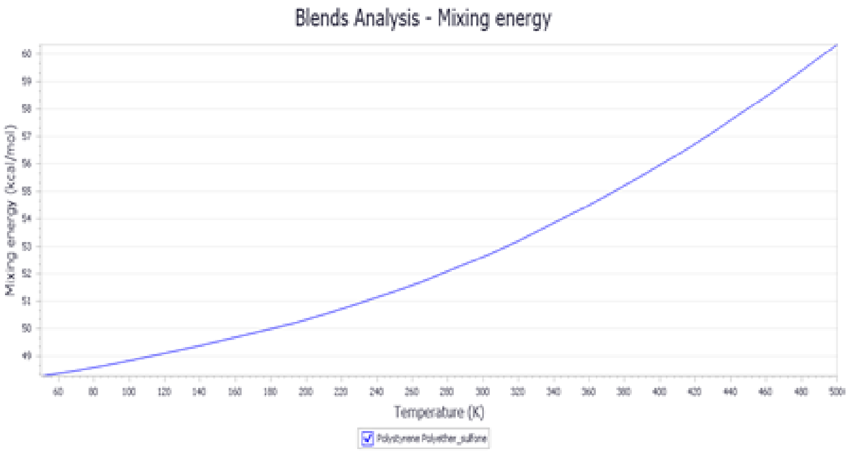
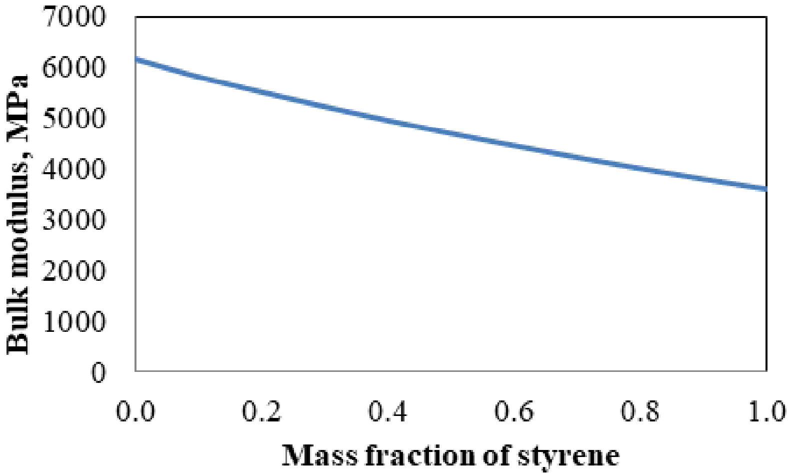


Figure 4. Mixing energy

3.5. Bulk modulus

The measure of decrease in volume with an increase in pressure is termed as Bulk modulus. Figure 5 reveals that the bulk modulus of the composite decreases linearly with increase in mass fraction of styrene.



3.6. Shear modulus

The ratio of shear stress to shear strain is known as Shear modulus. It indicates the response of the composite to shear deformation. Figure 6 shows that with increase in mass fraction of styrene shear modulus decreases and then increases with further increase in mass fraction of styrene.

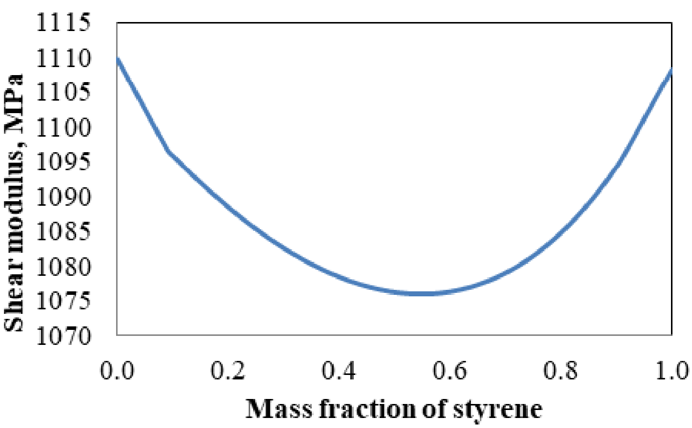


Figure 6: Change in shear modulus with mass fraction of styrene

3.7. Young's modulus

The ratio of stress to strain is called Young's modulus. It compares the relative stiffness of the composite. Figure 7 shows that the Young's modulus of the composite decreases slowly with increase in mass fraction and then slowly increase with further increase in mass fraction of styrene.

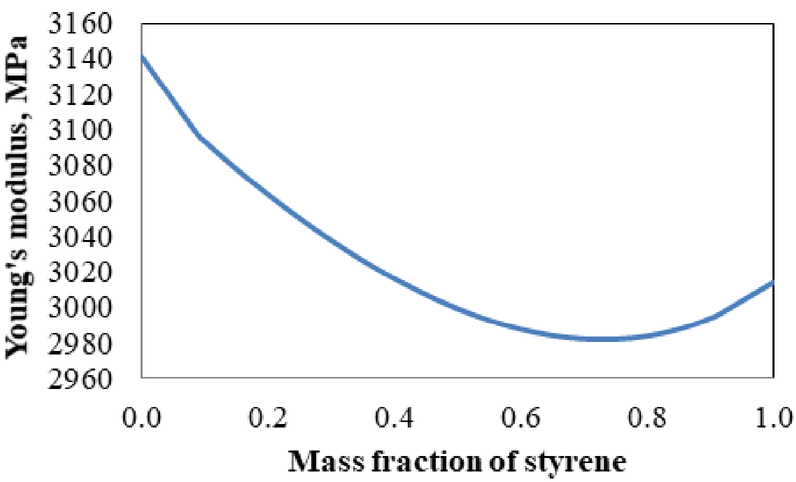


Figure 7: Change in Young's modulus with mass fraction of styrene

4. Conclusions

The possibility of use of polystyrene and ethyl sulfone to form a homogeneous blend was explored using BIOVIA Materials Studio. Based on free energy of mixing, chi parameter and mixing energy the components were analysed. The results indicate that the pair can have very good compatibility at different ranges of temperature. The mechanical properties of the composite were studied based on bulk modulus, shear modulus, Young' modulus, Poisson ratio and brittle stress fracture. The results indicated that the values of all the properties changes with change in mass fraction of styrene.

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Fabrication of Polyacrylonitrile (PAN) nanofibers using electrospinning method

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Abstract

Herein, a simple single-step electrospinning method was used for synthesizing polyacrylonitrile (PAN) nanofibers membrane. In this synthetic procedure, 10 wt% of PAN in 5 mL of DMF was used as an electrospinning solution, followed by some electrospinning experiments. During the electrospinning experiment, the applied voltage kept 12 kV, the flow rate was 1 mL/h and the distance of collector to tip of the needle was 15 cm. FESEM characterization methods were used to confirm the formation of PAN nanofiber's structure. FESEM profiles confirmed the formation of continuous nanofibers with diameters 200-300 nm. The synthesized nanofibers membrane can be used for various applications such as wastewater filtration, photocatalyst, biomedical and adsorbent materials.

Keywords: Polyacrylonitrile, Electrospinning, Nanofibers

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1. Introduction

Nowadays, nanofibers materials have received much more attention among all researchers due to their less density, high surface area, porous nature, and superior chemical or physical stability [1–4]. Among various nanofibers, electrospun nanofibers are more popular that can be applied in various field of research [4]. Hence, many methods are used for the syntheses of nanofibers, including sol-gel, hydrothermal, reflux and microwave procedures, but the main disadvances of these methods are not to produce continuous nanofibers. In recent time, researchers are using a simple electrospinning method to solve these problems for the synthesis of various polymeric nanofibers. Nanofibers produced by the electrospinning method is called electrospun fibers [5].

Electrospinning is a method to fabricate nanofibers with diameter nm to µm in a contentious manner. A simple electrospinning set-up contains one syringe pump connected with a needle, one high DC voltage and one metallic collector (Figure-1). In this procedure, a polymer solution is required. First, we have to prepare a suitable wt% of polymer with the appropriate solvent [6–8]. Then the solution is loaded in a syringe, which connects a metallic needle. An electrospinning experiment was performed after that. This method applied a high voltage of about 10-15 kV depending upon the polymer to optimize the parameters, e.g., flow rate, solution viscosity, humidity, and polymer properties. The nanoscale fibers are generated by applying a strong electric field on polymer solution or melt [9]. The nanofibrous mats produced by this technique mimic extracellular matrix components compared to conventional techniques [7–10]. Electrospinning has been recognized as an efficient technique for the fabrication of polymer nanofibers. Various polymers have been successfully electrospun into ultrafine fibers in recent years mostly insolvent and some other melt forms [6]. Recently, these polymer electrospun nanofibers are used in various applications in medicine, filtration, food, energy, textile, and packaging (Figure-2) [4].

