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Environment and Sustainability

Volume II

Editors

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PREFACE

We are delighted to publish our book entitled ***"Environment and Sustainability Volume II"****. This book is the compilation of esteemed articles of acknowledged experts in the fields of basic and applied environmental science.*

This book is published in the hopes of sharing the excitement found in the subject. Environmental science can help us unlock the mysteries of our universe, but beyond that, conquering it can be personally satisfying. We developed this digital book with the goal of helping people achieve that feeling of accomplishment.

The articles in the book have been contributed by eminent scientists, academicians. Our special thanks and appreciation goes to experts and research workers whose contributions have enriched this book. We thank our publisher Bhumi Publishing, India for taking pains in bringing out the book.

Finally, we will always remain a debtor to all our well-wishers for their blessings, without which this book would not have come into existence.

- Editors

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ENVIRONMENTALISM AND ECOLOGISM: UNDERSTANDING APPROACHES TO ENVIRONMENT PROTECTION AND SUSTAINABILITY

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ABSTRACT:

The issue of environment protection has been at the center stage since the mid of the 20th century in most of the national and international platforms. Relation between nature and human society has been a matter of inquiry in every age and civilization because human activities, since time immemorial, have encroached upon the sphere of nature. However, for a long time there remained a balance between human needs and carrying capacity of nature, but the rapid industrialization and uncontrolled growth model of development destabilized this balance. This excessive industrialization started showing alarming signs of environment degradation by the mid of the 20th century. Therefore, since 1960s the need for rethinking relationship between humans and nature was strongly felt and this rethinking resulted in emergence of environmental movements and ideologies. The issue of environment, like gender issue, became a cross cutting issue addressed by different disciplines of Science, Social Science and Humanities. The need for a model of development which can be in tune with the goal of environment conservation – what is called sustainable development- was felt globally. However, despite this global consensus to protect environment, there is difference of opinion on the questions of factors responsible for environmental degradation and measures to be adopted for preserving environment. This diversity of opinions has resulted in different schools of environmentalism which are not only different from each-other but even opposite sometimes. The paper aims at presenting an overview of different schools of environmentalism and ecologism, and their approaches to environment conservation and sustainability.

KEYWORDS: Ecology, Deep Ecology, Shallow Ecology, Dark Green, Light Green, Anthropocentric, Eco-centric.

INTRODUCTION:

Relationship between nature and humans has gone through many phases. In the initial phase, i.e. the pre-modern times, human society was fully controlled by nature and dependent on it, the forces of nature were seen as mystical power beyond human comprehension. With the advent of modern science and technology, human beings with their ability of rational inquiry came at the center and man became the measure of everything. This paradigm shift impacted every aspect of human life and the relationship of human being with their environment also got restructured. Now with the help of science, humans got the capacity to understand and explain nature and hence, nothing remained mystical about nature. However, humans did not confine the use of science and technology only to understand and explain natural events and processes but rather applied it to have control over nature. Nature became the object to be controlled, used and exploited by humans who claimed to have proprietary right over nature. Thus, the relationship of humans with their environment, gradually, became asymmetrical and unequal (Roberts, 1998). This changing pattern of relationship of humans with their environment is lucidly explained by Crosby in his seminal work *Ecological Imperialism* (Crosby, 2004).

Though changes in environment also happen due to non-human elements, but there is no denial of the fact that uncontrolled human interventions in recent decades is responsible for massive climate change (Goudie, 2009). The human activities and its devastating impact on environment started disturbing the internal balance mechanism of environment. Increasing population and its pattern of uncontrolled consumption has resulted in undue burden on 'carrying capacity of earth' and thus, in imbalance between human needs and demands on environment and the regeneration capacity of nature (Wackernagel, 1996).

However, nature did not accept this over consumption and uncontrolled human intervention passively and retaliated back by showing alarming signs for human survival and thereby forced human society to rethink their relation with environment which resulted in emergence of environmental ideologies, movements and policies.

Emergence and Growth of Environmentalism and Ecologism

For a long time, environment was seen as a phenomenon to be studied by the scientists in natural sciences who were interested in understanding nature and its processes, study of relationship between human society and nature by scholars in humanities and social sciences started of late. Social science and humanities for a long time did not pay attention to relationship between nature and individual because they were mostly engaged in understanding, explaining and analyzing relationship of individual with society, group, culture, state and so on. Human

society and its problems and search for a good society, obviously, were the locus of humanities and social science. But the environmental crisis, resulting from flawed model of development based on over-consumption of natural resources and excessive intervention in natural processes, made it very clear by the mid of the 20th century that the question of relationship of human society with nature is central to any narrative of a good society. Without rethinking this relationship, the very survival of humanity would be under threat. Now it got realized that environmental crisis is not confined to one region or country but is of global concern, any country, however developed it may be, is not immune to this existential crisis. It was this period when ecology, a term coined by German Zoologist, Earnest Haeckel in 1866, got a political meaning with the emergence of environmental politics.

Environmental movements and ideologies, which are often called Green Movements, asserted that human life can only be understood in the context of natural world. Environmentalism emerged as an ideology addressing the questions of relationship between humans and their environment and limits of human intervention in nature. Environment is 'a system which include all living things and the air, water and soil which is their habitat' and, therefore, humans are part of a complex and interrelated structure (Goldsmith, 1972). Any irresponsible behaviour on their part would result in disturbance in ecosphere and humans, with all their scientific and technological advancement, would not be able to immune themselves from its effects. During 1960s and 70s many remarkable works were produced by activists and scholars to uncover the gray side of economic growth model of development and to sensitize the global community.

Rachel Carson's *The Silent Spring* (1962) highlighted the impact of pesticides and agricultural chemicals- used for increasing productivity- on humans and wild life. Carson tried to create awareness against indiscriminate use of pesticides: 'The world has heard much of the triumphant war against disease through the control of insect vectors of infection, but it has heard little of the other side of the story- the defeats, the short-lived triumphs that now strongly support the alarming view that the insect enemy has been made actually stronger by our efforts. Even worse, we may have destroyed our very means of fighting' (Carson, 1962). Restating the Malthusian theory and reinterpreting it in the context of 1960s, Paul R. Ehrlich in his work *The Population Bomb* warned against increasing population and its detrimental impact on the carrying capacity of the planet. 'Overpopulation is now the dominant problem in all personal, national and international planning. No one can do rational planning, nor can public policy be resolved in any area unless one takes into account the population bomb' (Ehrlich, 1968). *The Limist to Growth* (1972), report of a study conducted by a team of researchers from MIT to

analyze implications of economic and population growth, examined impact of five factors- population growth, agricultural production, nonrenewable resource depletion, industrial output and pollution generation. It emphasized the need for a pro-active approach to deal with the crisis because ‘ if the present growth trends in world population, industrialization, pollution, food production and resource depletion continued unchanged, the limits to growth on this planet will be reached sometime within the next hundred years’ (Donella *et al.*, 1972). The unofficial UN report *Only One Earth* (1972) echoed the same view and questioned the consumption pattern and consumerist life styles of industrialized societies. It informed that ‘in the last twenty-five [years], the power, extent and depth of man’s interventions in the natural order seem to presage the most revolutionary [change] which the mind can conceive’ (Ward & Dubos, 1972). Edward Goldsmith et al. in their work *The Blue Print for Survival* (1972) again emphasized the need for rethinking relationship of humans with their environment and advocated total restructuring of the present system to ensure survival on the planet. They asserted that ‘radical change is both necessary and inevitable because the present increases in human numbers and per capita consumption, by disrupting ecosystems and depleting resources, are undermining the very foundations of survival’ (Goldsmith *et al.,* 1972). They suggested the model of small self-sufficient communities as the remedy to ensure sustainable living.

The environmental consciousness created by these studies compelled the global community to rethink their approach to development and ponder upon the issue of sustainability. The first conference organized at global level to contemplate on the issue of environmental security was the United Nations Conference on the Human Environment at Stockholm from 5 to 16 June, 1972. Stockholm Declaration was the first comprehensive document that dealt with the issue of environmental degradation. It pronounced 26 principles on human environment and provided a basis for formulation of an international policy to conserve environment. It set the goal of sustainable development and emphasized that ‘ the natural resources of the earth including the air, water, land, flora and fauna and especially representative samples of natural ecosystems must be safeguarded for the present and future generations through careful planning or management as appropriate’ (Stockholm Declaration, 1972). The declaration stressed the need for ‘reconciling the conflict between development and environment’ and advised the nation states to come up with such a model of development which would be compatible with the goal of environment conservation (Stockholm Declaration, 1972).

The Stockholm Declaration was followed by some major global conventions on the protection and improvement of environment like The Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973; The Convention for the Protection of

Marine Pollution by Dumping of Wastes and Other Matter, 1972 and The Convention for the Prevention of Marine Pollution by Dumping from Ships and Aircrafts, 1973.

The journey started with the Stockholm Conference, to sensitize global community and to motivate them for formulating policies and programmes for environment protection and sustainability, is still going on. Some of the major landmarks in this journey were: the UN Conference on Environment and Development (Rio Earth Summit), 1992; UN General Assembly Special Session on Sustainable Development, 1997; World Summit on Sustainable Development (WSSD), 2002; UN Conference on Sustainable Development (Rio+20), 2012; UN Sustainable Development Summit, 2015; UN Framework Convention on Climate Change: 21st Conference of Parties (COP 21), 2015 and UN Climate Action Summit, 2019.

The above account speaks of the increasing environmental awareness in global community, now the relation of mutual dependence between nature and human society has been globally recognized. It is clear now that quality of life of humans depends on the quality of environment, thus, the protection of environment is not at all any altruistic project but an existential need of human society.

Environmentalism and Ecologism: Major Features and Approaches

There are two terms - often used for the ideologies which are concerned with environment- 'environmentalism' and 'ecologism'. Though both challenge the unlimited growth model of economy and advocate for rethinking relation between nature and humans, but they differ in their emphasis and perspectives on human-nature relationship. Environmentalism is often used to 'refer to a moderate or reformist approach to the environment that responds to ecological crisis but without fundamentally questioning conventional assumptions about the natural world'. Ecologism, on the other hand, stresses 'the central importance of ecology…In calling for radical socio-political change and fundamental rethinking of the relationship between human beings and the natural world, ecologism has developed into an ideology in its own right' (Heywood, 2017). Scholars have tried to trace roots of environmentalism and ecologism in ancient civilizations and religious traditions; their argument is that the ancient communities especially the tribal groups had an eco-friendly approach towards life. However, environmentalism and ecologism are modern ideologies emerged in response to excessive industrialization during 20th century. 'The real origin of Green Movements is in the great social and political upheavals that swept the United States and the entire Western World during the 1960s' (Tokar, 1992).

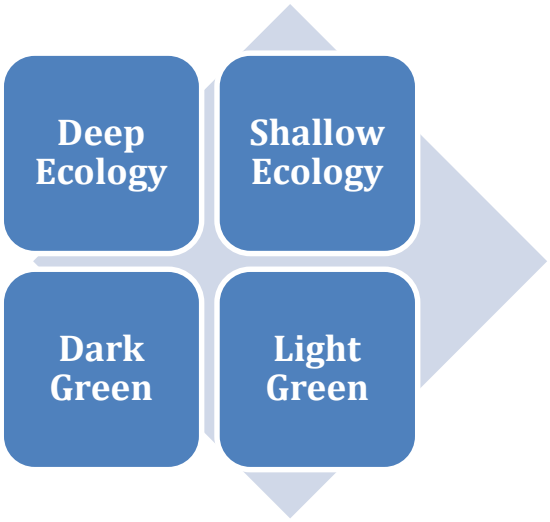
Environmentalism is a broad ideology encompassing different perspectives and groups- reformists to radical. Some of the major features of environmentalism on which most of the environmental theorists and groups agree are as follows:

- It challenges the modernist human-centric approach which considers human beings as the owner of the nature and nature as the object to be controlled, conquered and exploited. It considers this 'arrogance of humanism' responsible for present deplorable state of environment (Ehrenfeld, 1978).
- It suggests that human beings must learn and recognize that they are the very part of nature and not its master; their well being can be defined and ensured only in relation with natural world. It emphasized the need for an alternative paradigm to replace 'Cartesian- Newtonian paradigm' (Capra, 1997).
- It challenges the idea of unlimited growth and emphasizes on sustainability. Environmentalism considers 'growth mania' of human society to be responsible for environment degradation and therefore, advocates for 'steady-state economy' (Daly, 1974).
- It warns the human society that this unlimited growth model is neither possible nor desirable. To illustrate, Kenneth Boulding's idea of 'spaceship earth'- where he compares earth with a spaceship with limited and exhaustible wealth- suggests that human society must change its consumption patter in order to survive (Boulding, 1996). Schumacher also highlights the infeasibility of unlimited growth and argues that 'economic growth , which viewed from the point of view of economics, physics, chemistry, and technology, has no discernable limit, must necessary run into decisive bottlenecks when viewed from the point of view of the environmental sciences. An attitude of life which seeks fulfillment in the single- minded pursuit of wealth- in short , materialism- does not fit into this world, because it contains within itself no limiting principle, while the environment in which it is placed is strictly limited' (Schumacher, 1973). Therefore, an economical and enlightened use of natural resources as well as a steady economy approach is required to attain the goal of sustainability.

Diversities within Environmentalism and Ecologism

All environmentalists and ecologists show their concern for environment degradation and aim at attaining the goal of environment conservation but from this point of agreement they go in different directions. There is strong disagreement among them on questions like what is the

relationship of human beings with their environment? What is the cause for environment degradation? Why should environment be protected? What are the measures to protect environment and remedies for present environment crisis? What should be the role of State and Government in protecting environment? Therefore, 'just as there are many socialisms and many liberalisms, so there are many ecologisms and environmentalisms' (Dobson, 1990).



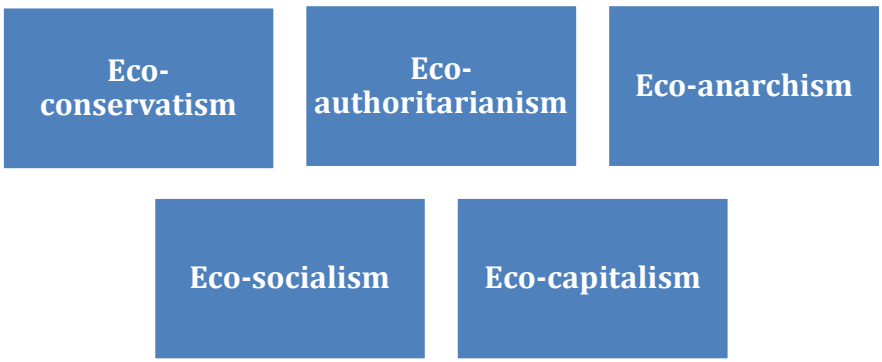
Ecologism has been classified by Arne Naess into deep ecologism and shallow ecologism (Naess, 1973). Deep ecology considers environment as of intrinsic value; on the other hand, environment is of instrumental value for shallow ecology. In deep ecology 'the primary locus of value is not the human individual', it is eco-centric and holistic and considers ecosphere as an integrated whole where relationship between different elements is of equality. Thus, it believes in bio-centric equality and rejects atomistic individualism (Heywood, 2017). It believes in 'ecosophy' and argues that the purpose of human life is to sustain nature; hence, the human individuals are for nature, not the other way around (Naess, 1989). Some of the major features of deep ecologism are: eco-centrism, mysticism, radical holism, intrinsic value of nature, anti-growth and bio-centric equality.

In contrast to deep ecology, shallow ecology is anthropocentric which looks at nature from a human centric perspective and considers nature as of instrumental value for human well-being. The difference between the conventional anthropocentric ideologies and shallow ecology's light anthropocentrism is only that while former considers uncontrolled use of natural resources as key to human well-being, the latter recognizes that this over consumption is not feasible in long term, and hence, suggests limited use of natural resources to ensure well-being of human society. The major features of shallow ecologism are: reluctant holism, prudential and light anthropocentrism, rationalist and scientific approach, instrumental value in nature and sustainable growth (Heywood, 2017). While making distinction between deep and shallow

ecologism, Naess stresses upon intrinsic value and instrumental value argument and explains that for shallow ecology 'natural diversity is valuable as a resource for us' and 'plant species should be saved because of their value as genetic reserves for human agriculture and medicine', while for deep ecology 'natural diversity has its own value' and therefore, 'plant species should be saved because of their intrinsic value' (Naess, 1984).