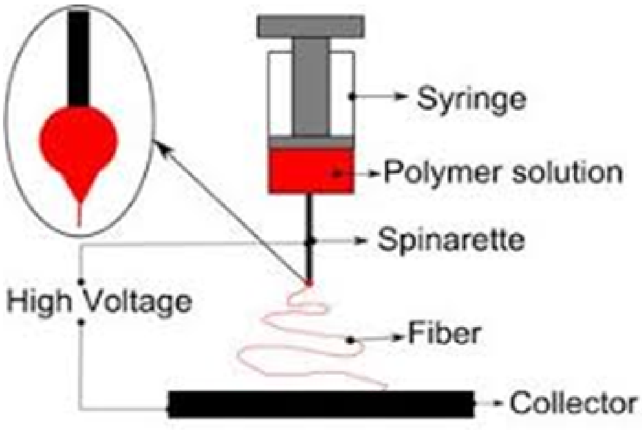

Figure-1: Electrospinning setup

Figure-2: Different application of electrospun nanofibers

2. Materials and Methods

1.1. Materials used

Polyacrylonitrile (PAN) (molecular. weight: 2000) was brought from Sigma-Aldrich (USA). N,N-dimethyl formamide (DMF), Acetic acid, ethanol were brought from Merck (India). All the above mention chemicals were used for the experiment without any purification.

1.2. Synthesis of PAN nanofibers using electrospinning method

The electrospinning instrument used to synthesise PAN nanofibers contains a syringe pump, 5 mL general syringe containing a metallic needle, a high voltage and a collector (aluminium foil). To synthesise PAN nanofibers using electrospinning method, the first 10 wt% of PAN homogeneous solution was prepared. Here 0.5 g of PAN was dissolved in 4.5 g of DMF for 6 h through magnetic stirring. Then the prepared solution was taken into the syringe and connected to the syringe pump. Then electrospinning process was carried out by maintaining a flow rate of 1 mL/h, collector to needle tip distance of 15 cm and 13 kV of the voltage supply. Finally, the fibers were collected on a collector. The synthetic procedure was shown in Figure-3.

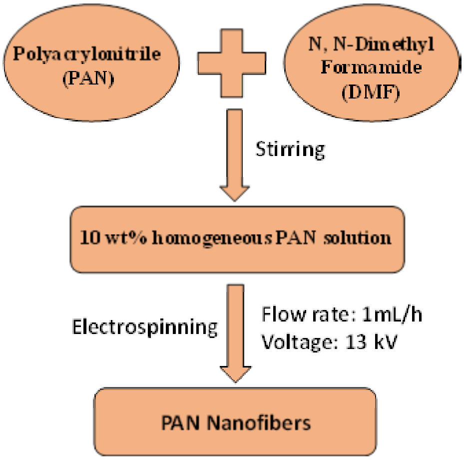

Figure 3: Synthetic procedure of PAN nanofibers using electrospinning method

3. FESEM study of PAN nanofibers

The formation and morphology of the prepared PAN nanofibers was analyzed by FESEM method. From the FESEM images (Figure 4 (a) and 4 (b)), it was seen that the diameters during the formation of fine continuous nanofibers were in the range of 200-300 nm. This confirms the formation of nanofibers *via* electrospinning process.

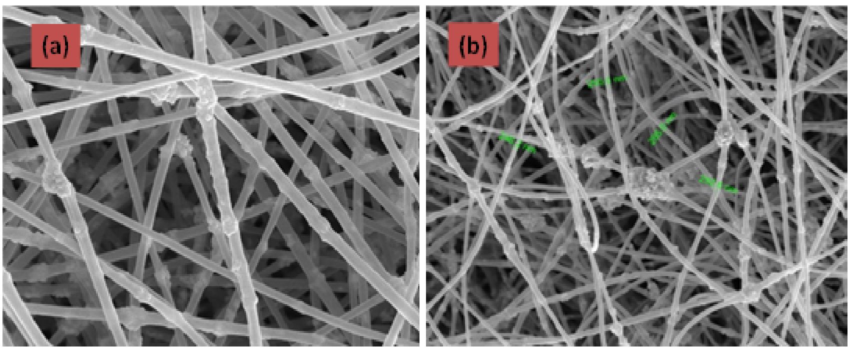

Figure 4: (a) and (b) FESEM images of PAN nanofibers

4. Conclusions

The electrospinning method was used for synthesized polyacrylonitrile (PAN) nanofiber membranes. In this synthetic procedure, 10 wt% of PAN in 5 mL of DMF was used as electrospinning solution and performed electrospinning experiment accordingly. During electrospinning, the applied voltage was kept at 12 kV, having the flow rate of 1 mL/h and collector to tip of the needle distance was 15 cm. FESEM characterization method was used to confirm the formation PAN nanofibers structure. From FESEM images, it was confirmed that the formation of continuous nanofibers belong to the 200-300 nm range.

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Role of ZnO based nanomaterials as Photocatalyst: A mini review

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A K Pradhan[1,2] and S Nanda[1]

Abstract

Zinc oxide is a novel material which is on the focus of material scientists, engineers and industry personnel for its exotic applications in science and technology. It has numerous applications in the field of sensors, transparent conductive oxide, photodetectors, solar cell, photocatalysis, and sunscreens etc. These properties of ZnO have been studied rigorously and multiple approaches have been put forward to enhance the applicability of ZnO. The incorporation of suitable foreign elements by the mechanism of doping, a significant upgradation in the material properties of ZnO has been observed. So, it is very interesting to see how a particular dopant enters the crystal lattice of ZnO and makes changes in the energy levels of the host. Photocatalysis is a very fundamental technique by which degradation is being carried out by

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different catalysts in presence of light. In this present work, we have studied ZnO nanomaterials doped with different elements and the photocatalytic properties of ZnO nanocatalyst in the degradation of different dyes have also been reported.

Keywords: ZnO, Coinage metal, Sonication, Photocatalysis, Luminescence, Catalytic reaction

1. Introduction

The novel properties of nanostructured materials differ from the bulk counterparts for which much attention has been focused in this direction [1, 2]. Interest of researchers has aroused in designing different devices by controlling the dimension and morphology of these materials for industrial and technological applications [3, 4]. Nanomaterials have small size and large surface area due to which these materials show unique properties andapplications that are substantially different frombulk materials [5, 6]. The practical applications of nanomaterials are determined by the changein the electrical, optical and magnetic properties which significantly alters with the parameters such as size and morphology [7]. Inorganic metal and its oxides have received a lot of attention in the past decade due to their tremendous applications in technology. Among metal oxides such as $TiO_{2,}$ ZnO, MgO, SnO_2 and CaO are considered to be materials of high importance as they are stable and safe materials to human beings and animals with great industrial relevance. Zinc oxide (ZnO), being a versatile n-type semiconductor material shows distinctly novel properties among these metal oxides [8-10]. ZnO has many unusual and new physical properties such as high excitation binding energy (60 MeV), wide and direct band gap (3.37 eV), high conductance, chemical and thermal stability [11-15]. It is also harmless to the environment andhas good radiation resistance. Its wide direct band gap and high excitonic binding energy at room temperature make it a potential candidate for optoelectronic applications and light emitting devices. Further, this has vast range of applications in information storage devices, UV blocking agents and sensors [16-20].

ZnO system has exciting applications for its poly-morphological structure and inherent properties.As discussed in the previous section, ZnO material properties are highly dependent on synthetic tools. Further, it has been well documented that the physical and chemical properties of ZnOdepend on its size, shape and intrinsic defects like oxygen vacancy along with doping of selective impurities. So, by creation of native defects and incorporation of external impurities is a promising approach to enhance the existing electrical, optical and magnetic properties of ZnO. This will make it possible for great applications of ZnO nanostructures in preparing solar cell, acoustic, electrical and optical devices, chemical sensors, catalysts, cosmetics, and varistors [20]. Defect states in ZnO will enhance its fluorescence properties to be used in room temperature UV lasers and short wavelength optoelectronic devices.