The distinction between these two ideologies has deeply influenced environmental politics, there are few environmental groups which believe in deep ecologism and suggest radical approach to environment conservation and demands fundamental change in the present system. On the other hand, there are groups based on shallow ecologism adopting a gradual reformative approach. To illustrate, in Germany, the environmental groups are divided into 'light greens' (who are called realists) and 'dark greens' (who are called fundamentalists). The basic difference between these two is that while 'light greens' believe in sustainable growth, the 'dark greens' considers 'zero growth' as solution to environmental crisis. The 'light greens' explore the possibility of making material prosperity compatible with environment protection by adopting the model of sustainable growth. It suggests piecemeal changes like reform in tax system to promote environment friendly practices, use of eco-friendly technologies and small scale production in place of large scale production. In contrast, the 'dark greens' want total change in existing system and assert that the narrative of sustainable growth cannot solve the problem because growth and environment cannot go together and hence, what is required is a 'zero growth policy' and 'construction of a post-industrial age' (Heywood, 2017).

Apart from the above fundamental divisions in ecologism, there are many other groups within environmentalism who are divided on the question of the role of state, market and capitalism in environment protection.



Eco-conservatism associates modern urban life style and institutions based on atomistic individualism with environment degradation and sees close link between protection of ecology and traditional values and institutions. It has a nostalgic attachment to rural life and hence, it

suggests return to a pre-industrial age rather than construction of a post-industrial age as the remedy for present environmental crisis. It believes in conservation of traditional values, ethos and institutions as well as of environment.

Eco-authoritarianism questions the environment protecting capacity of democracy and argues that the goal of sustainability cannot be attained in a democratic system but rather what is required is a rule of eco-elites i.e meritocratic rule of those who have expertise in ecological matters. It advocates the idea of climate dictatorship on the ground that for protecting environment some tough decisions are to be taken which is not possible in a democracy (Beeson, 2010). To quote Lovelock: 'we need a more authoritative world. In times of crisis you have a few people with authority who you trust who are running it' (quoted in Klatte and Rehbaum, 2020). Thus, it sees democratic institution and liberal market as the part of the problem and centralized authoritarian rule as the solution to the environmental crisis.

On the other extreme, eco-anarchists consider total decentralization as the solution to exploitation of environment. Anarchism idealizes stateless self-sufficient small communities and ecologism also supports the idea of small self-sufficient communities and small scale production. Therefore, eco-anarchism argues that anarchist ideas correspond to the ecological needs. According to it, such self-ruled communities would be close to nature and decentralization would lead to 'a more intelligent and more loving use of environment' (Heywood, 2017).

Similarly, eco-socialism, considers capitalism as the root cause of the present environmental crisis. Rudolph Bahro, a German eco-socialist, associates capitalism with excessive industrialization resulting in environmental degradation (Bahro, 1982). It presents socialism as a solution to ecological crisis because common ownership of wealth would serve the interest of whole humanity and ultimately this change of ownership would resolve the issue of over consumption and thereby the problem of environmental degradation.

In contrast to eco-socialism, eco-capitalism conceives market as the part of the solution and emphasizes the need for optimum utilization of market's potentials for environment conservation and improvement. It argues that market can play significant role in protecting and improving environment through producing environment friendly products and technology (Vincent, 1992).

Thus, environmentalism is widely divided and, unfortunately, has become a hat which has lost its shape because everyone is wearing it.

CONCLUSION:

To sum up, the last century has witnessed a rapid growth in environmental groups and an increase in environmental awareness. A number of changes in policies and programmes in tune with the goal of conservation of environment have been observed at local as well as global level. But still there is lack of agreement among nation states as well as environmental groups who are ideologically divided. This divide, sometimes, prohibits them from coming together on one platform and, unfortunately, is weakening environmental concerns and environmental consciousness. Further, despite being a global concern, in practice, the environmental crisis is not affecting everyone equally due to difference in their bargaining capacity. Therefore, dynamics of environmental politics cannot be understood in isolation with the divide between North and South; developing and developed, ethnic /tribal communities and residents of metropolis and such other divides.

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AN ENVIRONMENTALLY SAFE AND EFFECTIVE PEST CONTROL SYSTEM BASED ON GENETICALLY MODIFIED INSECTS: FROM LAB TO FIELD

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ABSTRACT:

Insect transgenesis is constantly being developed in order to improve the efficiency of population suppression and replacement tactics aimed at controlling economically and hygienic important insect species. GM insects might lessen the demand for pesticides and the hazardous residues they leave behind in the environment. The fitness of the transformant individuals must not be compromised so that, once released in the field, they can efficiently compete with or even out-compete their wild-type counterparts for matings in order to lower population size or transmit desirable genes into the target population. Recent research has revealed that producing fit and competitive transformants is now possible, and that transgenes may not always carry a fitness cost. In this chapter, we evaluate the most recent published results of fitness assessments of several transgenic insect lines and emphasise the need of meeting major ecological safety standards. Fitness evaluation studies in field cages and medium/large-scale rearing will reinforce the current promising laboratory results, providing an indication of the performance of the transgenic insect genotype following release in pest control programmes.

KEYWORDS: Transgenesis, SIT, Population replacement, Ecological safety

INTRODUCTION:

Arthropod pests are responsible for more than $470 billion in agricultural crop losses globally (Culliney, 2014). Insecticides, whose worldwide annual market value is expected to

reach $16.44 billion by 2019, are the weapon of choice for combating such pests (Statistica, 2019). Insecticides will continue to be a key component of IPM systems, however there are issues regarding their off-target impacts. In addition, pesticide resistance is an increasing issue, with 586 insect species reported to be resistant to one or more insecticides (Sparks and Nauen, 2015). Other pest management strategies will play an increased role in the future. Already, during the last two decades, the use of genetically engineered, insect-resistant crops (i.e., Bt crops expressing insecticidal proteins from the bacterium *Bacillus thuringiensis*) has played a significant role in lowering the usage of traditional pesticides in cotton, maize, and other crops (James, 2017). However, like with traditional pesticides, the efficiency of Bt crops is jeopardised by the evolution of insects resistant to the Bt proteins expressed in them (Tabashnik and Carrière, 2017). Genetic pest management now incorporates genetic control of the insect itself, in addition to genetically modified pest-resistant crops. Indeed, transgenic techniques to increasing the efficiency of (1) population reduction, primarily via the Sterile Insect Technique (SIT), and (2) population replacement tactics against agricultural pests and disease vectors have been proposed (Handler, 2002; Scott *et al.,* 2005). Population suppression is self-limiting, including the release of mosquitoes carrying a fatal gene, affecting progeny production in a specific insect population. Population replacement is self-sustaining and includes the introduction of transgenic mosquitos resistant to a specific pathogen to replace the natural population, interrupting the transmission cycle. RIDL (Release of insects carrying a dominant lethal) is one example of the possible function of transgenesis in pest management (Alphey and Andreasen, 2002; Alphey *et al.*, 2002), a variant of the typical SIT in which the same construct performs both genetic sexing and sterilization.

Insects that have been genetically modified (GM) are created by adding new genes into their DNA. Many genes have been identified that can change insect behaviour and biology. When these genes are put into the genome of an insect, they are referred to as transgenes, and the insect is referred to as transgenic or genetically modified. Transgenes are often introduced using short DNA sequences that randomly integrate into the insect's genome, bringing the transgenes with them. Genetically modified strains with complicated arrangements of transgenes can be generated by injecting DNA containing the necessary genes into the eggs of insects. Over the last 10 years, novel technologies for manipulating DNA have allowed various insects to be genetically altered, including agricultural pests like the Mediterranean fruit fly and disease vectors like mosquitos. Researchers are preparing certain GM insects for environmental trials, with the 2006 release of a GM pink bollworm moth (a cotton problem) harbouring a marker gene in the United States being the first use of GM insects in a plant pest management programme.

Beneficial insects would be unaffected by genetically engineered insects since they would only target a specific insect pest type. GM insects might lessen the demand for pesticides and the hazardous residues they leave behind in the environment. When deployed in disease control programmes, genetically modified insects would protect everyone in the release region, regardless of socioeconomic class. Disease management employing GM insects would need less community engagement, making it less vulnerable to individual failure to participate in a control programme.

The usage of GM technology is controversial. Some organisations that monitor the use of genetic technology are concerned that reliance on high-tech remedies, such as genetic modification, could detract from more effective but poorly implemented strategies to reduce insect damage. Furthermore, environmental non-governmental organisations (NGOs) believe that GM insects may have unanticipated and widespread effects on the environment and human health because to the complexity of ecosystems and the large number of unknown elements, making risk assessment difficult. They have expressed many restrictions regarding the discharge of genetically modified insects. New insects or illnesses may occupy the ecological niche left by the insects that have been suppressed or replaced, potentially causing new public health or agricultural issues. The new genes inserted into the insects may spread to other species, a process known as horizontal transfer, resulting in unexpected effects for the environment. Releases would be hard to control and irreversible, as would any environmental harm.

Population reduction approach for development of GM insects

The SIT is a species-specific and ecologically sustainable insect control method based on mass rearing, sterilisation, and field release of large numbers of insects (Knipling, 1955). Competition for mating with wild females between released sterile and resident males reduces reproductive potential, and if continued releases of high-quality sterile males in massive numbers over many subsequent generations are accomplished, a progressive reduction in population size and, ultimately, complete eradication of the pest population will happen **(Fig 1)**. The SIT is now the most extensively used control tool for tephritid fruit flies (Enkerlin, 2005; Klassen and Curtis, 2005) and it is also used to manage the pink bollworm moth *Pectinophora gossypiella* (Saunders) and the codling moth *Cydia pomonella* (L.) (Bloem *et al.,* 2005). Successful AW-IPM programmes, which included the application of SIT, resulted in the elimination of the New World screwworm *Cochliomyia hominivorax* (Coquerel) from numerous parts of Central and South America (Robinson et al. 2009). The eradication of the tsetse fly *Glossina austeni* in Zanzibar, Tanzania, in 1997 demonstrated the viability of using an AW-IPM approach with a

SIT component as a tool for creating tsetse-free areas, even though topographical and ecological conditions influenced the success of tsetse-eradication campaigns (Vreysen, 2006). Despite these successes, SIT is not appropriate for every disease vector because key requirements include (1) intensive rearing of large numbers of vector insects for mass release, (2) the availability of efficient sex-separation methods, (3) sterilisation techniques capable of producing large numbers of insects with minimal fitness effects, (4) effective release methods, and (5) efficient marking systems to identify released individuals. In the case of mosquitos, several trials were conducted to control species such as *Aedes aegypti*, *Aedes albopictus*, *Culex pipiens*, *Culex quinquefasciatus*, *Anopheles albimanus*, and *Anopheles gambiae*; however, while many attempts resulted in a decrease in the mosquito population, only few accomplished eradications in the release area or long-term control (Benedict and Robinson, 2003). Transgenic technology has the potential to improve operational SIT programmes on three fronts: genetic sexing, sterilisation, and monitoring. RIDL, a version of the standard SIT in which both genetic sexing and sterilization are done by the same construct, is one example of the possible role of transgenesis in pest management (Alphey and Andreasen, 2002; Alphey *et al.*, 2002). This population reduction approach employs an insect strain that is homozygous for a dominant deadly genetic system, such that the'sterilization' of the released insects is triggered by homozygozity for a dominant fatal gene rather than irradiation (Alphey, 2007). Mating with wild individuals produces offspring who are heterozygous for the fatal gene, resulting in the death of all descendants and, as a result, the ultimate extinction of the species owing to a decline in reproductive potential (Heinrich and Scott, 2000; Thomas *et al.*, 2000).

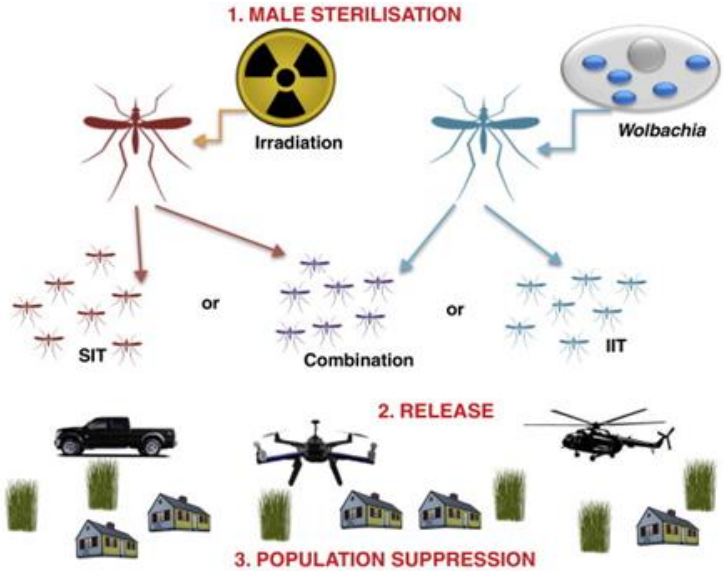

Figure 1: The sterile insect technique (SIT), incompatible insect technique (IIT) or a combination of the two could be used to suppress mosquito populations (Lees *et al.*, 2015)

Population replacement approach for development of GM insects

Population replacement, on the other hand, aims to introduce a resistance mechanism to reduce disease spread **(Fig 2)** (James, 2005; Rasgon and Gould, 2005). This strategy necessitates the development of both a resistance mechanism and a way for disseminating the gene among a population. Resistance mechanisms have been established in numerous mosquito species, such as RNAi to inhibit dengue transmission in *Aedes aegypti* (Franz *et al.,* 2006), *A. stephensi* malaria development inhibited by synthetic peptides (SM1) (Ito *et al.,* 2002) and cecropin expression to inhibit malaria development in *A. gambiae* (Kim *et al.,* 2004). Wolbachia symbionts, for example, are being studied as a mechanism for propagating a gene throughout a population (Rasgon and Scott, 2003; Sinkins and Godfray, 2004), engineered underdominance (Davis *et al.,* 2001), fitness manipulation (Hahn and Nuzhdin, 2004), multiple independently assorting loci (Schliekelman and Gould, 2000), meiotic drive systems (Mori *et al.,* 2004; Huang *et al.,* 2007) and transposable elements (Boete and Koella, 2002; O'Brochta *et al.,* 2003; James, 2005).

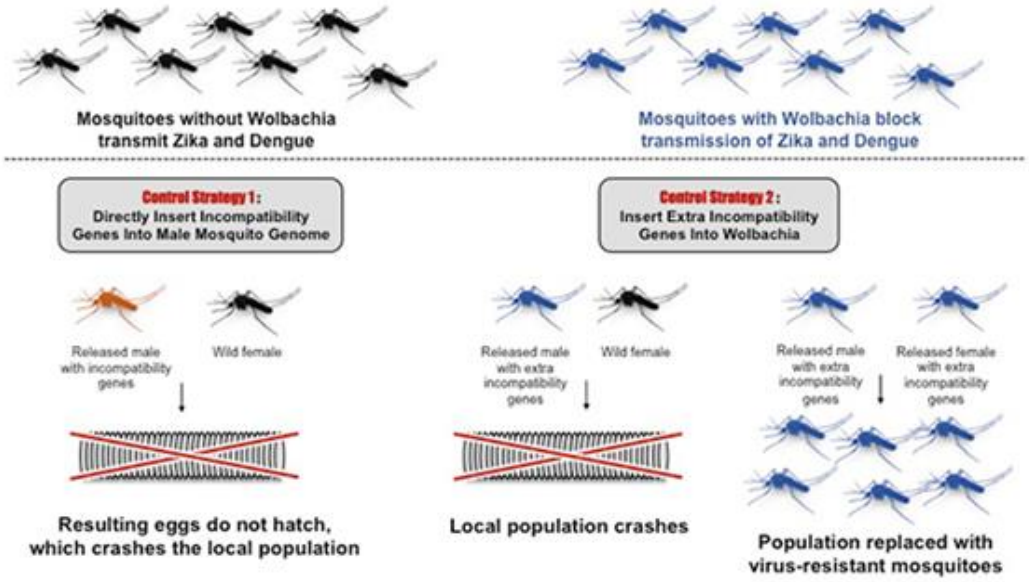

Figure 2: Comparison between the Population suppression approach and Population replacement approach

Insect transgenesis and its cost of fitness

Transgenic technologies, which are generally mediated by transposable elements, have the potential to alter fitness at several levels and with a wide variety of consequences. For example, because germ-line transformation by microinjection requires random integration of the transgene into the host genome, the transgene may insert in transcriptionally active sites

(Thibault *et al.,* 2004). Because of the negative impacts of insertional mutagenesis, the new insertion may interfere with, or even disrupt, the normal function of one or more genes, reducing the fitness of the target person **(Fig 3)** (Mackay, 1989; Rasgon and Gould, 2005). Second, the chromosomal environment around the insertion site might modify the intensity of transgenic expression (position effect), perhaps due to local chromatin organisation or nearby cis-acting regulatory elements, occasionally resulting in transgene silence or abnormal expression **(Fig 4)** (Venken and Bellen, 2005; Williams *et al.,* 2008). Finally, foreign protein products of transgenic systems, like as fluorescent transformation markers, may accumulate in high amounts, creating toxicity in the regions where they are produced and, as a result, a fitness cost for the GM insect **(Fig 5)** (Liu *et al.,* 1999; Marrelli *et al.,* 2006). Even if numerous causes of fitness loss may be recognised, fitness expenses are not always well understood in terms of their causes and real costs. Because their impacts may diminish the efficacy of transgenic strains in implementing control measures, strains generated for use in field programmes must be assessed precisely and effectively.