2. Application of ZnO as catalyst

Nanomaterials comprising of semiconductors show interesting physical and chemical properties with multiple applications in comparison to the bulk materials. Due to high surface-to-volume ratio of semiconducting materials, it has a lot of research prospective for many years and has attracted significant interest in interdisciplinary application.The increase rate of globalization and industrialization leads to generate huge amounts of noxious organic complexes into water. The exitance of different pollutants in water media causes various problem to living organism. Problem related to wastewater treatment is currently the major concern all over the world. Wastewater treatment is one of the major challenging issues now in all over the world. Technologists use many traditional technologies for treating wastewater such as biological treatment, adsorption, coagulation, ultrafiltration, reverse osmosis, ion exchange etc., However, these techniques create secondary pollution as these are non-destructive in nature and tend to transfer the organic compounds from one phase to another.The incidence of photons having energy $h\upsilon$ on the photocatalytic material ZnO creates an electron in the conduction band (CB) and leaving a hole in the valence band (VB). This energy is equal or greater than the bandgap energy (E_g = 3.2 eV) of ZnO. The hole which is generated in the valence bond may react with the hydroxyl groups ($^{\cdot}$OH) present in the surface or with the adsorbed water molecule. This may produce Ï%OH which is a strong oxidizing agent.

The electrons generated in the conduction band reacts with many species which may be some electron acceptors. These species are O_2molecule adsorbed on the surface of the catalyst or dissolved in water which get reduced to superoxide radical anion O_2Ï%-.Wide range of organic and inorganic pollutants may be degraded by using these two high potent radicals (Ï%OH and O_2Ï%).The below Figure-1 shows the schematic representation of photocatalytic process occurring in Eu doped ZnO semiconductor [21].

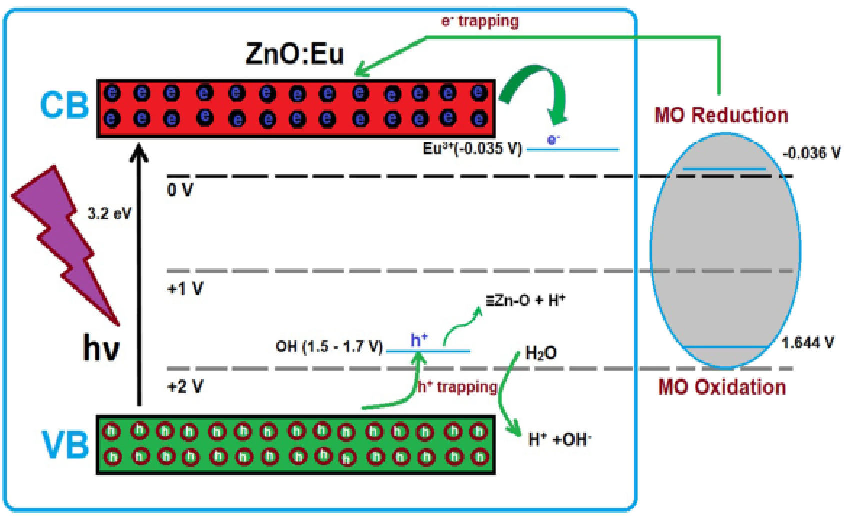

Figure 1: Mechanism of semiconductor photocatalysis [28]

Many semiconductorphotocatalysts have bandgap of about > 3.2 eV and absorb this energy for excitation. However surface and volumetric charge recombination hinders heterogeneous photocatalysis to complete degradation of contaminants.To overcome this electron–hole recombination rate andenhance the activity of photocatalysts for applications numerous other mechanisms have been proposed. In this regard, dopedsemiconductor nanomaterials are useful to reduce the effective bandgap with induction of many energy states in the band gap of semiconductor This lead to produce improved visible light absorption [22]. ZnO is basically has non-toxic property and widely used to detoxify water by the production of H_2O_2. ZnO is available with large number of active sites.This may provide a larger surface area for the reaction to be initiated, which results in a high rate of mineralization of the reactant [23]. But there are some factors like high recombination rate of the photo-induced carriers, very poor response to visible light and higher probability of the photo-corrosion, which let the photocatalytic efficiency of ZnO drop substantially [10-15].To cater this challenge, we may introduce the process of suitable doping mechanism by elements into ZnO which will be very effective in trapping the photo-induced carriers which will lead to an improved photocatalytic performance [15-20]. For this purpose, several transition-metal, noble-metal and lanthanide ions are doped into ZnO.Tremendous enhancement in PC behaviour of ZnO is observed with the doping of rare earth (RE) ion dopants synthesized by several methods. The rare ions, when doped into ZnO, delays the electron–hole pair recombination. Different impurity levels are created by the doping of impurities like La^{3+} in the bandgap of ZnO.This helps in the enhancement of the light absorption capabilities of ZnO. So, the electrons from the conduction band can be trapped by these impurity levels with partially filled f-orbitals.

3. Conclusion

In this chapter, we have discussed semiconductor nanomaterials such as ZnO, which is one of the advanced materials for various applications. The application of ZnO in the field of catalysis and environmental purification has been discussed. The unique physical and chemical properties of ZnO have made it under the intense focus of researchers. ZnO acts as a promising photocatalyst which is highly beneficial for the degradation of industrial waste materials and hazardous dyes for controlling environmental pollution.

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Role of Intercropping System in Agricultural Sustainability

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Abstract

Intensification of agriculture in terms of adoption of high energy inputs, overexploitation of natural resources and other means of industrialized agriculture cause a lot of harm to agricultural sustainability. As a result, enhancement of production and productivity has been achieved for a time being at a cost of sustainability. Considering the ever-growing human population and food needs, there is an urgent need for relooking into agricultural sustainability. Modern agriculture witnessed diversity in agriculture, reliance on fossil-fuel based inputs, farm mechanization and monocropping resulted in increase in yield. But for agricultural sustainability, there are requirements of diversification in agriculture and enforcing ecosystem services. The intercropping system has enough potential to nurture all the issues, including crop diversification, yield

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enhancement, ecosystem services, and agricultural sustainability. The present article focuses on the potential of an intercropping system in agricultural sustainability.

Keywords: Intercropping system, advantages, agricultural sustainability, crop diversity

Introduction

Worldwide farmland has been diminished because of the enhancement of the global population and industrialization, while global demand for food increases. Modern industrial agriculture based on huge quantities of chemicals has adverse effects on human and animal health, natural resources, agro-ecosystem, and quality of agricultural produces (Zaman *et al*., 2017). Furthermore, monoculture augmented yields, but at the cost of the environment. In contrast, sustainable agriculture focuses on balancing farming practices and nature with a holistic approach for creating agricultural systems by nurturing diversity and integrating plants and animals into a diverse landscape to fulfil the human requirements for today and the future. The creation of multiplicity and its execution for sustainable agriculture is vital and intercropping suggests pretending nature's principle of diversification on crop lands. Thus, intercropping is to be evaluated as a pro-ecological approach to raising crops, supporting above and below ground bio-diversity aiming for sustainable agriculture.

A system consists of different components and these are diligently related with a proper interaction among themselves. Emerson (2007) mentioned that the cropping system refers to the production of crops in sequences or mixture and the management involved in a specific field for some time. Farmers generally adopt various cropping systems to maximize farm output, profitability and production sustainability (Hauggaard-Nieson 2001). The system approach always aims for better utilization of resources and agronomic manipulations and thus assures sustainable productivity and enhancement of cropping intensity. The intensive cropping systems focus on the maximization of farm output from the unit area. The modern concepts of agronomy narrate that the efficiency of a cropping system hangs on the single crop in monocropping and / or different crops cultivated in the sequential or intercropping system.

Moreover, time and space dimensions are also considered to measure the efficiency of the system more accurately (Willey & Reddy 1981; Willey *et al*. 1983). However, modern agriculture resulted in mechanization, monoculture, improved varieties and hybrids of crops, and the use of chemical fertilizers and nutrients led to a simplification of the interacting components in agricultural systems and ultimately caused genetic erosion, greater susceptibility to abiotic stress, and thus vulnerability in the cropping system. Restoration of biodiversity through growing of different crops and adoption of farming systems that result in the efficient exploitation of available resources is important for sustaining farm output (Jackson *et al.* 2007; Scherr & McNeely 2008). Modern agriculture has assured enhancement in production and productivity, but simultaneously brought uncertainty in farming with a threat to agricultural sustainability (Tilman *et al.* 2002; Lichtfouse *et al.* 2009). India welcomed the Green Revolution in the 1960s and a decade after the country realized its adverse effects.

The Green Revolution was characterized by mainly research development and initiatives for transfer of technology and no doubt these enhanced agricultural productions worldwide, particularly in the developing countries. The production enhancement noted was mainly due to arrangement of assured irrigation, use of huge quantities of chemical fertilizers and cultivation of ideotypes and high yielding varieties of crops. During that period monocropping became the economically effective path to move. Soon fertilizer shortages and increasing prices developed which created another problem including lowering of profit. As synthetic fertilizer is a fossil fuel-based product, agriculture was gradually becoming dependent on crude oil extraction. Also, environmental complications associated with non-judicious use of fertilizers and other agro-chemicals were becoming prominent. These resulted in surface and groundwater pollution, degradation of soil and ultimately created an unbalance on crop-ecology (Zaman *et al.* 2017). Monoculture is characterized by being devoid of diversity and increases pest, disease and weed problems. The plant protection became difficult because of insufficient population of pest predators (Horrigan *et al.* 2002) which further encouraged use of more plant protection chemicals. As these and other problems associated with the monoculture system became more apparent, interest in intercropping grew as possibly, part of the solution to achieving and maintaining sustainability.

Intercropping has sufficient potential in solving food, nutrition and economic issues in developing nations of the world where small and marginal farmers are in majority in the peasant society. The main reason for the acceptance of intercropping for smallholders is that it has greater stability than monocropping. Due to different aberrant environmental conditions, there may be a chance of crop failure is common in fragile ecologies of the developing countries and intercropping ensures stability as it ensures partial restoration of species diversity and improvement of soil fertility (Li *et al.* 2001) which are not common in monocropping.

Intercropping: a felt-need

For achieving sustainable agricultural productivity, the researchers of the developing countries always focus on low-input and energy-efficient agricultural systems (Sarkar *et al.* 2000) and intercropping is considered as a choice. Besides, diversity in agricultural systems can be further enriched temporally by crop diversification or spatially by adoption of intercropping systems (Altieri 1999). Maintenance of on-farm diversity is very much common in many countries and mostly in the developing world, where traditional farming systems are observed with cultivation of different crops together in the form of mixed and intercropping (Maitra *et al.* 2001a). In an intercropping system, two or more crops may be sown or harvested together or at different time, but they coexist the field for a major portion of their life cycles and the main crop generally gets more importance for economic gain (Maitra *et al.* 2001b) and additional crop provides support to enhancement of productivity and income. The sequential cropping is no doubt important for increasing the intensity of cropping, but the intercropping system benefits a lot by enhancing farm output, monetary advantage and efficient utilization of available resources.

Agricultural Sustainability

Food production and distribution are becoming industrialized and globalized and this has led to degradation of soil, deforestation, water scarcity, eutrophication and different environmental issues which ultimately cause unbalance in the agro-ecosystem. The significance of modern agriculture is reflected worldwide. The modern agricultural production system is inefficient; causing huge emissions of greenhouse gases along with non-judicious use of inputs with a massive carbon footprint (Lal 2004; Wood *et al.* 2006). However, there is a need for food and feed, and population growth further intensifies the issues. The world's population is expected to grow to 9 billion plus in the middle of the twenty first century (Hole *et al.* 2005). The population growth will enhance the need for water by 30-85% with an increased food production target of 70-85% more; this indicates the requirement of more farmland and agricultural intensification. The industrialized agriculture and food production system of the present time already exhibit enhanced crop yields in some corners of the world, but malnutrition and food scarcity are also common phenomena (McMichael *et al.* 2007). This leads to focus on a target of conservation biology to fulfill the food demands for the growing population in a sustainable way by managing natural resources and ecosystem services. All of the services are related to the agricultural production system (Hocking & Babbitt 2014). There is an urgent need to maximize diversity in crop production for attaining farming sustainability.

At present different issues and concerns related to sustainability are into the main focus to develop full-proof farming technologies that will not do any damage to the agro-ecosystem with more accessibility to the growers, and lead to increase in agricultural productivity as well as positive influence on environment as well as agro-ecosystem. Sustainability in agricultural systems includes both resilience and persistence with assuring wider economic, social and environmental outcomes. Agricultural systems are actually amended ecosystems that have a variety of different properties. Modern agricultural systems have amended some of these properties to increase productivity by some technologies which are the obstacles to achieve sustainability in agriculture. Sustainable agro-ecosystems, by contrast, have to seek to shift some of these properties towards natural systems without significantly trading off productivity. Modern agriculture is based on supply driven technologies and mainly dependent on fossil fuels-based energy.

Sustainable agriculture points to a range of strategies for addressing many problems that affect farming. Such issues are depletion of soil fertility and productivity due to soil erosion and associated plant nutrient losses, surface and groundwater pollution from pesticides, fertilizers and sediments, impending shortages of non-renewable resources, and low farm income because of improper marketing facilities. Actually, sustainable agriculture is a holistic approach that enables us to achieve environmentally sound, economically viable, ethically acceptable and socially responsible from cropping and soil management practices. The concept of sustainable agriculture has been conceived differently by different authorities and it is a complex issue associated with producing food and fiber while maintaining our bio-physical resources including soil and water with no adverse impact on the wider environment and ecology. The Food and Agriculture Organization (FAO) narrated very clearly that sustainable agriculture must nurture healthy ecosystems and support the sustainable management of land, water and natural resources, while ensuring world food security (FAO 2014). Besides, FAO (2014) suggested that sustainable agriculture must fulfill the requirements of present and future generations in terms of various products and services by assuring profitability, environmental health, and social and economic equity.

In principle, sustainable agriculture strives for using nature as the prototype for creation of agriculture systems and the natural system assures sustainability. Sustainable agriculture is designated mainly as farming system approaches and is capable of maintaining continuous farm productivity. Further sustainable agriculture focuses on resource conservation, social support, soundness of environment and economic benefit. Sustainable agriculture can be assumed broadly as scientific ecosystem services (Altieri 1995) which is more accomplished in the efficient use of natural resources, and applied inputs for enhancement of production as well as the benefit of people, and is in equilibrium with the agro-ecosystem without misplacing soil fertility. Presently, the approach to maximize agricultural production is synonymous to an enhancement in crop productivity per unit area and it needs the creation of efficient and sustainable cropping systems inclusive of intercropping as intercropping offers for diversification in agriculture. Planting geometry, seed rates, and maturity dates must be kept into consideration for raising of intercrops. Under properly managed conditions, Intercrops can exhibit more yield and income than growing of sole crops. Moreover, it assures another social responsibility of more employment opportunity which is a key indicator of sustainability.

Intercropping and agricultural sustainability

The huge application of chemical inputs for nutrient management and plant protection is very common in industrialized modern agriculture and the monocropping system has received global concern. Presently it has been realized that monocropping is not the right way for attaining sustainability, because enough of chemical inputs are used in industrialized monoculture which causes pollution and creates imbalance in the biodiversity. In other words, it may be stated that intercropping as a type of diversified agricultural practice can be exploited to obtain sustainability as it is one of the possible ways to enrich multiplicity in a crop growing environment (Maitra *et al.* 1999; Maitra *et al.* 2000a).The cultivation of two or more crops simultaneously in mixed stands is based on some ecological principles. Intercropping system assures ecological balance, above and below ground diversity, higher deployment of available resources, maximization of productivity and eases harm due to biotic agents (Yildirim and Eikinci 2017; Maitra *et al.* 2000b). In an intercropping system, depending on their morphological and genetic structure, crops of different types are cultivated. Upon mixed cultivation of crops, the role of allelopathy is also reported upon the selection of different types of crops or varieties as well as the type of their released substances (Sharaby *et al.* 2015; Hikal *et al.* 2017).

Besides, agricultural sustainability directs us towards higher productivity for fulfillment of the needs of the population without ecological disturbance. Increased crop productivity is among the most important benefits of intercropping. In many cases, intercropping assures better utilization of the available resources and more yield in comparison to each sole crop considered in the intercropping system (Willey 1979; Maitra *et al.* 1999). Yield advantage articulates due to efficient use of growth resources and applied nutrients which ultimately absorbed and converted into assimilates production by the intercrop species both spatially and temporally. But there could also be expressions of competitive ability for growth resources among the crops cultivated in the mixture. Moreover, intercropping has been noted to reduce the risk of crop failure under any biotic or abiotic stress conditions and thus guarantees the stability of crop yield over time (Bybee-Finley *et al.* 2016; Raseduzzaman & Jenson 2017).

Further, intercropping is synonymous to improvement of soil health and cuts environmental pollution by reducing nitrogen losses (Sanderson *et al.* 2013). Increased plant diversity maximizes beneficial soil micro-organisma creating nutrient uptake by plants more efficiently and reduces the population of plant pathogens living in the soil (Vukicevich *et al.* 2016). Plants are not the standalone entities of agro-ecosystem as they host different micro-organisms in the rhizosphere and growing environment. All biotic agents (including endophytes and ectophytes) play their significant role in the crop environment. The host plants' biology, plant microbiome and their functioning as well as the catalyzing roles of micro-organisms for different plant species are also important. The interaction between micro-organisms and plants may be symptomless, but it may be pronounced in terms of enhancement of productivity and enrichment of soil microbial diversity. The intercropping system creates microbial diversity in the soil.