Figure 3: Potential fitness costs of Insertional mutagenesis

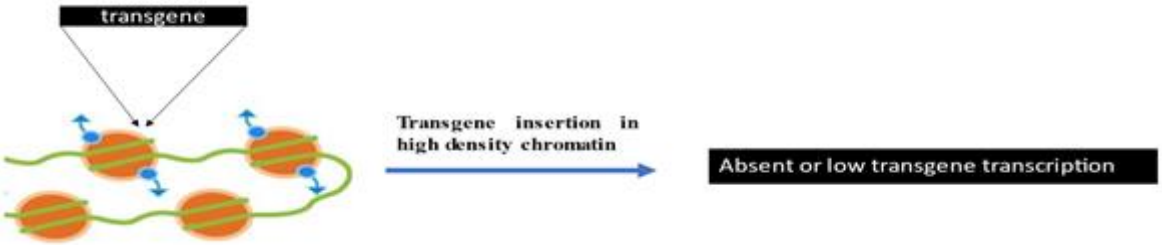

Figure 4: Potential fitness costs of Position effect

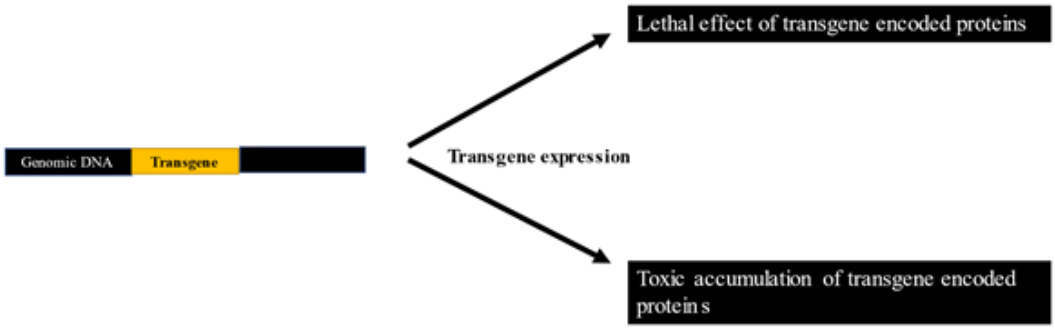

Fig 5: Potential fitness costs of Transgene product

A review of current fitness studies on transgenic insects

New world screwworm

Cochliomyia hominivorax (Diptera: Calliphoridae) is a major cattle pest in neotropical regions and was the first insect to be managed with the SIT (Wyss, 2000). Successful AW-IPM programmes, including the use of the SIT, have resulted in the elimination of this species from the southern United States, Mexico, Central America, Panama, and certain Caribbean islands, constituting unquestionably the most successful example of SIT use (Robinson *et al.,* 2009). They were utilised to assess the post-larval fitness costs of metamorphosis, including as average pupal weight, adult emergence, male ratio, and mating competitiveness (Allen *et al.,* 2004). In compared to the wt control, fecundity, fertility, larval production, and lifespan (Allen and Scholl, 2005) showed essentially no consistent fitness loss. CLAY, the strain with the brightest fluorescent phenotype that matched the non-transgenic parental strain in mating competition and performance testing, was also successfully cryopreserved, allowing for its application in mass production (Handler *et al.,* 2009). This looks to be very promising for the adoption of this strain into future SIT programmes, however sterilisation via an early expressed conditional lethal system, as well as fitness testing on the final strain, must still be undertaken before it is considered for release.

Mediterranean fruit fly

The SIT has been effective in decreasing, controlling, and eliminating medfly populations globally. The SIT against this species was developed and implemented so quickly and effectively that it has been validated and used on an industrial and area-wide basis (Hendrichs, 2000; Klassen and Curtis, 2005). The medfly was also the first non-drosophilid insect to be transformed (Loukeris *et al.,* 1995) and this success paved the door for the genetic modification of many additional pest insects that are the targets of SIT programmes. (Handler and McCombs, 2000). Various medfly strains are already accessible, which should improve the efficacy and cost effectiveness of the SIT throughout the mass-rearing, releasing, and monitoring stages since they provide (1) genetic marking for the detection of transformed insects (Zwiebel *et al.,* 1995) (2) male-specific fluorescent sorting (Scolari *et al.,* 2008b); (3) sexing for male-only strains (4) reproductive sterility caused by embryonic lethality. A recently developed transgenic sperm-marked strain is a potential alternative for practical enhancement of medfly SIT monitoring systems following further limited field trial studies (Scolari *et al.,* 2008b). By combining the promoter of the spermatogenesis-specific medfly b2-tubulin gene with the reporter genes expressing a red or green fluorescent protein, several lines harbouring two testes-specific markers were created. The mating capacity of transgenic homozygous males in contrast to weight was measured in a first set of laboratory studies. Twenty-five transgenic males competed with wt males for copulation with wt females in a 1:1:1 ratio. These studies, conducted in ten

repetitions for each line, revealed that numerous transgenic lines had decreased fitness, most likely due to a genetic bottleneck that occurred during their establishment, transgene expression, or its specific insertion into the genome. The high competitiveness of the transgenic lines, as well as the complete embryonic lethality that causes reproductive sterility without the need for irradiation, has a significant potential for improving the efficiency of operational medfly SIT programmes, paving the way for future studies that compare the fitness costs of transgenic lethality and radiation-based sterility.

Mosquitoes

Several release attempts using sterile male mosquitos of various species have been done in recent decades (Benedict and Robinson, 2003), However, operational challenges in rearing, inadequate sex separation, impaired male competitiveness, ineffective marking methods, and limited sterility in eggs deposited by wild females hampered the success of the SIT campaigns (Klassen and Curtis, 2005). There are currently no large-scale SIT programmes in place against any mosquito species (Benedict and Robinson, 2003), Despite the fact that a recent attempt to produce SIT against *A. albopictus* in Italy revealed a 36 % decrease in the number of viable eggs in the release region (Bellini *et al.,* 2007). In this context, the global health and economic problems caused by mosquito-borne diseases have sparked an extraordinary effort aimed at developing new molecular tools and gaining a better understanding of mosquito biology and genetics, which has resulted in notable technological advances in the genetic manipulation of several species. These promising findings have increased the number of feasible techniques for eradicating local vector populations. The development of sexing methods for sex separation at early developmental stages, in order to acquire male-only mosquito strains, in particular, may substantially aid SIT or its derivation, the RIDL. RIDL technology is fast evolving, and a strain of *Aedes aegypti* is currently available for field testing. This transgenic strain (LA513A) contains a late-acting tetracycline repressible RIDL system, which allows for larval competition. The LA513 RIDL system resulted in death at the larval/pupal boundary with up to 97 % penetrance of lethality, encouraging the testing of this line for mosquito control. Furthermore, the RIDL approach has the potential to be relevant to a wide spectrum of mosquito vectors, and it has been developed in *Aedes albopictus*, a dengue and chikungunya vector. A recent advancement in the RIDL system demonstrated the ability to create late-acting, repressible, tissue-specific, and female-specific transgene expression in female *Aedes aegypti* to produce a flightless phenotype. The promoter obtained from the *Aedes aegypti* Actin-4 gene leads to the production of tTA in a stage, tissue, and sex-specific way in these newly discovered strains, combining late acting lethality with efficient female sterility. This effective sterility is caused by the flightless females' inability to emit their characteristic wing-beat frequencies, which function as sexual signals to males. Female incapacity owing to the flightless phenotype may be deemed fatal for a RIDL

strain. The creation of this method offers all of the advantages of traditional RIDL, including late-acting lethality, but allows for the release of any life stage, potentially facilitating the control of *Aedes aegypti* and other mosquito species.

The advancement of gene transfer technologies for a variety of vector species also enabled the creation of gene drive systems to disseminate genes that can prevent disease transmission. Transposable elements, Wolbachia, meiotic drive genes, and homing endonuclease genes have all been suggested to do this. The next phase will be the wide-scale field release of GM mosquitos with a desired characteristic, such as malaria resistance and the capacity to distribute it to a substantial proportion of the wild-type vector population. However, before any of these control strategies can be used in the field, it is necessary to analyse the fitness and population ecology of genetically modified mosquitoes.

CONCLUSIONS AND PERSPECTIVES:

In this chapter, we outline the important phases of the process through which transgenesis might aid in pest management programme implementation, emphasising the need of creating fit and competitive altered insects. Several conclusions may be drawn from prior research on the fitness of transgenic insects. First, many transgenic lines should be generated since insertional mutagenesis produced by transposon-mediated germline transformation might have an unpredictable influence on an individual's overall fitness. As a result, it is critical to develop many transgenic lines, compare them, and pick the best compatibility. The availability of several independently acquired lines of the same construct is particularly critical since chromatin surrounding the insertion site might alter the intensity of transgene expression. To avoid this side effect of germ-line transformation, try using insulator elements to modulate position effects. Given that inbreeding has been shown to have a major influence on fitness, it is especially promising that homozygous transgenic strains can perform similarly to wt, especially given that mass rearing of homozygous lines is frequently necessary. Transgenic homozygous lines will therefore (1) simplify rearing methods, lowering strain maintenance costs, (2) allow direct assessment of eventual hitchhiking effects, and (3) allow for robust expression. The availability of site-specific recombination mechanisms mediated by phiC31 in medfly and *Ae. aegypti* marks a significant advancement in transgenic manipulation technique. The ability to generate stabilised lines as a result of these post-integration transgene stabilisation approaches, combined with the ability to add additional functional transgenes at innocuous genomic positions, will allow for the development of many different strains without the need for additional germ-line transformation and its associated potential fitness costs, multiplying the experimental opportunities. Fitness studies designed to determine factors such as survival rate, dispersive ability, mating competitiveness, sperm transfer and functioning, motility and mobility of

potential stable transgenic lines will identify the fittest, which will become suitable targets for future applications. Among these are (1) the establishment of novel studies on functional genetics and genomics, (2) the achievement of easier mass-rearing and improved line stability, and (3) the improvement of genetically modified insect performance in the field for the betterment of pest control methods, both in terms of population suppression and replacement. Finally, future assessments of GM insect fitness will need frequent semifield experiments, followed by the release of GM insects in isolated locations properly defined in terms of the genetic and ecological structure of local insect populations, as well as disease transmission data. Only if GM insects meet essential fitness and ecological safety standards, as determined by actual field use, will they be effective for upgrading existing control tactics.

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A STUDY ON THE BIODIVERSITY AND CULTURAL ASPECT OF THE SACRED GROVES OF SOUTHERN KERALA

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ABSTRACT:

Sacred groves are unique green patches of land spread at different parts of the world with distinct biodiversity. These mini forests have been preserved inside our societies as treasure houses of rare and endemic species and considered as having holy features and worshipped. Sacred groves are usually devoted to serpent worship. Kerala is one of the states in the country that is known for its extensive sacred groves. This study had tried to understand how sacred groves had played a role in the conservation of biodiversity, role of religion in the conservation of biodiversity of some of the southern districts of Kerala as well as the role of religion in biodiversity conservation. The study had adopted the qualitative approach. The sample were recruited using purposive sampling and researchers' observation and in-depth interviews were conducted. The data was collected from the total of 50 respondents and the observation was done at 15 sacred groves. The results showed a positive relationship between the sacred groves and the conservation of biodiversity. Religion acting as one of the mediums of biodiversity conservation was also proved through the research. Besides these, the study brings to light the fast disappearance of these groves as well as the condition of an indigenous community called The Pulluvans that is on the cusp of a wipe out.

KEYWORDS: Biodiversity, Sacred Groves, Culture, Pulluvan, Traditions, Religion

SACRED GROVES OF INDIA:

Sacred groves are some of the unique patches of biodiversity that preserves natural ecosystem at its best. These green patches of lands have flora and fauna that are very unique to themselves. Everything residing under these groves are under the protection of the reigning deity of the grove and the removal of any material, even very futile things like twigs or leaves are considered to be against the will of the God residing inside it.

The concept of Sacred Groves exists in many parts of the country and is known in different names, Lyngdoh in Meghalaya, Kovilkadu in Tamil Nādu, Dev Bhumi in Uttarakhand,

Kavu in Kerala, Sarna and Deorai in Madhya Pradesh, Diovan in Himachal and Ummagalai in Manipur. However, states some of the states like Nagaland, Andaman and Nicobar Islands etc. have very less or no sacred groves reported.

The Indian history is not bereft of information about imaginary divine forests. The great epic Mahabharata had mentioned about Upyanaas, which can be understood as the contemporary sacred groves. Not only in Mahabharata but also many different Indian ancient novels, the existence of divine forests is mentioned. The Indian epic Ramayana mentions about the Ashoka Vatika where Sita was taken into custody by Ravana. Many scientists have claimed Ashoka Vatika as a sacred grove of Ashoka trees. Ashoka trees are considered sacred for the Hindus as well. Mahabharata also gives references of gardens in Vrindavan that Krishna used to stroll on. These gardens are mentioned as sacred and of medicinal properties. Some of the plants that are mentioned include Tulsi, Ramacham, flowering medicinal plants, Champa etc. Even though there is no apt mentioning about the prevalence of a deity inside these groves, it could be inferred from the explanations that sacred groves existed from ancient times itself. However, these data are not substantiated with any objective truth as epics are mostly considered myths. Nevertheless, there has been connotations on sacred groves in most of the Hindu ancient scripts.
One of the unique features of the biodiversity that exists inside these sacred groves is that they are unique to the ecosystem. None of the flora and Fauna that resides inside the sacred groves thrive outside it. Although these sacred groves are like mini forests, they do not belong to the larger forest area. These sacred groves exist inside the communities.

Sacred groves can also be considered as one of the many sacred conservation practices followed by the communities around the world. In the recent years a lot of importance have been given to indigenous methods of biodiversity conservation, and in relation to that the sacred groves can be considered as a very unique practice that protects ecosystem as well as adheres to common values of the world.

Sacred groves on a larger value sense can be considered as Commons. Commons are shared resources like water, grazing lands, forest areas etc. These are different from other properties like an agricultural land or a house, which are owned individually. Commons as the name suggest are common to everyone and it is expected that the protection of these properties are the responsibility of every stakeholder in the society.

The sacred groves found in India can basically be classified under three categories.

- Traditional sacred Groves-It is the place where the village deity resides, who is represented by an elementary symbol.

- Temple Grove-Here a grove is created around a temple and conserved.
- Groves around the burial or crimination grounds.

Sacred groves through the medium of religion have been able conserve a thick biodiversity. It is believed by the local community that any kind of taking away of properties from the groves are considered to be a taboo and can inherit the wrath of the deity that resides inside it. Since long, these groves have been untouched by the common people. Because of the same, these green patches have been thriving with excellent natural diversity. Hunting or collection of timber wood are prohibited. However, on special occasions, common people are allowed to collect medicinal plants of some unique wild flowers for ceremonial purposes.

SACRED GROVES OF KERALA:

The sacred groves of Kerala can be broadly divided into three types. The Ammadaivakavukal that worships female goddesses like Kali Devi, Bhagavati etc. The second type of sacred groves are dedicated to Purushadaivakavukal or Male gods. The male gods who are usually worshipped include God Ayyappa, Village Gods etc. The third type of sacred groves are the Mrigadaivakavukal or that is dedicated to animal worship. These groves usually worship serpent gods and goddesses. The northern and central districts of Kerala have sacred groves that usually has male and female deities in them however the southern districts of Kerala have sacred groves that are dedicated to serpent gods and goddesses. This study is focused on the sacred groves of southern part of Kerala. the sacred groves of southern districts have distinct rituals from that of the other sacred groves. These sacred groves have rituals that focus on snake worship. An indigenous scheduled caste community called the Pulluvans have ancestral rights to perform rituals\ at these groves. Pullavans usually perform Pulluav Pattu or pulluvan songs using very unique musical instruments called the Kuda and Pullvan Veena.

Almost all sacred groves of Kerala have prohibitions and taboos associated with it that decline general people to enter the groves. Only very few people including the priest who perform rituals are allowed inside the groves. The general public usually withdraws from entering these groves fearing the wrath of the serpent gods and goddesses. However, on some special occasions like the Aayilyam divas, the general public are also given a chance to go inside the grove and do their offerings.

In the recent years, with the skyrocketing prices of properties in the state thrusted by development has not done any good to the sacred groves. The state of Kerala has been on a faster run for development whereby the government has invited many companies to invest in the state.

These investments have contributed to a boom in the price of land in the state. This sudden demand as aggravated the problem of destruction of sacred groves. Most importantly, these groves have been positioned at areas where property prices were soaring. These sudden soar in the land prices have contributed to a situation where people have given away the thought of preservation of sacred groves.

With development and modernity, the protection or existence of sacred groves are considered to be nothing but a superstitious belief. Often at many places of the state it has been reported that the groves were cleared in the name of development. According to a recent survey by the forest department of the state, it has been reported that, the state had a total of 10,000 sacred groves during the 1950's, which has gone down drastically by 1200 only existing in the society. This decline has also have had a negative impact on the sustenance of many a unique flora and fauna. As many as 475 species of birds, 100 species of mammals, 156 species of reptiles, 91 species of amphibians, 196 species of fish and 150 varieties of butterflies abound in the groves have been affected.

Apart from development, the disintegration of joint family systems or Tharavadu systems can also be considered as an important factor for the disintegration of sacred groves in the state. In the Tharavdau system, each family had a sacred grove inside their premises. These sacred groves were considered to be the possessions if the members of the family. It was also believed that the snake deity that preserved inside the sacred groves protected the family members. Monthly and annual religious rites and various other rituals were performed inside these groves in order to ensure the blessings of the deity. This system continued for generations among the Nair Tharavadu systems. However, development started affecting the family structures also in different parts of the country. And Kerala was no exemption. The surge in land prices have led to a situation of immediate property divisions among most of the tharavadu families. These property divisions did not really take into consideration the importance of conservation of the unique ecosystem that they had. As a result, most of the sacred groves were destructed for construction purposes or were cleared for sale.

Hence, there is a need to conserve these ecosystems for the future generations. Most of the flora and fauna that cohabit inside these groves, over the years, have gone into categories like endangered, extremely endangered or extinct.

There has been a lot of studies that have gone into understanding these unique patches of ecosystems.

There are many literary works that focuses on the prevalence and importance of Sacred Groves in different parts of the country. Most of the literary works give importance of sacred

groves in preserving biodiversity and also a place which ensures the sustainability of medicinal plants. The importance of sacred groves in preserving biodiversity and culture at Chilkigarh has been the focus of (Bhakat, 2003). The article is based on a study conducted in Rajasthan by understanding the importance of sacred groves in preserving human culture and also suggesting strategies for the effective long-term conservation and better management of the groves.

A study conducted in the state of Kerala (Pushpangadan, 1998) on sacred groves gives importance to religion as one of the main factors for the sustenance of sacred groves in the state. Kerala being a state which has a huge hold of religion in its culture, it has always ensured the maintenance of these groves by attaching deities to each grove thereby restricting people from destroying it.

However, some literatures from Tamilnadu (Amrithalingam, 1997) have also focussed on a different aspect of Sacred Groves called as the Sthalavrikshas. Such literartures have shifted the focus from the idea of sacred grove being a tiny forest to that of as individual trees that are worshipped by the communities surrounding the tree. Such sthalavrikshas are restricted from being chopped off due to religious ethos.

Literatures that have focussed on the negative impacts of developments in Kerala (Balasubramanian, 1989) have given due importance to the depletion of Sacred Groves in the different parts of the state due to land encroachments. Studies like (Bhakat, 2003), (Chndrashekar, 2004) have also emphasised on the long-term impact of developments by destroying the age-old traditions and cultures.

Literatures which focus on Sacred Groves of different parts of India, especially of Karnataka have been the focus of (Chandrashekar, 2004). The study has given importance to the surging developmental activities in different parts of the state, especially in Bangalore which have paved way for the disappearance of Sacred Groves form different parts of the states. The study has shown the pace of disappearance of Groves from 2 to 3 per Km to 0 in past few years. Bhise (1998) have also thrown light on the disappearance of sacred groves while giving importance to Sacred Groves in different parts of Rajasthan. According to the study sacred groves near the Aravalli hills near Madar village of Udaipur district is in the verge of extinction. However, as an action plan a project proposal has been submitted to the WWF for the restoration of the sacred grove.

Studies focussed on biodiversity of Tamil Nadu (Balasubramanian, 1989) have also given due importance to sacred groves associated with temples as the harbours of medicinal plants and also a shelter for many birds and animals. These groves are degraded by encroachments and are in need of immediate attention. The study have linked the extinction of groves to extinction of

various flora and fauna which are dependent on it .Encroachments in the name of agricultural developments and increasing demand for land are some of the reasons for the degradation of these sacred groves. Considering the significance of sacred groves in ecological balance, culture and tradition, the Environmental education centre has taken efforts to identify and select endangered sacred groves for restoration in Andhra Pradesh, Karnataka and Tamil Nadu. Rajasree (2000) have explained fragmentation as the most important factor for degradation of groves. Population growth and agricultural requirements are the major causes of fragmentation. Once the interior of the grove is exposed, the microclimate of the grove slowly disappears leading to the flora and fauna of the place to move away or to wade. This would ultimately result in the extinction and isolation of the groves.

Conservation of Sacred groves has also been topics of discussion in many literatures (Amrithalingam, 1997; Vanaja, 2010). Sacred groves serve as repositories of genetic diversity and are provided with comprehensive and rich ecological niche. Creating awareness among the inhabitants about the importance of invaluable genetic diversity and sustainable use of resources can lead to a secure future of these conserved patches. Government and international conservation agencies should support traditional institutions of sacred grove management, whether at family, community or even regional level.

Gadgil and Vartak (1976) gives the example of a grove in the Raigad district that contains the only specimen of a certain vine within many kilometres. This vine is relied upon by the people of the villages in the area for the treatment of snake bites in cattle. A new species of frog was discovered in 1997 in a sacred grove in Madhya Pradesh (Malhotra *et al.,* 2001). The groves not only protect species of biological diversity value, they also protect species that are important to agriculture. They harbor species of plants that are closely related to local crop varieties and may be used to improve the cultivated types. Sacred groves provide living space for species of insects and birds that control crop pests or act as pollinators for crops. They may also serve as seed banks and nurseries for species of trees and plants of commercial or cultural importance, such as fruit trees and medicines, acting as a source for re-forestation and propagation (Malhotra *et al.,* 2001).

Sacred groves in India may be owned by a family, clan, or a trust body, and are in some cases managed by a temple committee made up of clan elders. Religious rituals and cultural events such as rights of passage and harvest festivals performed in the grove strengthen the belief in the importance of the sacred grove, and encourage people to adhere to the taboos associated with it. In the Kerala region, these rituals include the Theyyam ritual (Jayarajan, 2004).

According to (Jayarajan, 2004) there are 352 sacred groves are reported in Kannur district, which are having an extent of more than 5 cents. Unnikrishnan (1990) recorded Theyyottukavu (24.282 hectares) of Kankol-Alappadamba panchayats as the largest grove in his study area. Largest kavu according to Mohanan and Ramachandran was Iringolkavu in Ernakulam district (20.234 hectares). The earlier surveys have missed Kammadath, Thavidissery, and Kottiyurkavu. Kammadath and Theyyottu kavus are larger than Iringolkavu. Next large ones according to Mohanan and Ramachandran were in Kannur and Kasargod districts and only 12 sacred groves exceeded one hectare in extent in this region.

According to Gadgil and Vartak (1976) sacred groves are the treasure of rare and endemic species. According to Unnikrishnan (1990), among the plants that grow in the Kavus of North Kerala, at least 50 are endemic to Western Ghats and folk practitioners utilize most of them as raw drug source.

MATERIALS AND METHODS:

The study concentrated on the three southern districts of Kerala, namely, Thiruvananthapuram, Pathanamthitta and Allapey. These districts were selected due to the predominance of sacred groves in them. The report prepared by the state assembly committee on forest and environment has also reported the coastal district of Allapey with highest number of sacred groves. The Manarasala Sree Naga raja Temple of Allapey district is also known internationally as one of the biggest temples of serpent worship.

Thiruvananthapuram, as per the recent record given out by the government has 45 sacred groves, Pathanamthitta has 25 sacred groves and Allapey has 22 sacred Groves. The sacred groves which were thus selected were mostly associated with the temples worshipping serpent deities. The total area of groves ranged from 0.04 ha to 24.0 ha. All the sacred groves had more than 75 percentage of vegetation and one peculiar thing noticed from these groves include a running stream of water. Ten out of 15 sacred groves that were observed had water running inside them. These streams provide water to the animals, birds and plants that reside inside it.Those sacred groves that did not have any kind of water stream were either on the verge of extinction or was having less vegetation.

This study relies extensively on primary data which was collected from the fields and the collected data was developed on the basis of the available secondary data from sources like books and journal articles.

The tools of data collection included an interview guide through which a structured interview was conducted. However, taking into consideration the needs of some of the objectives of the study, an observation was also conducted on the identified areas.

The sample for the study was chosen through a purposive sampling method taking into consideration the availability of the respondents at the area of the study. The sample size of the study was 50 which included both men and women. However, the sample was not equally divided on the basis of gender. The most representative population of the study were the people who were closely associated with the sacred groves. In order to understand the biodiversity inside these groves, help from Botany Professor of the University of Calicut were also taken.The data thus collected was analysed through qualitative research methodology taking into consideration the nature of the study.

RESULTS AND OBSERVATION:

These unique patches of ecosystems are on a cusp of wipe out due to various developments that are happening in the state. The ever-skyrocketing prices of land have almost swallowed some of the prominent sacred groves in the state. The division of properties among the individuals of Nair families that have inherited sacred have also paved way for its destruction. Some of the families who still preserve these groves have transferred the deities to the nearby temples citing less knowledge for preforming rituals to the serpent gods and goddesses. The removal of the deity from these groves makes it more prone to destruction as the fear associated with entering the groves exists no more.

The decline in the number of sacred groves have also threatened the sustenance of the indigenous community of the Pulluvan. From years this community has been performing various rituals inside the sacred groves. However, in recent times many a people of the community have shifted from pulluvan folklore and folksong performances to other occupations citing low economic benefits, status and recognition. The extinction of sacred groves also means the wiping away of a community from the state and leaving the Pulluvan people in an identity crisis. Losing Pulluvan folklore is equal to losing an oral history of the state and also some of the unique artifacts. The Pulluvan Veena and Kudam, Ila thalam are some of the musical instruments that will go extinct from the cultural history of Kerala.

The loosening hold of religion on the people of the state is also one of the major factors in the thinning of these groves. Religion has played as medium in conservation of these groves. There are a number of taboos associated with entering the groves. People in the past declined from entering these groves or collecting any produce fearing the wrath of the residing deity. The

people were allowed to enter the groves only on certain auspicious days to offer "Noorum, Paalum" (milk rice and turmeric) to the deities. However, in the recent times, these systems and their rituals are now considered mere superstitions. People have created roads, canals and even power lines through these groves. The increased need for timber and other wooden raw materials has also led to the fragmentation of these groves. These practices clearly indicate that the fear of the inheriting deity has almost gone away from the minds of the people.

On a biodiversity point of view, sacred groves have protected innumerable number of unique flora and fauna of the state. Sacred groves are nothing but mini forests that reside inside a society. However, the disappearance of the sacred groves has threatened the existence of many plants and animals that reside in it. The most important being the snakes. According to the people living near to these groves, the citing of snakes has become very rare in the recent years compared to some years ago. According to the data collected, there were approximately 50 endangered species that resided inside these groves. Almost 15 species of butterflies belonging to 4 families were identified from the groves. These include the Bush Hopper, Chestnut Bob, rice swift etc. Apart from butterflies almost 12 species of birds were also identified from the sacred groves. These birds include the Common Myna, Common tailor bird the Black- rumped woodpecker etc. As examined, the soil of the sacred groves is usually of high porosity and low bulk density which allows thick vegetation, water retention and root development. Hence, the groves are also home to some of the rarest of plant species like Kunsteria Keralensis, Belpharistermma membranifolia, Buchanania Lanceolotta etc. According to many studies, these plants are found only inside the sacred groves. Hence it is very necessary to conserve them.

CONCLUSION:

Sacred groves and the role it has played in the in the sustenance of the state's culture is immense. There is a need to understand the increasing disappearance of these ecosystems in the state and a quick awareness has to be bought so as to conserve these unique ecosystems. Development in the state should not be a reason for the hampering of these green patches. The study has more scope in the coming years since environmental issues are on a rise day by day. A par between development and environmental conservation has to be made for the sustenance of an age-old culture and tradition and also for a greener ecosystem.

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SAND SPIT: A PROMINENT COASTAL FEATURE ALONG EAST COAST OF INDIA

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ABSTRACT:

Sand spit is mostly found near the coastal inlets of the river, lagoon, and bay along the east coast of India. It is a depositional land form of the coast which occurs by the complex interaction of existing wind, wave, and tide regimes. The littoral and fluvial sediment transport decides the shape and size of the sand spit. The present work describes the evolution of major three sand spits along the east coast of India, situated near the inlets and bay. The Google earth and observed literature data were used to execute the dynamics of sand spits. Major three sand spits along the Odisha coast named Rushikulya, Chilika, and Hukitola were considered. It is observed that the sand spit is continuously progressing northerly along with the northward shifting of the river inlet throughout the year. Results show that the spit grows towards the northeast mainly by the deposition of sediment brought by the long shore drift from the south and fluvial sediment supplies. This works is immensely helpful for coastal management purposes.

KEYWORDS: sand spit; length; perimeter; wave; inlets; east coast of India

INTRODUCTION:

Beaches are a natural part of the environment. Beach is the most dynamic landform on earth's surface where three spheres (land, air, and sea) interact considerably. Sand spit is a significantly existing and sustained for long period compared to other coastal features. Sand spits can be defined as a type of barrier-forming a narrow and elongated sand body, attached to a land mass at one end and terminating in open water at the other (Evans, 1942). Sand spit is a depositional feature along the coast perceived near the inlets which are open to the sea. The development of sand spits and their dynamic depends upon the wave-induced sediment transport (King, 1970 and Schwartz, 1982). The alongshore sediment transport and the fluvial sediment supplies will decide the shape and size of the sand spit. Sand spits developed across the bay or estuaries' mouth and elongated with the direction of the longshore transport (Thomson, 1981). Worldwide research on sand spit has been carryout with relation to the geological framework

(Riggs *et al.,* 1995); winds and tides (Tricart, 1967); sea-level rise (Hequette and Ruz, 1991); availability of sediment in nearshore regions (Aubrey and Gains, 1982 and Park and Wells, 2007); due to human activity (Bouaziz *et al.,* 2005 and Simeoni *et al.,* 2007). Sand spits protect the mainland coast from various oceanic forces during storms and tsunamis. It is reported that the stable sand spit was used for human settlement and important coastal habitat for flora and fauna.