Although multiplied plant diversity is often related to efficient use of resources, considerable benefits may be added by intercropping even two crops, predominantly from a mix culture of grasses and legumes. The grasses claim more nitrogen and legumes do not require it. Legumes can fix atmospheric nitrogen and share the fixed nitrogen with non-legume crops in association and in this way, mixture of grass and legume in intercropping are able to self-regulate based on availability of soil nitrogen. Such self-regulation is beneficial in terms of minimization of leaching of nitrate and de-nitrification, which are major providers to evils related to water quality and greenhouse gas discharges, respectively (Tang *et al.* 2017).

Intercropping systems can regulate the biotic agents in crop fields. On-farm biodiversity enables a natural regulation against the population dynamics of harmful biotic agents like insect pests, pathogens, and weeds, and so less chemical is used for plant protection which further provides a congenial environment to beneficial organisms; in an intercropping system, the population of beneficial insects like predators and parasites increases, which can maintain the pest population dynamics. Therefore, costs involved in plant protection and noxious chemicals are reduced, which in turn checks the agro-ecosystem's pollution. Further, intercropping can create the host and habitat complexity of insects as two or more crops are grown simultaneously. The management of plant diseases is also simple in intercropping as crops grown in a mixture provide functional diversity that limits the spreading out of pathogens due to differences in adaptation because of different kinds of pathotypes (Finckh *et al.* 2000). However, intercrops show advantages in weed management over sole crops because of more coverage of land area by crop combinations (Olorunmaiye 2010) and / or defeat of the growth of unwanted weeds through the effect of allelopathy. In an intercropping system, more land area is occupied by the crops and so growth of weeds is suppressed.

There is enough scope for creating diversity in agriculture in the form of crop rotation, cropping system, multiple cropping, mixed and intercropping. Intercropping offers a temporal and biological crop interaction (Maitra et al. 2000b). Ultimately harmony between nature and management is the key consideration where plants can grow under favourable ecological makeup targeting sustainability and the intercropping system can be considered as one of the suitable options where a high degree of ecosystem service is maintained. In sustainable agriculture, nature and agro-ecosystem is nurtured without making a major change of landscape and avoiding much reliance on out-sourced inputs. Sustainable agriculture creates the usefulness of farming to society. An efficient resource utilization and socially supportive agriculture are the key factors for attaining sustainability. In an intercropping system, available resources are fully utilized, and it provides food and nutritional security to smallholders with employment opportunities which is the indicator of connecting society with farming. One should remember that sustainable agriculture not only assures continuous production with proper care of agro-ecosystem, but it provides commercially competitive farming under environmentally sound conditions in which above and below ground diversity can play a vital role.

Conclusion

Intercropping systems can be regarded as interactions among the crops which will influence the growth and yield of plant species used and greater productivity. A better understanding of interactions among plant species and higher resource use potency in agro-ecosystems are noted with intercropping. The impulses of sustainable practices in agriculture and the ecological concerns obtained from modern agricultural practices have had intercropping systems reassessed. The extent of accelerating crop productivity through appropriate intercropping systems has nonetheless been utilized to its full potential. Complementarities in resource use should be considered to induce productivity in intercropping systems without any ill effects on agro-ecosystem. Sustainable agriculture seeks to use nature as the model for planning agriculture systems targeting uninterrupted production for the present and even for the future. Since nature consistently integrates and maintains diversity with the most ecosystem services, the intercropping system also creates the same by maintaining diversity in cropping and facilitating basic principles of sustainability.

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First record of Chestnut-winged Cuckoo at Chinnar Wildlife Sanctuary, Kerala, India

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Abstract

Chestnut-winged Cuckoo *Clamator coromandus* (Linnaeus, 1976) is reported for the first time in Chinnar wildlife sanctuary, Kerala, India, as a chance encounter.The Center for Wildlife Studies conducted a Grizzled Giant Squirrel (Ratufa macroura) survey, Kerala Agricultural University between the 19th and 21st March, 2014 associated with the Western Ghats range. A *Clamator* species have been identified for the first time in the forest tract during the survey. The current paper describes the species and the unusual behaviour of an individual observed from the sanctuary. Not many research works have been done on this Cuculid member. The importance and implications of this finding are discussed hereby. This finding may help in further researches on the species in the Chinnar Wildlife Sanctuary.

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Keywords: *Clamator coromandus*, distribution, Chinnar Wildlife Sanctuary, Western Ghats

Introduction

Clamator coromandus, commonly called Chestnut-winged Cuckoo, has been classified as Least Concern (LC) (Bird Life International 2016). It has been recorded at the Palak Lake in Mizoram, during April-May, in primary mature forests disturbed for cane and palm extraction, heavy NTFP collection and selective logging (Birand and Pawar 2004). The species has also been reported at Sunderbans East Wildlife Sanctuary in Bangladesh, a rare resident in mangrove woodlands. Transitional habitats form their secondary habitat (Khan 2005). The bird has been sighted at the Salak Phra Wildlife Sanctuary in Thailand during March and April in the lowland bamboo forests of Salak Phra (Wiles 1979). The bird was recorded in the Chunxiu Nature Reserve in China in May. The species has also been reported from Kalakkad-Mundanthurai Tiger Reserve in Tamil Nadu (Johnsingh 2001). In Kerala, the bird has been recorded at Munnar and Periyar East, at the middle (500-1000m) or high (>1000m) elevations. It has been observed to be uncommon or rare at all localities (Zacharias & Gaston 1999). It has been reported at Wayanad (Uthaman, 1993), Nelliampathy Reserve Forest (Nameer & Praveen 2006), Vazhachal Reserve Forest, Sholayar (Das 2008), Thattekkad Bird Sanctuary (Sugathan & Vargheese 1996), Idukki Wildlife Sanctuar (Raghu 1995), Periyar Tiger Reserve (Relton 2001; Robertson & Jackson 1992), Arippa (Sushantkumar 1991), Top Slip and Karian Shola, Indira Gandhi Wildlife Sanctuary (Jafer 1997) and at Pathiramanal Island, Vembanad Backwaters (Jafer 1997). There are few historical records from Peermade (Jackson 1971), Sulthan Bathery and Thattekkad (Ali 1969; Sashikumar et al. 2011). A species of the evergreen and moist deciduous forest, *Clamator coromandus* has a quasi-disjunct status (Zacharias and Gaston 1999) with populations in the Western Ghats, in the Himalayas and connecting populations in the Eastern Ghats and the hills of Madhya Pradesh. The bird is a rare winter visitor or passage migrant to South India. Its migration is thought to be controlled by the South-west monsoon (Ali 2003). The bird has been regarded as a circulating migrant (Wiles 1979). This cuculid is currently listed on the IUCN Red List of Threatened Species as Least Concern (IUCN 2007).

Taxonomical Information

Kingdom : Animalia

Phylum: Chordata

Class: Aves

Order: Cuculiformes

Family: Cuculidae

Genus: Clamator

Species: coromandus

Chinnar Wildlife Sanctuary

The Chinnar Wildlife Sanctuary is the only wildlife sanctuary in Kerala with dry deciduous scrub vegetation and associated animals. The Chinnar region is the easternmost part of a contiguous belt of forests extending from the high ranges and the Pooyamkutty region. Chinnar Wildlife Sanctuary is sandwiched between Indira Gandhi Wildlife Sanctuary of Tamil Nadu and the Eravikulam National Park of Kerala (Figure 1 & 2). It is located in the rain shadow region of the Western Ghats, between 10Ú15' to 10Ú22' N latitude and 77Ú05' to 77Ú17' E longitude (Nair 1997). Apart from the famed Grizzled Giant Squirrel, this sanctuary also harbours tiger, elephant, macaques, gaur, various bird species, star tortoise, spotted deer etc. The primary vegetation includes xerophytic species to the rainforest species (deciduous species, riparian species) etc. (Figure 2). The rivers surround the wildlife sanctuary are mainly Chinnar, Athioda and Pambar (Kumar 2007).

Record of the presence of the Chestnut-winged Cuckoo

This report is the first sighting of Chestnut-winged Cuckoo (*Clamator coromandus* Linn.) at Chinnar wildlife sanctuary. It is an addition to the Checklist of birds in the Chinnar Wildlife Sanctuary (Nair 1997). The bird was seen on 21st March, 2014 during a survey of the Grizzled Giant Squirrel (*Ratufa macroura*) conducted by the Center for Wildlife Studies, Kerala Agricultural University, between the 19th and 21st March, 2014. Only a single individual was sighted (Plate 1-2). The bird was first confused with *Centropus* spp. It was only after a closer look that the bird was correctly identified and photographed. The bird was seen along the river adjoining the Thuvanam waterfalls at a distance of about two hundred meters from the waterfalls downstream. The GPS coordinates of the location of the sighting is 10Ú17^{1}23^{11} N and 77Ú11^{1}11^{11} E (620 m above MSL).