Sand spits are noticed along the Indian coast, while the sand spit dynamics along the east coast of India are scanty and less documented. The northerly dominant longshore sediment transport along the east coast of India plays a key role in sand spit formation. The development and dynamics of sand spit at the south of Rushikulya estuary is studied on a short-term (2005-2011) observational base at different time intervals (Pradhan *et al.,* 2015). The changes in spits morphology and inlets of the Chilika lagoon are investigated using real-time kinematic GPS observation for a period from 2009 to 2013 (Mohanty *et al.,* 2019). Murali and Vethamony (2014) used multi-temporal satellite images (1999–2009) to study the Morpho-dynamic evolution of the Ekakula sand spit. Ramakumar, (2000) investigated morphological changes of the Kakinada spit; Rupali *et al.* (2007) studied on Jatadharmuhana sand spit between Mahanadi and Devi Rivers along the Orissa coast and reported the dynamics and spatial-temporal variation of the spit. The present work investigates the two decadal variations of three sand spits named Rushikulya, Chilika, and Hokitola.

A conceptual model of sand spit formation by combining the action of longshore drift, tide, river currents, and/or due change in the direction of a coastline is shown in Figure 1. The presence of a break in the coastline leads to a drop in wave energy; consequently, longshore drift will deposit materials at a faster rate than it can remove. Gradually, a ridge is built up; projecting towards the sea and it continues to grow by the longshore drift and deposition of materials. Also, sometimes wind speed and direction, and discharge of fresh water from the river to the sea are responsible for the spit dimension and orientation. Therefore, investigation of the spit dynamics is quite useful and is the subject matter of the present study.

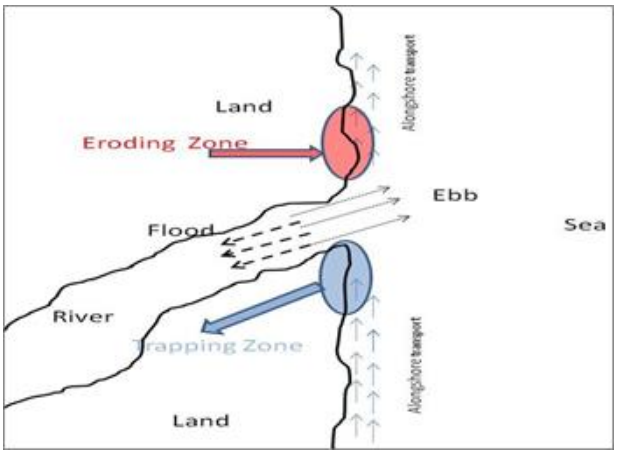

Figure 1: Development of a sand spit (Conceptual)

STUDY AREA:

Odisha is one of the maritime state of India situated western boundary of the Bay of Bengal having a coastline of about 450 Km. This coastline is gifted by many coastal features with beautiful biodiversity and having socio-economic importance: such as major rivers named Mahanadi, Subarnarekha, Baitarani, Bramhani, Budhabalang, and Rushikulya: Asia's largest brackish water lagoon named Chilika; three famous Olive Ridley sea turtle nesting ground; Mangrove forest and wetland at Bhitarkanika; sandy coastline with major three-port at Paradeep, Gopalpur, Dhamara; expose to fishing and tourist. Several researchers reported that the Odisha coast is more vulnerable to multiple hazards such as cyclones, storm surges, coastal flooding, and tsunami. This makes a greater impact on socioeconomic and geomorphological changes. The coast is within the tropical region and expose to the tropical cyclone with a frequency of 3-4 per annum (Rao *et al.,* 2007). The study area is shown in figure 2. The study area is experienced changing wave patterns due to seasonal reversal wind patterns as southwest (SW) and northeast (NE), which triggers the change in coastal circulation and makes different geomorphic changes along the east coast. The tide along the Odisha coast is identified as semidiurnal with a range of micro (<2m) along the southern part and meso (>2m) in the northern part. The east coast of India is associated with a large no of Rivers that supplies the fluvial martial and causes of changing inlet system as well as adjacent beach health. The coast is subjected to strong littoral drift and longshore current from south to north due to the oblique action of waves against the coast (Pradhan *et al.,* 2015).

River Rushikulya runs from the Eastern Ghat region and debouches to the Bay of Bengal. The river basin is having a catchment area of 7700 km^2 (CWC Report. 2015). It is a major estuarine system on the south Odisha coast that controls the shape and size of one of the largest Olive Ridley turtle nesting beaches. The northern adjacent beaches of the estuary are the nesting beach for the Olive Ridley sea turtle whereas, on the southern side, the continuous growth of a sand spit occurs (Pradhan *et al.,* 2015). The coastline orientation is about 48◦ with true north. The river is semi-perennial with weak flow during winter months and the estuarine region is mostly controlled by the tide.

The Chilika Lagoon is the largest brackish water coastal lagoon in Asia, which is connected to the Bay of Bengal (BoB) through inlets. The lagoon is about 65 km long and 20 Km wide with a variable surface area, as 950 km^2 and 1,165 km^2 during summer and monsoon, respectively (Pal and Mohanty, 2002). The drainage basin of Chilika covers an area of 3,987 Km^2, and the amount of freshwater discharge into the lagoon is 5158 million m^3/yr. The tide in the Chilika lagoon is semidiurnal, which varies from 1.72 to 2.39m during the spring tides and

0.18–0.85m during the neap tide, and hence the lagoon is categorized as a micro-tidal region (Chadramohan *et al.*, 1993). Cyclonic storms devastate the coastal areas and often cause severe shoreline erosion, formation, and erosion of sand spits, new inlet opening/closing, and damage to the coastal structures (Mahala *et al.*, 2015). Before 2000, there was an inlet at Sipakuda, while an artificial mouth was opened at Satapada and a sand spit was formed on the south of the inlet.

The Mahanadi is a major river in East Central India, having a catchment area of around 132,100 Km^2 and a total length of 900 Km. The river flows through the states of Chhattisgarh and Odisha and finally merged with the Bay of Bengal. Mahanadi river system is the third-largest in the peninsula of India and the largest river in Odisha state. The Hirakud Dam is upstream of Mahanadi. The minimum discharge is 31.9 m^3/s and a maximum of 56,700 m^3/s. On the southern side of the Mahanadi estuary, the Paradeep port is situated while the beach and long sand spit is on the northern side. The sea wall was made between the port and Mahanadi estuary to protect the land from erosion.

Figure 2: Study area shows three major sand spits along Odisha coast

DATA AND METHODS:

To fill the objective of this study, we used images from Google Earth Pro App. Google Earth is a computer program based on satellite imagery. In this program, the final three-dimensional images are prepared by superimposing satellite images, aerial photos, and GIS data onto a three-dimensional globe. The clear images (cloud-free, undisturbed) are used for estimation of the length and area of sand spits. A total of 12, 10, and 9 Google maps are used to estimate the sand spit length and perimeter for Rushikulya, Chilika, and Hukitola, respectively. A reference line was made (red) at the base of the sand spit where it is connected to the land. The length of the spit was measured from the base to the tip of sand spit by connecting the middle

portion as shown in Figure 3 (a). Similarly, the Perimeter of the sand spit was measured by connecting the watermarks as shown in Figure 3 (b).

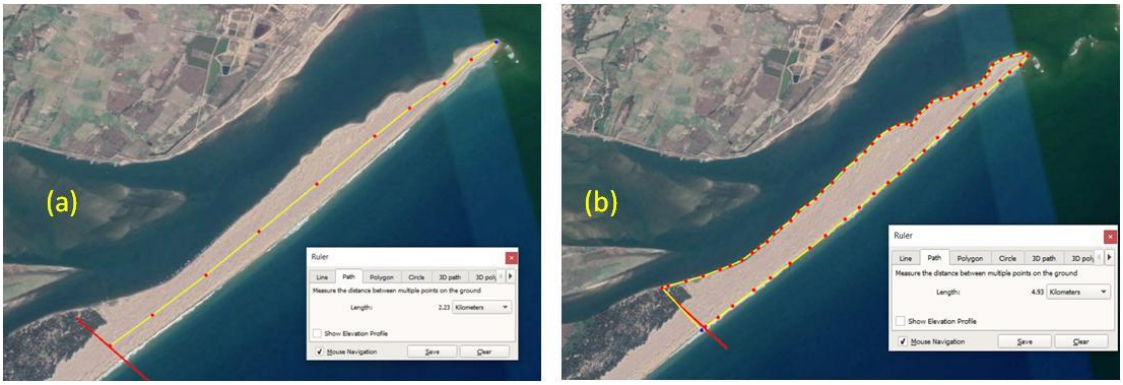

Figure 3: Shows the measurement of length (a) and Perimeter (b) in Km

RESULTS AND DISCUSSION:

Environmental forcing:

All along the east coast of India, the sand spits are generally developed on the south of inlets. The northerly longshore drift (March-September) is the most dominant which makes more sand movements along beaches and the subsequent changes in the beach morphology. The accretion, erosion, and transportation along the coast are decided by the existing hydrodynamic conditions. Mainly wind, wave, and the tide is the major driving agent for nearshore hydrodynamics/ circulations. In general, the sand spits develop with the dominance of oblique incident waves and huge supplies of sediment to the nearshore region either from the rivers or coastal cliffs with the interaction of tide. The tide along the east coast of India is semi-diurnal with an increase in the tidal range from south to north. The Odisha coast is experienced reversal wind patterns as it is south and southwest during monsoon (May to September) and north and northeast during winter (December to February). Most of the rainfall occurs during the monsoon season. The tidal range is below 2 m throughout the time series observations made during three seasons and the tidal range is quite higher (1.8m) in May, while it is minimum (1.6m) during December at Rushikulya (Pradhan *et al.,* 2020). The tide in the Chilika lagoon is semidiurnal and it varies from 1.72 to 2.39m during the spring tides and 0.18–0.85 m during the neap tide, and hence the lagoon is categorized as a micro-tidal region (Chadramohan *et al.,* 1993). For the Paradeep region, the tidal range is 2.25m during spring tides and 1.10m during the neap condition and the highest high water level (HHWL) is 3.5 m while the lowest low water level (LLWL) is 0.7m and the mean sea level (MSL) is 1.65m (www.paradipport.gov.in). AT Gopalpur, the annual (2008–2009) significant wave height (Hs) is ranged from 0.26 to 3.29m with an average of 1.06m. The Hs during southwest monsoon months (JJAS) is ranged from 0.7 to 3.29m with an average of 1.49 m; post-monsoon (ON) is from 0.4 to 2.18 m with a mean

value of 0.88 m. Similarly, during the fair-weather months (DJF), it is ranged from 0.26 to 1.83 m with an average of 0.53 m, and in pre-monsoon/transition months (MAM) it is ranged between 0.35 to 2.19 m and with an average of 1.09 m (Patra et al., 2016). The zero-crossing periods (Tz) are shown in Fig. 4b. Tz has a wider range (2–14 s) during pre-monsoon (MAM) and a narrow range (4–9 s) during SW monsoon. The annual wave information for the Chilika nearshore region was reported by Chadramohan *et al.* (1993). For three major seasons as the Hs varied between 0.5 and 2.2m during the southwest monsoon, 0.2 and 2.4m during the northeast monsoon, and 0.2 and 2.2m during the fair-weather period. The zero-crossing periods (Tz) varied between 6 and 18 s during the southwest monsoon, 5 and 18 s during the northeast monsoon, and 4 and 15 s during the fair-weather period. At Paradeep, the waves during the monsoon period are high compared to winter. During monsoon, Hs vary from 1.25 m to 3.75 m and Tz ranges from 8 to 17 seconds (Varadarajulu *et al.*, 1979). During the winter, Hs reaches around 2.25 m with Tz of 11 seconds (Varadarajulu *et al.,* 1979). The current direction was the reversal in nature and southerly during NEM and northerly during SWM along the east coast of India (Shankar *et al.*, 2002). The average current speed was < 0.20 m/s and the maximum speed was 0.5m/s during NE-monsoon. During SWM, the average current speed is > 0.2 m/s while the maximum is 0.35 m/s (Pradhan *et al.,* 2020). The current at Paradeep is an order of 0.1-0.8 m/s during May 2006 and 1.2m/s during November month of the same year (Sanil Kumar *et al.,* 2006) which indicates higher in winter compared to monsoon.

Rushikulya Sandspit:

The sand spit of Rushikulya is situated south of the inlet while the beach on northern side of the inlet is a world-famous Olive Ridley sea turtle nesting ground. Pradhan *et al.* (2015) reported that the northerly growing sand spit is a major cause of erosion on the nesting beach. The 12-number of Google maps depicts the dynamics of the sand spit. The spit was detached from the main land by digging at different times. From 2003 to 2022 the sand spit was cut four times, first in 2006 (Pradhan *et al.,* 2015); the second time in 2012, and the third time in 2019 (figure 4) while recently (May 2022) repeated. Once the sand spit was detached from the mainland, it seems to be an island. This island part of sand spit came across the dominated southwest wave and northerly current and washed out. Mostly the sediment washed from the detached part and started depositing at the nesting beach and became a healthy beach for sea turtles. The cutting of sand spit helps to flush out the flood water during cyclonic rainfall and intrusion of salt water in the river.

The length and perimeter of the sand spit indicate a continuously increasing trend from detached from the main land to the next detachment (Fig. 4 & 5). Based on the Google map analysis, the sand spit length during 2003 was 1.8 Km and with timing, it increased up to 6.4 Km

(2011). After the cut of sand spit from the mainland, the sand spit length was 0.76 Km and again it was increased up to 3.36 Km (2018). Similarly, once again sand spit was cut in 2019, then the sand spit length was 2.2 Km and elongated northward up to 5.8 Km. The perimeter of the sand spit was following the increase and decrease trend of length. In 2003, the perimeter of the sand spit was 3.9 and it increased up to 12.06 Km (2011). After the cutting of sand spit in 2012, the perimeter was 2 Km and increased to 7.2 Km by the end of 2018. After cutting of sand spit in 2019, the perimeter was 5 Km then it was 12.12 Km in the early the year 2022.