The bird was exhibiting an unusual behaviour of staying on the ground for a long time. This is unusual behaviour for Cuculids in general and the Chestnut-winged Cuckoo in particular. For the whole observation period (from 0815 hrs to 0950hrs), the bird never flew over to perch on any tree. The bird, instead, was flying along the riverbed, from rock to rock. The habit of the bird has been described as "strictly arboreal" (Ali 2003). The very sighting of the bird has been considered rare, primarily because of its arboreal, retiring habit. It is rather inconspicuous when perched among the foliage. The bird also habit to descend to the lower storey of bushes (but not to the ground) to feed (Grimmet 2011). Chinnar Wildlife sanctuary has all the suitable habitats for Chestnut winged cuckoo. In the non-breeding season, cuculids, especially *Clamator coromandus,* are unobtrusive and silent, as a result of which their status and distribution at this season are poorly known (Grimmet 2011). In the breeding season, the birds are highly vocal, often sounding more than their numbers. Due to this feature, there is a requirement of concerted efforts by ornithologists around the world to study the status and distribution of the cuculids, as the populations are, at present, likely to be grossly overestimated. Use of new technology (remote sensing and the like) to identify the migration patterns of these birds is of utmost importance for the realistic estimation and long-term survival of populations of these birds.

Discussion and Conclusion

Information in this paper revealed the presence of Chestnut-winged cuckoo, *Clamator coromandus* in Chinnar Wildlife Sanctuary. Despite being reported at many places in the Western Ghats, researchers were unsuccessful in finding this beautiful Cuculid. There are not many studies reported on the species. A systematic monitoring scheme is lacking. According to IUCN (2007), the current population trend is stable. But the continuing decline of mature individuals has not been studied adequately. These all point towards emerging conservation actions. For sustaining the populations of this species, concerted efforts are to be made. Future research may throw more light into the distribution and ecology of the species.

Acknowledgements

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Microbased Biorefinery for Gold Nanoparticle Production

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Abstract

The multifaceted utility of nanomaterials is indispensable to meet environmental challenges across the globe. Nanomaterials substantially contribute to delineating the rapidly advancing field of nanotechnology. Recently, primary emphasis has been laid down on augmenting the biological methodologies for the synthesis of nanomaterials. In this aspect, green nanotechnology has revolutionized the entire process of nano synthesis. Essentially biofabrication of nanoparticles can have long-range applications, primarily in the field of medical applications such as drug delivery, cancer diagnostics and genetic engineering processes. Biocompatible and stable nanoparticles synthesized from biological sources can be an effective alternative against the chemically

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synthesized nanoparticles owing to their non-expensive and eco-friendly attributes. Biological systems including bacteria, yeasts, fungi, actinomycetes, and plants have already been exploited in the field of nanotechnology. The use of microbes seems to be a very effective and economical approach for the biogenic synthesis of NPs. Fungi including *Hormoconis resinae*, *Rhizopus oryzae*, *Hansenula anomal*, *Yarrowia lipolytica*, *Aspergillus niger*, *Pleurotus ostreatus*, *Alternaria alternata* and *Fusarium oxysporum* possess the ability to synthesize gold nanoparticles. Gold nanoparticles possess anti-oxidation activity, are highly stable and biocompatible in nature. Fungi-mediated nanoparticle biosynthesis is more advantageous as compared to bacterial synthesis. Fungi, including yeasts, are very much preferred as they secrete more enzymes that mediate nanoparticle biosynthesis. Here, we have reported the recent advancements and future implications in the field of micro-based biorefinery for gold nanoparticle production.

Keywords: Biofabrication, Biocompatible, Fungi, Nanomaterials, AuNPs, Green nanotechnology

Introduction

Nanomaterials have widespread applications and are considered an illustrious component of several manufacturing sectors (Salata 2004; Narkeviciute et al. 2016; Figure 1). Though the importance of nanomaterials is numerous, their synthesis has always been the key factor. The nanoparticles (NPs) such as zinc, gold, silver, titanium and many more have always been of profound interest (Reddy et al. 2007; Reddy et al. 2011). The present scenario demands effective and eco-friendly synthesis of NPs, which is barely possible only when biological methodologies, including green synthesis routes, are prioritized (Duran & Seabra 2009). Among many, gold nanoparticles (AuNPs) have gained substantial attention owing to their biocompatibility nature, stability and resistance properties (Alkilany & Murphy 2010). AuNPs have been effectively used in various applications, including cancer diagnostics, gene delivery approaches, genetic engineering, drug delivery processes and many more (Arvizo et al. 2010; Yang et al. 2015; Daraee et al. 2016). Synthesis of metal NPs have been tricky, and most chemical methods are employed, which are not eco-friendly (Zhang et al., 2007; Reddy et al., 2008; Hassan et al., 2014; Reddy et al., 2014). Usage of expensive and hazardous reducing agents such as amino acid derivatives, citrate, PEG 4000 during synthesis of NPs through chemical route leads to an increase of toxic components in the environment and may severely affect the sustenance of life forms (Kimling et al. 2006; Roy and Lahiri 2006; Sugunan and Dutta 2006; Akbarzadeh et al. 2009; Ravindra 2009). This is alarming to re-modify our approach of synthesizing NPs by prioritizing environmentally friendly processes such as the use of biological systems like bacteria, yeasts, fungi, and plants. Microbes can be used economically and effectively to synthesise AuNPs (He et al. 2007; Dhillon et al. 2012). Most importantly, the synthesis of microbe-mediated NPs is concurrent with the chemical synthesis approach as far as features of NPs are concerned. Microbial synthesis of AuNPs includes intracellular and extracellular synthesis routes. For instance, *Acidithiobacillus thiooxidans*, *Hormoconis resinae* and *Rhodococcus* sp. have been effectively used for intracellular synthesis of NPs (Ahmad et al. 2003a; Varshney et al. 2009; Lengke et al. 2005).

Similarly, *Thermomonospora* sp. and *Fusarium oxysporum* have been involved in extracellular synthesis (Ahmad et al. 2003b, c). The cyanobacterium *Plectonema boryanum* have been implicated in both intracellular and extracellular synthesis of NPs (Lengke et al. 2006). Growth parameters, including growth stage of cells, pH and temperature, significantly affects the size and shape of AuNPs (Gericke & Pinches 2006). Extracellular synthesis of NPs is relatively preferred as the isolation process is compatible with that of intracellular production. As far as the biogenic synthesis of AuNPs is concerned, many microbes such as *Alternaria alternata*, *Helminthosporum solani*, *Penicillium brevicompactum*, *Hansenula anomala*, *Rhizopus oryzae* have been successfully used (Siddiqi & Husen 2016). Even though the bacterial-mediated NPs synthesis has been successful, the fungus can be a better alternative as fungus are considered to secrete more enzymes that would boost the biosynthesis of NPs and consequently lead to large-scale production. Even mycelia's presence, which enhances the surface area, plays a significant role in scaling up the biosynthesis process (Kitching et al. 2015). Across the globe, hundreds of plant species are constantly infected by an extremely fierce fungal pathogen, *Macrophomina phaseolina* (Mihail & Taylor 1995). Essentially, it is anamorphic Basidiomycetes. The common symptoms of this infected fungal disease are charcoal rot, stem blight, stem rot and damping-off (Khan 2007). Excitingly, *Macrophomina phaseolina* secretes a range of hydrolytic enzymes resulting in the degradation of the plant cell wall and thus allowing it to enter into the host tissue. Reportedly, *M. phaseolina* harbours many paralogs for the oxidoreductase class of enzymes, as confirmed from genomic studies (Islam et al., 2012). These oxidoreductases facilitate the fungus to sustain in unfavourable environmental conditions and mediate the infection event. Remarkably, this group of enzymes catalyze the synthesis of NPs (Ramezani et al. 2010). Relative to the activity of these oxidoreductase enzymes in other fungal species, *M. phaseolina* displays a higher rate of activity and thus can be substantially exploited, which would be economical and eco-friendly. Importantly, since this fungal pathogen is known for its infective approach, instead, they could be channelized in the biogenic synthesis of NPs, which would ultimately serve for the growth of plants.