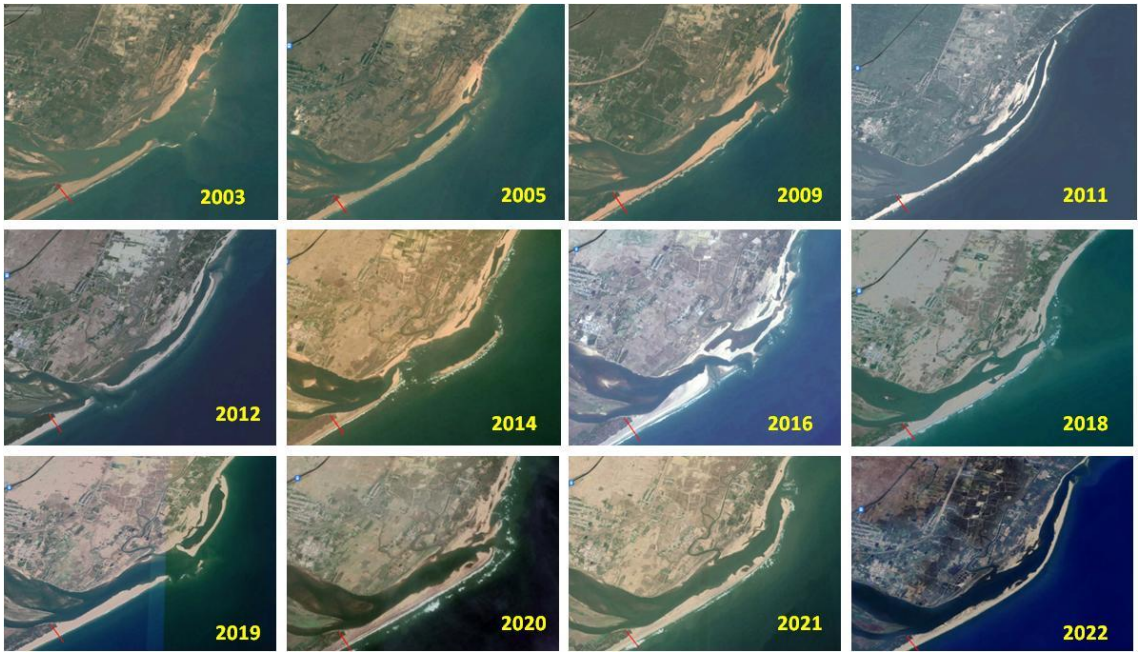

Figure 4: Sand spit at Rushikulya from 2003- 2022

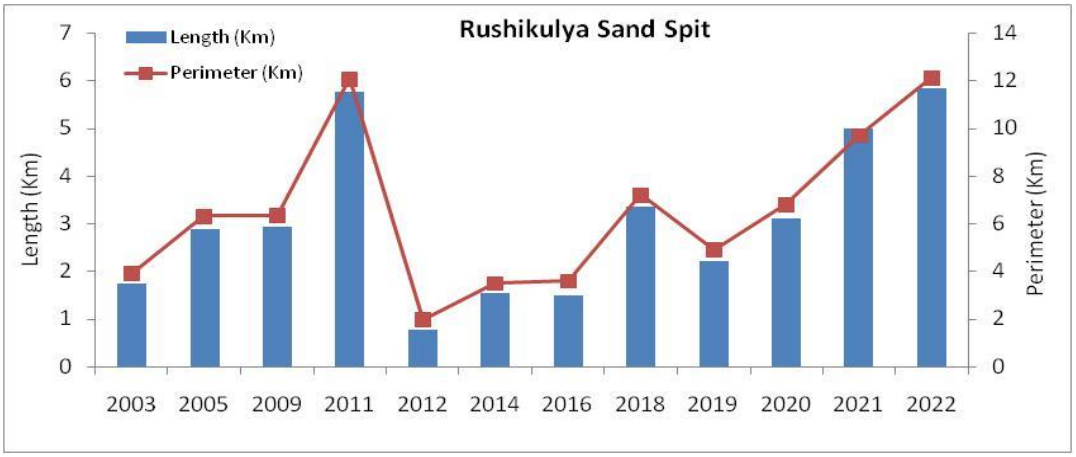

Figure 5: Temporal variation of Sand spit length and perimeter at Rushikulya

Chilika Sand spit:

The Chilika lagoon has one inlet at Arakhakuda before 2000. Though the inlet is narrow, the flux from the sea was very less. To improve the biodiversity/ Productivity of the lagoon a new inlet was opened at Shipakuda. Subsequently, the productivity of the lagoon was hiked and

the sand spit developed south of the new mouth. The sand spit was elongated northward with a shifting of inlets also. A total of 10-number Google maps are shown in Figure 6, which clears the sand spit is consciously elongated northward and inlet also. During 2019 and 2020, there were two inlets and in between them, a small island formed and with timing, it is disappearing. The sand spit slowly became stable and plantations were made (forestation) on it from 2019 onwards (Fig. 6). The length and perimeter of the sand spit (Chilika) was shown in figure 7. The spit length increases from 4.32 Km to 10.7 Km while the perimeter changes from 8.8 to 21.8 Km. the sand spit increased its length and width by 2.5 fold from 2004 to 2021. The predominated net northerly sediment transport was trapped at the south of the inlet because of tidal circulation where ebb shoal near the Chilika inlets act as barriers (Mohanty *et al.*, 2019).

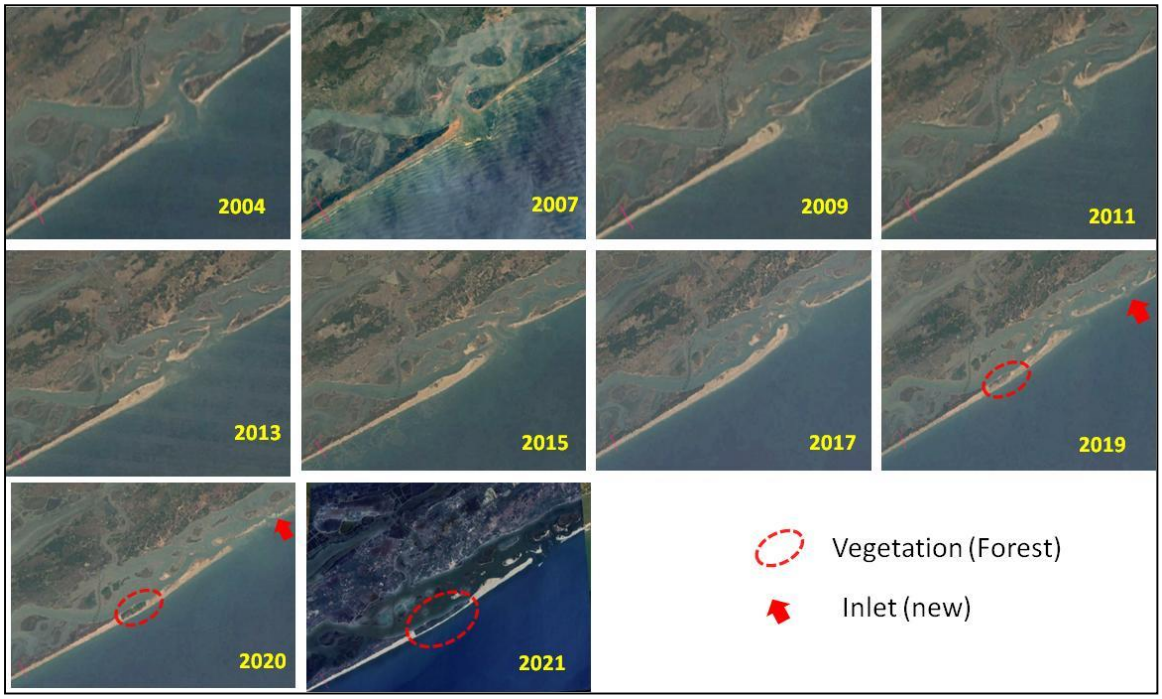

Figure 6: Sand spit at Chilika from 2003- 2022

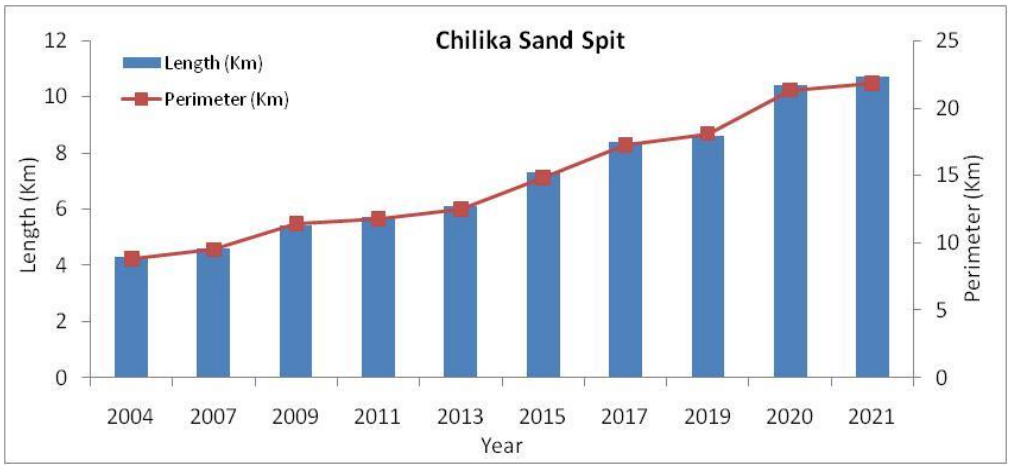

Figure 7: Temporal variation of Sand spit length and perimeter at Chilika

Hukitola Sand spit:

The Hukitola sand spit is a stable sand spit that stands on the north side of the Mahanadi estuary. The variation in shape and size of the sand spit is compared to the other two sand spits at Rushikulya and Chilika is less. A total of nine Google maps are used to understand the Hukitola Sand spit (Fig. 8). This sand spit is developed due to the trapping of longshore sediment transport to the south of Hukitola bay. The sand spit was gaining the saturated length. The tip of the sand spit is exposed to the waves and tide from the open sea and river connected to the bay by which the sediment was bypassing the northern part of Hukitola bay. As the port is situated on the south of Mahanadi estuary, the longshore sediment was deposited at south of the south groin (Gopalkrishna & Deo, 2017). The beach developed north of the estuary and spit developed towards the Hukitola bay confirming the sediment discharge from Mahanadi river and driven by the predominant northerly current along the east coast of India. Both the length and perimeter of the sand spit is continuously increasing from 2003 to 2019). During 2003, the length was 9.5 Km from the reference line, which reached up to 11.4 Km in 2019 (Fig. 9). Similarly, the perimeter of the sand spit was 22.2 Km in 2003 and it increases to 25.75 Km in 2019 (Fig. 9).

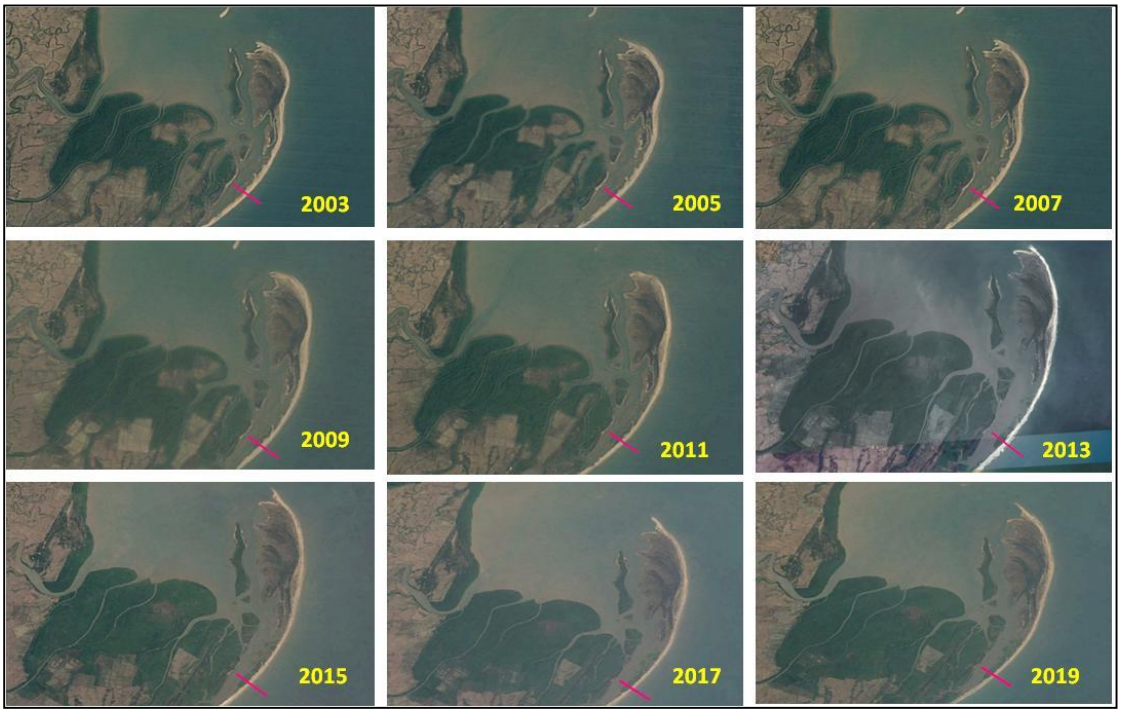

Figure 8: Sand spit at Hukitola from 2003- 2022

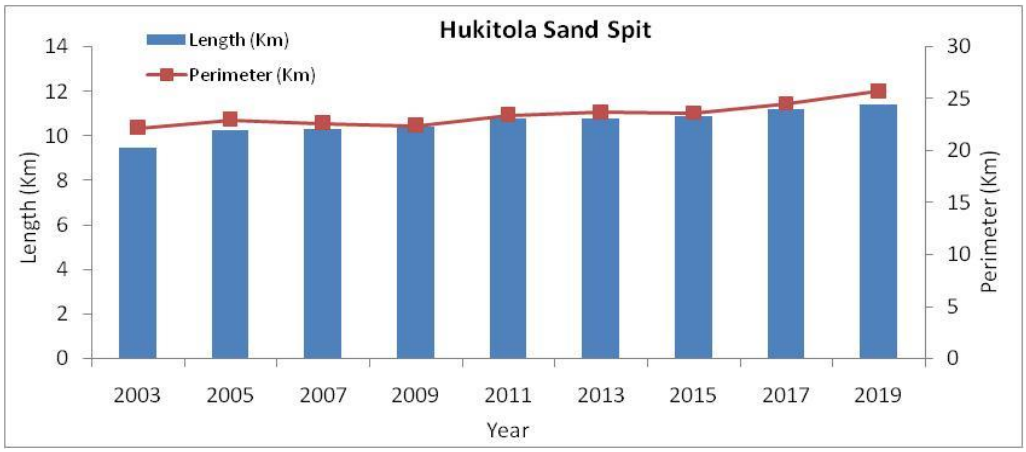

Figure 9: Temporal variation of Sand spit length and perimeter at Hukitola

CONCLUSION:

The development of the sand spit was remarkable with a shallow water depth of the sediment deposition region because sufficient wave energy cannot penetrate the shallow body of water. Generally, the rapid formation of a sand spit occurred at the south of the river mouth and bay along the east coast of India while erosion takes place on the northern part of the inlets. These changes in sand spit have been associated with strong northerly longshore drift and sediment supplied through the river system (fluvial). The geomorphologic conditions have a major influence on the type of development activities along the coastline. This study is immensely helpful to coastal researchers and stakeholders. A details study with accurate observation will lead the scientific analysis in the future.

ACKNOWLEDGMENT:

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PHYTOPLANKTON BLOOMS ALONG THE EAST COAST OF INDIA- A REVIEW OF DECADAL EVENTS

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ABSTRACT:

A review of algal blooms along the east coast of India from 1935 to 2022 shows that a total of 35 cases were reported. The reports of algal blooms indicate their predominance along the east coast of India, especially in the southern part. The majority of the blooms reported along the east coast of India are caused by diatom followed by cyanobacteria/BGA blooms. There have been 39 causative species responsible for blooms, of which *Noctiluca scintillans* and *Trichodesmium erythraeum* are the most common. Mass fish kill on the east coast of India are due to the blooming of *Pseudo-nitzschia* sp., *Gonyaulax polygramma*, *Microcystis aeruginosa*, *Noctiluca scintillans* and *T. erythraeum*,. Most blooms occurred during the retreat of the southwest monsoon and the pre-monsoon period. Algal blooms are is primarily affected by seasonal upwelling and monsoonal forcing, resulting in high river flow and nutrient-rich water that provides a competitive advantage for the blooming of phytoplankton species.

KEYWORDS: Algal bloom, Hypoxia, Water quality, Diatom, Dinoflagellate, Cyanobacteria, Bay of Bengal

INTRODUCTION:

Phytoplankton bloom is a natural phenomenon due to the sudden dense outburst of a group of microalgae, usually dominated by diatoms, dinoflagellates, or cyanobacteria. The water becomes noticeably colored (green, brown, yellow, red, or reddish-brown) concerning the high cell mass of the major affected species, primarily single species or single species ranging from a few meters to hundreds of kilometers, as thin on the surface or underground (Sarkar, 2018). The blooms are rapid, with a marked increase in microalgae biomass or resident crops, accounting for 2-5 million cells/liter and, in extreme cases, even over 10 million cells/liter. The frequency and severity of such blooms seem to have increased recently, especially in subtropical to temperate climates and has recently spread to coastal regions. Eutrophication alters the balance of nitrogen and phosphorus. Algal species that can successfully compete for nutrients that limit available

growth can become dominant and bloom. Phytoplankton is free-swimming tiny and microscopic plants that occur in the ocean and freshwater and form the basis of the aquatic food chain through the growth of photosynthesis. A small subset of phytoplankton can harm human health and the use of ecosystems. Harmful algal blooms are now commonly referred to as "harmful algal blooms" (HABs) and are commonly used to describe their occurrence and effects. From a human health perspective, the most important consequence is the production of biotoxins by several species. Normally, phytoplankton species that produce biotoxins occur at relatively low densities (about hundreds or thousands of cells per liter), and toxins are concentrated in the flesh of phytoplankton-eating organisms (especially bivalves). In most cases, these major consumers are not adversely affected, but this mechanism of concentration poses a health risk when shellfish are consumed by humans. Many phytoplankton species cause blooms or red tides, which are water discolorations due to blooms. Harmful algal blooms often cause human illness and fish kills (Anderson *et al.,* 2002; Hallegraeff, 2003; Glibert *et al.,* 2018b, Mishra *et al.,* 2022). Therefore, under cultural eutrophication, changes in nutrient ratios (N, P) and restricted nutrient supply stimulate increased production of allelochemicals, including toxins, by some algal species and other algae. It may amplify the adverse effects of these substances. India, being one of the major maritime countries, is endowed with a coastline of about 7,500 km, surrounded by two important seas: the Arabian Sea (AS) on the west and the Bay of Bengal (BOB) on the east coast of India. This marine environment embodies diverse habitats such as estuaries, mangrove wetlands, brackish lakes, coral reefs, islands, and offshore waters that support a variety of flora and fauna. The coastline is having 6 major ports, along the east coast of India. They serve as a gateway to international and domestic trade (Anil *et al.,* 2002). This study summarizes the scenarios of algal blooms on the east coast of India. The objectives of this study are to (1) provide reporting of algal and the frequency of species responsible for bloom formation, and (2) factors responsible for such blues based on environmental conditions during the bloom period.

Factors responsible for algal blooms

The phytoplankton blooms in the BoB in response to monsoonal forcings; bloom dynamics are presumably determined by river discharge as well as the local and remote effect of winds. Physical forcings that alter the salinity stratification in the BoB provide favorable biological conditions for bloom formation (Gomes *et al.,* 2000). In addition, rivers serve as additional sources of nutrients, enhancing phytoplankton productivity in the coastal and estuarine regions (Kumar *et al.,* 2004). The formation of blooms is influenced by various factors:

(a) Physical processes such as upwelling, cyclones, and eddies (Vinayachandran and Mathew, 2003; McGillicuddy *et al.*, 2007),

(b) Chemical processes such as increased nutrient conditions (eutrophication) (Anderson *et al.*, 2002; Smayda 2005) and

(c) Biological processes like competition, grazing, and allelopathy (Smayda 1998; Grane´liand Johansson 2003).

Chemical processes play a role when sewage-laden nutrient-enriched waters are prevalent, while biological processes become predominant as the bloom progresses. Furthermore, deterioration of the water quality and hypoxia condition occurred which leads to fish kills (Figure 1). Therefore, it becomes necessary to understand the causative factors and mechanisms that drive bloom formation along the coast.

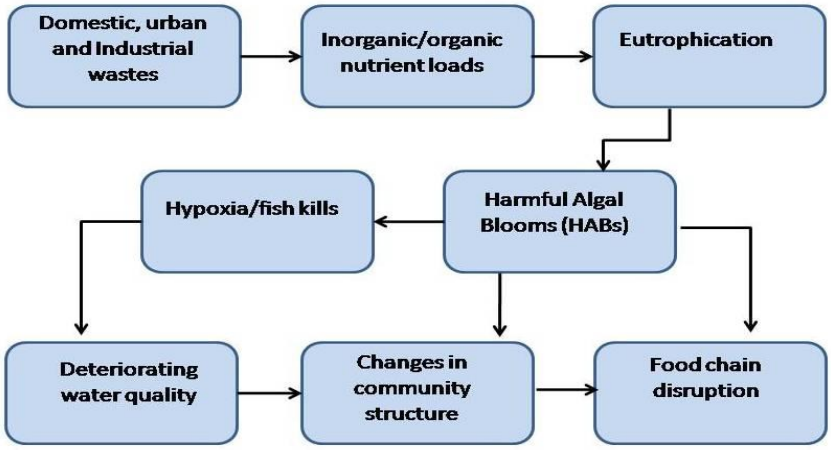

Figure 1: Factors responsible for algal blooms in the coastal waters

Phytoplankton blooms along the east coast

A review of algal bloom occurrences along the east coast of India from 1935 to 2022 showed a total of 35 bloom incidents (Tables 1). The *Trichodesmium erythraeum* and *Noctiluca scintillans* were the common blooming species on the east coast of India. With the enhancement in observation and monitoring, there has been an increased reporting of algal blooms. Based on these bloom periods, it is evident that in the recent two decades, there has been an exponential increase in algal bloom events along the east coast of India (Table 1). The occurrence of blooms in Indian waters is a matter of concern as most of the bloom cases reported so far have direct or indirect effects on these coastal waters and have affected fisheries, other marine organisms, and humans. Blooms of diatoms, dinoflagellates and cyanobacteria have been reported from coastal waters along the east coast of India. Among these groups, diatoms were the most predominant with 14 bloom cases being reported (Table 1). The spatial distribution of bloom occurrences

indicates their prevalence more towards the Tamil Nadu and Orissa coast (Fig. 2). Along the east coast of India, algal blooms occur throughout the year with the except for January and November. Overall, a maximum number of bloom cases was reported during the spring monsoon period from Jan- April. Most diatom blooms prevailed during the period (Jan–May), whereas dinoflagellate blooms occurred during April–August and were less frequent in the other months (Fig. 3c). Cyanobacteria blooms were during the PrM period (March). The first bloom occurrence of A. japonica was reported in 1967 in coastal waters off Visakhapatnam (Subba Rao 1969).

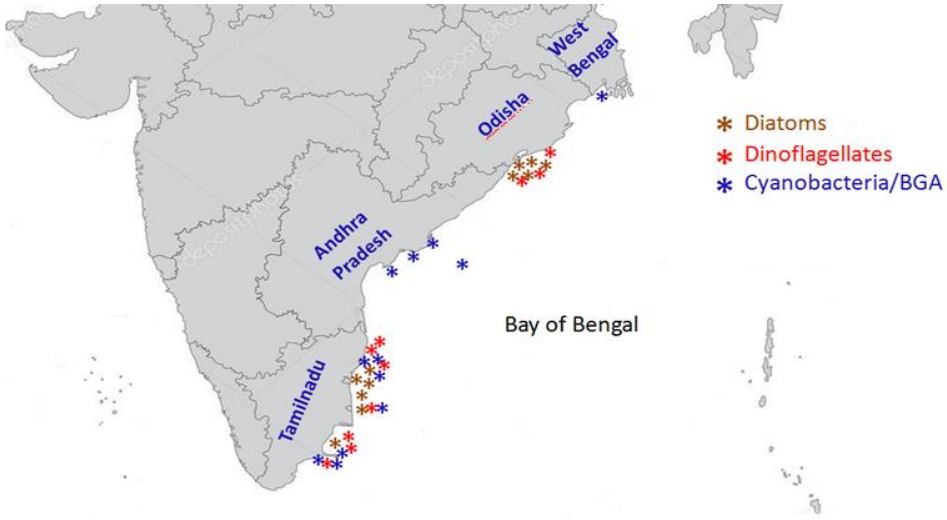

Figure 2: Phytoplankton blooms along the east coast of India

Subsequently, these blooms were reported from Tamil Nadu and Orissa coasts (Table 1). Among dinoflagellate blooms, *N. scintillans* were mostly reported on the east coast of India (Tables 2, 3). On one occasion, bleaching of corals was reported in the Gulf of Mannar due to the Noctiluca bloom that resulted in oxygen depletion. This, in turn, affected fishes and marine animals (Gopakumar *et al.*, 2009). There was also reporting of a Paralytic Shellfish Poisoning (PSP) outbreak in 1981 on the Tamilnadu coast that resulted in the hospitalization of 85 people and 3 deaths after consuming bloom-affected mussels (Silas *et al.*, 1982). Some incidents of Trichodesmium and *Pseudo-nitzschia* sp. bloom causing massive fish kill were reported in the coastal waters of Tamil Nadu and Puducherry (Chacko 1942; Chidambaram and Unny 1944; Chellam and Alagarswami 1978; Satpathy *et al.*, 2007; Anantharaman *et al.*, 2010, Mishra *et al.*, 2022).

Table 1: Occurrence of phytoplankton blooms along the east coast of India (1935 - 2022)

Sl.No.	Period of Occurence	Place of Occurence	Causative Species	Cell counts (CC) & Chlorophyll-a (Chl-a)	Nutrients (µM)	References
Diatoms						
1	Mar. 1950	Inshore waters off Mandapam, Tamil Nadu	*Rhizosolenia alata*	-----	-----	Raghu Prasad (1956)
2	Feb.1951	Inshore waters off Mandapam, TamilNadu	*Rhizosolenia imbricata*	-----	-----	Raghu Prasad (1956)
3	Apr.1967	Off Waltair, Andhra Pradesh	*Asterionella japonica*	CC: 6.7–93.2 x 10^6 cells L^{-1}, chl-a: 10.95-35.99 µg L^{-1}	PO_4= 1.84 SiO_4 =26.25	D V Subba Rao (1969)
4	Mar, Sept, Oct. 1983	Vellar Estuary, Tamil Nadu	*Asterionella glacialis*	CC: 0.2 x 10^5 cells L^{-1}	-----	Mani *et al.* (1986)
5	Mar.1988	Gopalpur coast	*Asterionella glacialis*	CC: 0.4 x 10^5 cells L^{-1} Chl a : 70 mg m^{-3}	-----	Choudhury & Panigrahy (1989)
6	Apr/May.1988	Rushikulya estuary, Orissa coast	*Asterionella glacialis*	CC: 0.30 –0.98 x 10^5 cells L^{-1}	NO_3 = 0.42-0.90 PO_4=0.67-1.07 SiO_4=6.29-8.45	Panigrahy& Gouda (1990)
7	May 1991	Bahuda estuary, Orissa coast	*Asterionella glacialis*	CC: 2.7 x 10^6 cells L^{-1}	-----	Mishra &Panigrahy (1995)
8	Sept. 1991		*Thalassiothrix fraunfeldii*	CC: 2.2 x 10^6 cells L^{-1}	-----	
9	June 1992		*Coscinodiscus centralis* & *Coscinodiscus ecentricus*	CC: 3.7 x 10^5 cells L^{-1}	-----	

10	May 1993	Off Kalpakkam, Tamil Nadu	*Asterionella glacialis*	CC: 5.5 x 10^{10} cells m^{-3} ,Chl a: 22.7 µg L^{-1}	-----	Satpathy & Nair (1996)
11	Mar-Apr, 2004	Gopalpur, Orissa	*Asterionella glacialis*	CC: 20.1–72.2 x 10^5 cells L^{-1}, Chl a: 63–238 mg m^{-3}	NO_3 = 0.96-1.32 PO_4=0.2-0.32 SiO_4=21.4-24.8	Sasamal *et al.* (2005)
12	Jan 2015	Kalpakkam, Tamil Nadu	*Asterionella glacialis*	CC: 5.63 ×10^7cells l^{-1} Chl a: 15.99 mg m^{-3}	NO_3 = 1.32 PO_4= 0.75 SiO_4=3.45	Sahu *et al.* (2016) Sahu *et al.* (2021)
13	Sept' 2019	Puducherry backwaters	*Pseudo-nitzshia* sp.	CC: 4.57 - 5.9 ×10^5cells l^{-1} Chl a: 43.2 -210.9 mg m^{-3}	NO_3 = 2.9 - 4.7 NH_4 = 8.2-61.4 PO_4= 2.4- 6.2 SiO_4= 73.8-148	Mishra *et al.* (2022)
Dinoflagellates						
14	June,1935	Madras, Tamil Nadu	*Noctiluca miliaris*	-----	-----	Aiyar (1936)
15	Apr.–July 1952	Palk Bay, Mandapam–Tamil Nadu	*Noctiluca miliaris*	-----	-----	Raghu Prasad (1953, 1958)
16	Aug.1966	Vellar Estuary, Tamil Nadu	*Noctiluca miliaris*	CC: 0.7–2.9 x 10^4 cells10 ml^{-1}	-----	Santha Joseph (1975)
17	Aug.1967					
18	May. 1968					
19	Oct. 1988	Kalpakkam, Tamil Nadu	*Noctiluca miliaris*	CC: 0.4 x 10^5 cells L^{-1}Chl a: 28 mg m^{-3}	-----	Sargunam & Rao (1989)
20	Apr. 2005	Rushikulya river, South Orissacoast	*Noctiluca scintillans*	CC: 2.83 x 10^5cellsL^{-1}	-----	Mohanty *et al.* (2007)
21	Oct. 2008	Gulf of Mannar	*Noctiluca scintillans*	CC: 13.5 x 10^5cellsL^{-1} Chl a: 116 mg m^{-3}	-----	Gopakumar *et al.*, (2009)

22	Oct. 2008	Mandapam & Keelakarai, Tamil Nadu	*Noctiluca sp.*	-----	-----	Anantharaman *et al.* (2010)
23	April 2014	Off Gopalpur port, Odisha	*Mesodinium rubrum*	$>10^4$cells ml^{-1}	-----	Sahu *et al.* (2016)
24	May 2016	Puri, East coast of India	*Gonyaulax polygramma,*	-----	-----	Baliarsingh *et al.* (2018)
25	Aug' 2019	Chennai coast	*Noctiluca scintillans*	CC: 0.19 x 10^5cells L^{-1} Chl a: 28.9 mg m^{-3}	NO_3 = 47.3 NH_4 = 12.8 PO_4= 1.4 SiO_4= 16	Mishra *et al.* (2022)
Cyanobacteria/BGA						
26	May1942	Gulf of Mannar	*Trichodesmium erythraeum*	-----	-----	Chacko (1942)
27	May 1942	Southern coast of Pamban, Gulf of Mannar	*Trichodesmium erythraeum*	-----	-----	Chidambaram & Unny (1944).
28	Mar. 1964, 1965, 1969, 1972	Porto Novo, Tamil Nadu	*Trichodesmium erythraeum*	-----	-----	Ramamurthy (1968), Ramamurthy (1970a, 1970b, 1973)
29	Mar.–Apr. & Sept. 1973	Gulf of Mannar, Tamil Nadu	*Trichodesmium thiebautii*	-----	-----	Chellam & Alagarswami (1978)

30	April 2001	Off Tamil Nadu	*Trichodesmium erythraeum*	-----	NO_3 = 0.05 PO_4= 0.9 SiO_4=2.2	Jyothibabu *et al.* (2003)
31	April 2001	off Kolkata			NO_3 = 0.14 PO_4= 0.56 SiO_4= --	
32	16thMarch 2007	Kalpakkam, Tamil Nadu	*Trichodesmium erythraeum*	CC: 4.1 x 10^6 cells L^{-1}	NO3 = 0.13 – 5.10 PO4= 0.14 – 0.46 SiO4= 5.78 – 12.53	Satpathy *et al.* (2007)
33	19th Feb 2008	Kalpakkam, Tamil Nadu	*Trichodesmium erythraeum*	CC: 2.94 x 10^7 cells L^{-1} Chl a: 42.15 mg m^{-3}	NO3 = 0.17 – 6.79 PO4= 0.09 – 1.51 SiO4= 7.58 – 16.28	Mohanty *et al.* (2010)
34	Dec. 2009	Vellar estuary, Tamil Nadu	*Microcystis aeruginosa*	CC: 37.6 x 10^3 colony L^{-1}, Chl a: 18.61 µg L^{-1}	-----	Santhosh Kumar *et al.* (2010)
35	May 2014, Apr. 2015	Western Bay of Bengal (KG basin)	*Trichodesmium erythraeum*	-----	-----	Jyothibabu *et al.* (2017)

Harmful Algal bloom (HABs)

Harmful algal blooms (HABs) are a serious biological disruption and are becoming a pandemic worldwide. These are primarily flagellate events that lead to mass mortality, physiological disorders, or other adverse effects in situ. HABs have been affected over the past few decades in terms of frequency, sustainability, regional/spatial scope, and economics as a result of changes in coastal eutrophication and increased climate change associated with the invasion of alien species due to ballast water exchange. The impact is increasing worldwide. This is also caused by the growing global trend of unscientific and irrational exploitation of coastal areas for conservation, food, construction, nutrition, aquaculture, recreation, and other commercial purposes, resulting in eutrophication. Naturally occurring red tides and harmful algal blooms (HABs) become increasingly important in eutrophic coastal environments and can have significant adverse effects on benthic and superficial coastal communities. Red tide bloom becomes fairly common, resulting in seawater discoloration (amber, red, maroon, brown, yellow-orange to purple) caused by a very dense population of coastal dinoflagellates & diatom (figure 3 a-b). The main contributors to red tide events include warm sea surface temperatures, calm waters, dormant dinophyceae turbulence, low salt content with heavy rains and subsequent sunny days, and reduced natural filtration due to deforestation. .. Red tide poses devastating and diverse environmental hazards, including fish kills, shellfish pollution, and even non-toxic effects. The bloom produces biotoxins, causes hypoxia, and can alter the food web. They are called "harmful algal blooms" (HABs) because they pose environmental health risks and can degrade water quality and habitat, and the main species belonging to the phytoplankton group are diatoms, dinoflagellates, cyanobacteria.