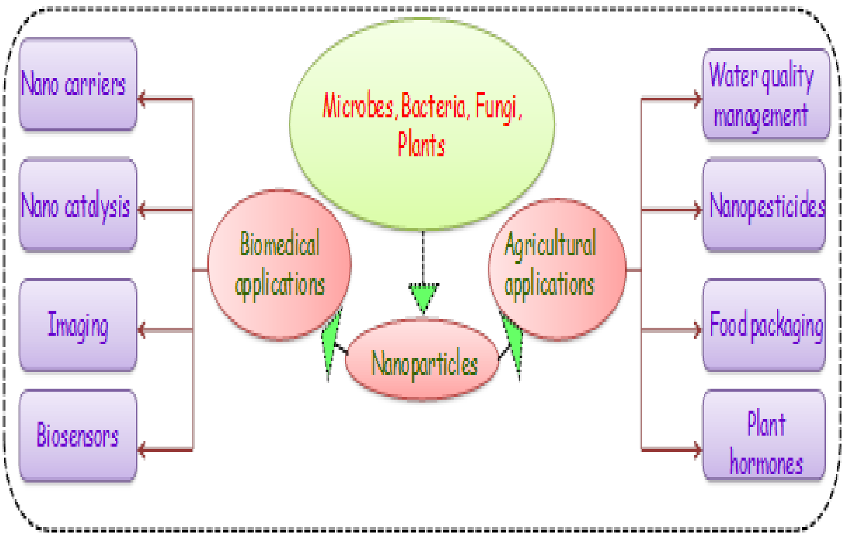

Figure 1: Wide range of applications of nanoparticles

Microorganisms-mediated synthesis of Nanoparticles

A variety of approaches have been extensively employed for the synthesis of metal NPs (MtNPs). These methods include physical, chemical, and biological strategies. Moreover, both physical and chemical methods possess disadvantages such as high heat generation, expensive processes, environmentally toxic and low production yield. The major drawback of these synthetic procedures is that they use toxic chemicals leading to environmental exertion. Thus, there is a need for an eco-friendly method for the synthesis of MtNPs. Green synthesis of NPs is treated as a suitable alternative approach and is being widely used nowadays. Green synthesis preferentially uses biological routes such as degradable polymers, polysaccharides, microbial enzymes, microorganisms and plants. Green synthesis approaches are advantageous to the physical and chemical methods owing to their cost-effective, eco-friendly and simple attributes and thus have gained substantial importance. Recently, synthesis and research on MtNPs have been significantly enhanced due to their inventive and varied applications in various fields, including agriculture, environmental sciences, and medical sciences. Broadly, top-down and bottom-up approaches are considered for the synthesis of MtNPs. In the top-down approach, bulk materials are dissociated into nano-sized materials, using several physical and chemical techniques. But the major setback of this approach is that the synthesized MtNPs bears flawed surface structures. This approach is also expensive and time-consuming, making it difficult for large-scale synthesis. Whereas, in the bottom-up strategy, self-assembly at atomic scales leads to the synthesis of NPs. Bottom-up approaches include chemical and biological methods. Among various green synthesis routes, microorganisms-mediated nanosynthesis is treated as superior as the growth rate of microorganisms is too high and they are easy to grow in ambient environmental conditions. Several microorganisms can act as biofactories, primarily for the environmental-friendly synthesis of MtNPs, including gold, silver, nickel, copper, zinc, palladium and titanium. MtNPs of defined composition, monodispersity, size and shape can also be achieved. Enzymatic conversion of metal ions into corresponding elemental forms is possible through microorganisms as they provide a suitable reducing environment. Microorganisms can tolerate heavy metals to a certain extent, and this factor modulates the capacity of microorganisms to synthesize MtNPs. Enhanced metal stresses affect microbial activities to a greater extent and enable them to reduce metal ions (Figure 2). Mostly, microorganisms which live in habitats rich in metal are particularly resistant to those metals, and subsequently, this approach mimics the bio-mineralization process. In the case of intracellular biosynthesis of MtNPs, transport systems in microorganisms involving the cell wall plays a critical role as it attracts positively charges metal ions towards it. After being transported inside the cells by metabolic reactions, the ions are reduced to form NPs (Tiquia & Rodrigues 2016; Hulkoti & Taranath 2014). Similarly, the extracellular biosynthesis of MtNPs is favoured by several reductase enzymes, which are primarily localized in the cell wall. Reductases mediate the synthesis of metallic ions, and also the presence of several biological molecules such as proteins, polysaccharides favours the synthesis process (Hulkoti and Taranath 2014). Strikingly, proteins secreted from microorganisms stabilize the entire event and prevents any agglomeration. Microbes are preferably cultured in a suitable growth medium maintained at optimum temperature and pH. The cultured microbes are harvested post-incubation and, after being processed thoroughly with sterile water, are exposed to the metal salt solution. Cell-free (CF) approaches have also been widely used where the cell-free extracts (CFE) or culture supernatant is used to synthesise MtNPs. In the CF approach, suitable enzymes are employed, which primarily act as capping and reducing agents. Here, the microbes are removed and suspended in sterile water and subsequently, the CFE is collected and then exposed to metal salt solutions (Singh et al. 2015). Usually, a change in colour during the cell-free process indicates the synthesis of NPs. For instance, upon the synthesis of AuNPs, the colour of the reaction mixture changes from pale yellow to dark purple and similarly, the colour changes from pale yellow to deep brown during the synthesis of silver NPs (Kalimuthu et al. 2008). There are numerous critical physiological factors such as pH, metal salt concentration, pressure, incubation time that significantly influence the synthesis of MtNPs; thus, optimizing these factors is highly important, which would result in the synthesis of NPs of desired morphology and composition. Post-synthesis of MtNPs, purification is essential to eliminate any unreacted biomolecule. Consequently, MtNPs derived from microorganisms are characterized by numerous analytical techniques, including UV-visible spectroscopy, Fourier transform infrared (FTIR) spectroscopy, transmission electron microscopy (TEM), scanning electron microscopy (SEM), atomic force microscopy (AFM), X-ray powder diffraction (XRD), energy dispersive x-ray spectroscopy (EDS), and Dynamic light scattering (DLS) (Ingale et al. 2013, Strasser et al. 2010).

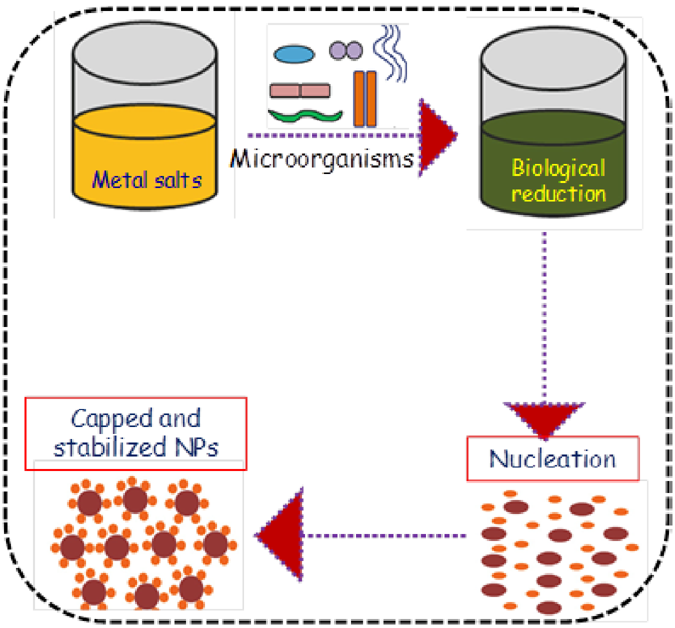

Figure 2: Microorganisms-mediated synthesis of nanoparticles.

Synthesis of Gold nanoparticles: Synthetic approach

Numerous solution-based methods have been developed and been practised since the last decade for the synthesis of AuNPs. AuNPs (AuNPs) of the desired shape, size and functionality is synthesized by following a wide array of methods. The synthetic process involving using citric acid onto the hydrogen tetrachloroaurate ($HAuCl_4$) results in the synthesis of AuNPs, whereby the citrate acts as both stabilizing and reducing agent. Further refinements to this approach were made to control the AuNPs size. Following this approach, spherical AuNPs with diameters of 10-30 nm is mainly synthesised. The major drawback during this synthesis process is the irreversible aggregation of the AuNPs, essentially during the functionalization process. Varied approaches have been formularized to overcome this issue, primarily using several chemical reagents such as thioctic acid and tween 20. Again, large scale production remains challenging after using these chemicals (Ali et al. 2010).

Interestingly, alkanethiol-stabilized AuNPs were synthesized following a biphasic reduction protocol (Yeh et al., 2012). This method has been very productive as it produces low dispersity AuNPs ranging from 1.5 to 5 nm, preferably by altering the reaction conditions such as reaction temperature, gold-to-thiol ratio and reduction rate. As compared to other synthetic processes, alkanethiol-protected AuNPs display higher stability, preferably due to the synergic effect of van der Waals and thiol-gold attractions. Consequently, AuNPs thus prepared can be extensively dried and can be applied as precursors for different processes (Kalimatu et al. 2008).

Plant and microorganisms as a source for the synthesis of gold nanoparticles

Chemical methods are extensively used to synthesise MtNPs, but the hazardous nature of the chemicals used make the entire process disadvantageous. Notably, the NPs synthesized through chemical routes may also have adverse effects in biomedical applications (Shankar et al., 2004; Noruzi et al. 2011). Thus, it would be significant enough to use greener ways to synthesise MtNPs including AuNPs which would be an eco-friendly and cost-effective process. AuNPs could be synthesized by various biological sources, including plants, enzymes and microorganisms (Mohanpuria et al. 2008, Singh et al. 2013). Recently, the biosynthesis of AuNPs from various plant sources such as *Aloe* *vera, Medicago sativa, Azadirachta indica, Pelargonium graveolens, Coriandrum sativum, Cymbopogon citratus* (lemongrass), *Terminalia catappa* and *Cinnamomum camphora* have been possible (Herizchi et al. 2016). Extracts from plants such as *Memecylon umbellatum, Cinnamomum zeylanicum, Cochlospermum gossypium, Terminalia chebula, Brevibacterium casei, Citrus sinensis, Macrotyloma uniflorum, Citrus limon, Citrus reticulata, Memecy-lon edule, Mangifera indica, Murraya koenigii,* and *Piper pedicellatum have* also been used for the synthesis of AuNPs (Herizchi et al. 2016). *Zingiber officinale* extracts have been successfully used to synthesize AuNPs of size ranging from 5-15 nm as the extracts of the plant act as both reducing and stabilizing agents (Kumar et al. 2011). Similarly, the presence of vitamin C in *Allium cepa* (onion) extracts makes it a suitable source for the synthesis of AuNPs (Parida et al. 2011). Numerous microorganisms, including bacterial and fungal species, have been reported to mediate the synthesis of AuNPs either through intracellular or extracellular mode. *Macrophomina phaseolina* has also been effective in the synthesis of AuNPs. The mycosynthesis of AuNPs from *Macrophomina phaseolina* is confirmed using UV-Vis spectroscopy. It has been reported that colour change from light yellow to pink/purple corresponds to the formation of AuNPs (Sawle et al., 2008; Bhambure et al., 2009). AuNPs shows an absorbance peak at 540 nm. Other fungal species such as *Cylindrocladium floridanum* and *Coriolus versicolor* shows similar absorbance peaks (Narayanan & Sakthivel 2013). The final yield of AuNPs was found to be 10 mg/ml of the reaction mixture used. It is of the view that the biofabrication of AuNPs primarily involves the synthesis of elemental metal from metal salts by the bio-reduction process. Consequently, the organic molecules secreted from the fungus mediate the stabilization of the synthesized NPs.

Gold nanoparticles: its application in bionanotechnology

AuNPs have a wide range of applications. They are imperative components for biomedical applications. AuNPs are extensively used for diagnostics and in the field of therapeutics. AuNPs easily conjugate with biomolecules such as oligonucleotides and antibodies, which enables them to detect target molecules. This allows the use of AuNPs for diagnostics applications, primarily in cancer. An ultrasensitive method, referred to as bio-barcode assay largely modulated by AuNPs, principally detects target various biomolecules. This assay uses conjugated AuNPs against specific target molecules for the detection and quantification of nucleic acids and proteins. For instance, prostate-specific antigen (PSA) present at a deficient level, i.e., 330 fg/mL, was successfully detected (Yeh et al., 2012). Cancer cells and small molecules are also easily detected by the use of specific aptamer-conjugated AuNPs. Lymphoma cells were detected by an aptamer-nanoparticle strip biosensor (Tiquia and Rodrigues 2016). Recently developed chemical nose method that uses AuNP and fluorophore has been demonstrated to be highly sensitive against several biomolecular targets (Yeh et al., 2012). Based on a specific lock and key approach, AuNP-fluorophore conjugates recognise their cognate molecules (Singh et al., 2015). AuNPs are also proven to recognize and differentiate normal, cancerous and metastatic cells (Kalimuthu et al. 2008; Strasser et al. 2010). An enzyme-amplified array sensing (EAAS) approach has been developed, enhancing the sensitivity through enzymatic catalysis, where AuNPs play a significant role. In biomedical treatment, AuNPs play an important role as they can get penetrated the cell membrane. Functionalized AuNPs with an orderly arrangement of amphiphilic molecules can penetrate the cell and thus can mediate the delivery of drugs into the destined locus. Effective drug delivery and targeting strategies have been employed to act on deformed cells including cancerous cells strategically. RNA-AuNP conjugates successfully down-regulates the expression of luciferase activity, demonstrating gene knockdown ability (Yeh et al. 2012). AuNPs have also been widely used for gene transfection assays (Ingale et al., 2013). AuNPs can associate with specific drugs by both covalent and non-covalent interactions. The AuNPs possess a cationic charge on their surface which facilitates the NPs to enter into the cell. Functionalized AuNPs have been reported to elevate the anti-proliferative effect against leukaemia cells and plasma cell disorder (Strasser et al. 2010; Ingale et al. 2013; Singh et al. 2015). The protein level of cell-cycle proteins p21 and p27 are upregulated, which inhibits the growth of multiple myeloma cells. Remarkably, due to the flexible electronic and optical properties of AuNPs, they have been widely used for cell imaging techniques, such as Raman spectroscopy, computed tomography, optical coherence tomography, dark-field light scattering and photothermal heterodyne imaging technique (Singh et al. 2015). Also, AuNPs act as contrast agents as reports suggest that these NPs can elevate the vascular contrast in computed tomography imaging. For small-animal Raman imaging, AuNPs are applied to prepare surface-enhanced Raman scattering (SERS) NPs. Localization and colocalization studies for SERS NPs within deep tissues have been studied using AuNPs coated with silica (Kalimuthu et al., 2008; Strasser et al. 2010; Singh et al. 2015). AuNPs have a wide range of applications and engineering these NPs would mediate multifaceted processes in the near future.

Conclusion and Future Prospects

Recently green syntheses of NPs have been prioritized owing to their eco-friendly attribute. Over the last decade, microorganisms have been used to synthesize NPs. The synthesis of NPs using microorganisms is considered a slow process relative to physical and chemical processes. Lowering the synthesis time would enhance the efficiency of the entire approach. The specific size of the NPs and monodispersity are also critical and must be further explored. The stability of NPs synthesized from microorganisms needs to be evaluated and enhanced for their effective use in different application fields. Intracellular and extracellular synthesis of NPs has been extensively studied and is found that the later has more advantages since other costly process such as ultrasound and chemical reactions are not required, unlike the intracellular approach. Detailed processes and mechanism(s) related to the synthesis of NPs from microorganisms are yet to be deciphered, as the synthesis is still not on a larger scale. The field of nanotechnology will be greatly improved if the biosynthetic approaches towards synthesis of NPs can be understood. There are ample aspects that need to be revealed, particularly the detailed role of microorganisms in the synthesis of NPs. The selection of microorganisms is equally challenging. Optimum conditions need to be controlled to obtain the synthesized NPs effectively. The combination pattern, independently dispersed with microorganisms in the solution or coated on the microorganism, is one of the critical factors determining the reaction rate.

Interestingly, a longer time is required for microbial processes to occur. For instance, due to the slow microbial reaction rate, a long retention time is observed for biological wastewater treatments. Similarly, extreme cold conditions would not favour microbial processes to occur.

Even though the detailed molecular mechanisms are not known, it is evident that microorganisms take countermeasures to defend themselves from toxic metallic ions, and thus their cell wall, which is negatively charged, secretes sticky secretion to attract the ions. The enzymes released by microbes mediate the conversion of the detrimental ions into non-harmful and thus have an explicit role in the synthesis of NPs. Still, approaches are sought better to control the monodispersity of NPs and particle size, and it is pretty revealed that the microbial species and the associated environmental factors significantly affect the synthesis of MtNPs. The biological methods to fabricate NPs are still in the embryonic stage. Efforts should be made to develop the biosynthesis process and realize the application of nanoparticle biosynthesis in practice.

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