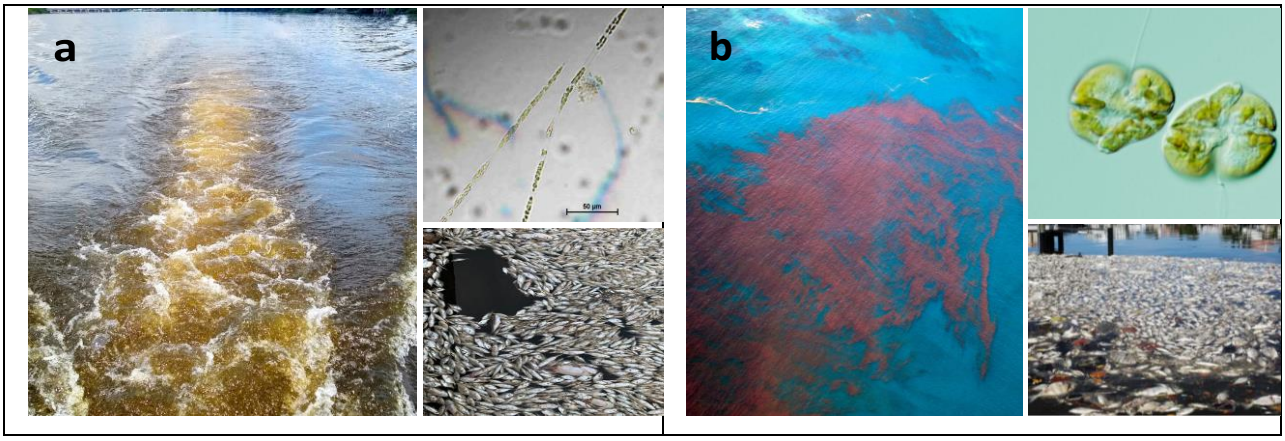

Figure 3 (a-b): Red tide occurrence and mass fish kills in the a) Puducherry backwaters (Pseudo-nizschia bloom) (https://www.sciencedirect.com/science/article/pii/S0078323421000968), b) Southwest Florida beaches (*Karenia brevis*) (https://floridainsider.com/government/red-tide-continues-to-irritate-southwest-florida-beaches/)

Impact of bloom on fishery and human health

The level of human health threat from HABs in Indian waters remains relatively low. Until the 1980s, the phenomenon of PSP was virtually unknown in Indian coastal waters. So far, four PSP cases have been recorded in the coastal waters of Tamil Nadu (1), Mangaluru (2), and Kerala (1). However, the dinophyceae that caused the outbreak of PSP could not be identified. The first outbreak of PSP was recorded in Tamil Nadu in 1981, with 85 hospitalized and 3 dead after eating the bloom-filled *Lajonkairia meretrix* casta (Silas et al 1982). In 1983, an outbreak of PSP killed a boy and hospitalized several people after eating mussels (*M. casta*) harvested at the mouth of the Kambul River in Mangaluru (Karunasagar et al. 1984). These mussels were analyzed by high-performance liquid chromatography (HPLC) and the toxin profile obtained corresponded to the strain of *Alexandrium tamiyavanichi* Balech isolated from Thai (Karunasagar *et al.,* 1990). Then, in 1985 and 1986, low-level PSPs were found twice in shellfish from estuaries near Mangaluru (Segar *et al.,* 1989). During a study of Mangaluru in the Kumta River, a floating and cystic form of *G. catenatum*, a dinophyceae that produces PSP, was detected (Godhe *et al.,* 1996) and was not toxic to shellfish. This study emphasized the importance of close monitoring of coastal waters, sediments and shellfish. Outbreaks of PSP were also reported in Kerala in 1997, killing 7 people and hospitalizing more than 500 after consuming flowering-affected *Perna indica* mussels (Karunasagar *et al.,* 1998). Another bloom that struck Kerala on September 17, 2004 resulted in an unpleasant odour emanating from coastal waters. The bloom resulted in massive fish kills and the hospitalization of 200 people, especially children, who suffered from the nauseating stinks of the bloom and nausea and shortness of breath caused by rotten fish. The causative organism reported during the stink event Included *C. polykrikoides* and *Karenia brevis* (The Hindustan Times, 2004). *N. scintillans* (Sahayak *et al.,* 2005) have been reported. India's fishery economy relies heavily on coastal areas of marine products and is particularly vulnerable to red tides and restrictions by toxic microalgae. HABs have a significant impact on fish population growth, recruitment, and mortality. In particular, it has a significant impact on algal bloom, which kill fish that directly and seriously harm coastal fisheries. This is very important because the coastal people in this region are heavily dependent on fishing and are therefore vulnerable to any incident that could affect the availability of seafood. The biggest problem for human society is caused by an increase in algae biotoxin problems in areas that are poorly prepared or under-monitored for the significant distribution of HABs species (Hallegraeff, 2010). Therefore, it is essential to tackle environmental issues such as HABs to maintain sustainable productivity from the sea.

CONCLUSION:

This chapter provides an overview of important drivers for the occurrence of algal bloom and their adverse impact on biotic and abiotic components. There is a significant difference in the type, frequency, intensity, and spatial extent of regional outbreaks and causative algae outbreaks, and their adverse effects on various tropical coastal areas. Bloom causative agents are naturally driven due to physical forcings such as monsoonal influences, river runoffs, and seasonal upwelling. In addition to these fluctuations, environmental factors (temperature, salinity, irradiance, water stability, nutrient-enriched waters), and biological factors (eg, prey availability) are also important factors affecting bloom formation. A review of bloom occurrences along the east coast of India indicates their predominance, especially the southern part. The majority of the blooms reported along the east coast are caused by diatoms followed by cyanobacteria blooms. Report of massive fish kills on the east coast has been associated with the blooming of *Pseudo-nitzschia* sp., *Microcystis aeruginosa*, *Noctiluca scintillans*, *Trichodesmium erythraeum*, *Trichodesmium thiebautii*. The majority of the blooms occurred during the retreat of the southwest monsoon and the pre-monsoon season. Since these algal bloom outbreaks are sporadic and unpredictable, regular monitoring of bloom-prone areas will provide significant insights into bloom dynamics and thus provide a useful tool for bloom monitoring as a step ahead.

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SPATIO-TEMPORAL CHANGE ANALYSES OF LAND COVER USING RS AND GIS AND ANALYSIS OF FEW MAJOR CONSTITUENTS IN SURFACE WATER BODIES OF BISHNUPUR DISTRICT, MANIPUR

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ABSTRACT:

This project examines the use of GIS and Remote Sensing in mapping Land use or land cover in Bishnupur District, Manipur between 1988 and 2003 so as to detect the changes that has taken place between these periods. Subsequently, analysis of major constituents of surface water of Loktak Lake, Manipur River and Khuga River are also analyzed. Digital Image Processing techniques (DIP) were done to produce satellite image classification maps of 1988 and 2003 landsat image. Both supervised and unsupervised classification techniques were attempted. The accuracy of supervised classification is 86% and 88%. The result of this work shows that agricultural land is the predominant class and it also shows a rapid growth in built-up land and wetlands between 1988 and 2003. Analyzing the constituents of the water bodies' shows that is fit for drinking but it should be taken after treatment and it can be used for irrigation and other ecological purposes. The types of datasets, statistical approaches, mapping techniques, and spatial analyses implemented in this study could provide appropriate information for both the assessment and planning of landscape patterns. The changes in certain land use / land cover raises serious questions with regard to both the landscape health and the longer-term potential for land degradation. Further studies over a longer period are necessary to develop a better understanding of the relationships between changes in landscape structure, human impacts, and other factors. A comprehensive analysis or further research on water quality from different zones of these water bodies is necessary and has to make awareness among the people.

KEYWORDS: Landuse and land cover; Bishnupur; Manipur water constituents; DIP; RS & GIS

INTRODUCTION:

Every parcel of land on the Earth's surface is unique in the cover. Land use and land cover are distinct yet closely linked characteristics of the Earth's surface. Land use is the manner in which human beings employ the land and its resources. Examples of land use include agriculture, urban development, grazing, logging, and mining. In contrast, land cover describes

the physical state of the land surface. Land cover categories include cropland, forests, wetlands, pasture, roads, and urban areas. The term land cover originally referred to the kind and state of vegetation, such as forest or grass cover, but it has broadened in subsequent usage to include human structures such as buildings or pavement and other aspects of the natural environment, such as soil type, biodiversity, and surface and groundwater (Meyer, 1995). Changes in land use and land cover are pervasive, increasingly rapid, and can have adverse impacts and implications at local, regional and global scales. During the past millennium, humans have taken an increasingly large role in the modification of the global environment. Any conception of global change must include the pervasive influence of human action on land surface conditions and processes.

To better understand the impact of land use change on terrestrial ecosystems, the factors affecting land use must be more fully examined. Growing human populations exert increasing pressure on the landscape, as demands multiply for resources such as food, water, shelter, and fuel. These socioeconomic factors often state how land is used regionally. Land use and land cover change has become a central component in current strategies for managing natural resources and monitoring environmental change. Since the late 1960's, the rapid development of the concept of vegetation mapping has led to increased studies of land use and land cover change worldwide. Providing an accurate assessment of the extent and health of the world's forest, grassland, and agricultural resources has become an important priority. Over the past two decades, data from Earth sensing satellites has become important in mapping the Earth's features and infrastructure, managing natural resources, and studying environmental change. Remote sensing and Geographic Information Systems (GIS) are providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analyses of earth-system function, patterning, and change at local, regional, and global scales over time; such data also provide a vital link between intensive, localized ecological research and the regional, national, and international conservation and management of biological diversity (Wilkie and Finn, 1996). By utilizing remote sensing technologies and implementing GIS mapping techniques, land use and land cover change of designated areas can be monitored and mapped for specific research and analysis. The dynamics of forest conversion to agricultural pastures as well as its spatial distribution and patterns are the primary focus of this research.

Change detection is an important process in monitoring and managing natural resources and urban development because it provides quantitative analysis of the spatial distribution of the population of interest. Change detection is useful in such diverse applications as land use change analysis, monitoring shifting cultivation, assessment of deforestation, study of changes in vegetation phenology, seasonal changes in pasture production, damage assessment, crop stress

detection, disaster monitoring, day/night analysis of thermal characteristics as well as other environmental changes (Singh, 1989).

Macleod and Congalton (1998) list four aspects of change detection, which are important when monitoring natural resources: Detecting those changes have occurred, identifying the nature of the change, measuring the aerial extent of the change and assessing the spatial pattern of the change. Digital change detection is a difficult task to perform accurately and unfortunately, many of the studies concerned with comparative evaluation of these applications have not supported their conclusions by quantitative analysis (Singh, 1989). All digital change detection is affected by spatial, spectral, temporal, and thematic constraints. The type of method implemented can profoundly affect the qualitative and quantitative estimates of the change. Even in the same environment, different approaches may yield different change maps. The selection of the appropriate method therefore takes on considerable significance. Not all detectable changes, however, are equally important to the resource manager. On the other hand, it is also probable that some changes of interest will not be captured very well or at all by any given system. An image differencing technique has been implemented in this change detection study. According to recent research by Coppin & Bauer (1996), image differencing appears to perform generally better than other methods of change detection; and such monitoring techniques based on multispectral satellite data have demonstrated potential as a means to detect, identify, and map changes in forest cover. Image differencing is probably the most widely applied change detection algorithm for a variety of geographical environments (Singh, 1989). It involves subtracting one date of imagery from a second date that has been precisely registered to the first.

Usually change detection in remote sensing involves the analysis of two registered, aerial or satellite multi-spectral bands from the same geographical area obtained at two different times. Such an analysis aims at identifying changes that have occurred in the same geographical area between two times considered.

Another recent development in the use of satellite data is to take advantage of increasing amounts of geographical data available in conjunction with geographic information systems to assist in interpretation. Geographical data describe objects from the real world in terms of (a) their position with respect to a known coordinate system, (b) their attributes that are unrelated to position (such as color, type, cost, pH, incidence of disease, etc.) and (c) their spatial interrelations with each other (topological relations), which describe how they are linked together or how one can travel between them (Burrough, 1986). With the increasingly widespread, combined implementation of remote sensing and GIS technology, more natural resource professionals have been provided with efficient and accurate tools for mapping and maintaining management information on forests and other natural resources in regional areas.

GIS technology is expanding, allowing for greater integration of remote sensing with digital cartography, thus providing the means to produce more accurate land use and land cover maps.

This research addresses land use and land cover changes over a 15-year period of study, 1988 to 2003. The dynamics of forest conversion to agricultural pasture and the spatial distribution and patterns are the primary focus of this study. Land use and land cover change is defined as the conversion from one land cover category to another. This type of phenomena results in a change of reflected electromagnetic radiation (EMR) values representative as a surrogate of the Earth's surface, which can be remotely sensed. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. Moreover, change detectability is a function of the "from" and "to" classes, the spatial extent, and the context of the change. Essentially, it involves the ability to quantify temporal effects using multi-temporal data sets. And also assess the present water quality of Loktak Lake (situated in Bishnupur District), the Manipur River and Khuga River (both depositing their load in the Loktak Lake) by various physical and chemical analyses. The present study was conducted in Bishnupur District of Manipur with the following objectives:

1. To delineate the land use/ land cover data in Bishnupur District of Manipur with the application of Remote Sensing and GIS tools.
2. To analyze the major constituents of surface water of Loktak Lake, Manipur River and Khuga River.

STUDY SITE:

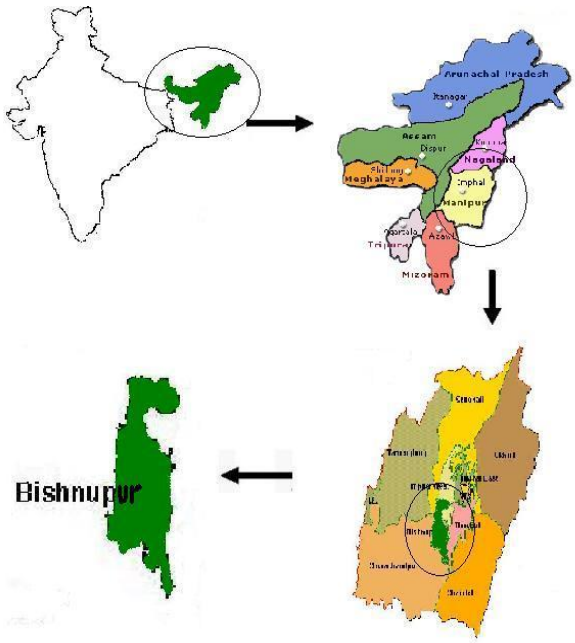

Figure 1: Map showing location of study site

In this research, the spatio-temporal change detection of Bishnupur District, Manipur, India is studied using Remote Sensing and GIS technology and also analyzing the present water quality of Loktak Lake, the Manipur River and Khuga River situated within the district. Loktak Lake, covering an area of 28,700 ha and comprised of 20 small and larger wetlands, is the largest and most important wetland of the northeast and designated as one of the Ramsar site under Ramsar Convention in 1990 (Trisal and Manihar, 2004). Bishnupur District is located between 93.43°E and 93.53°E longitudes and 24.18°N and 24.44°N latitudes having 530sq.km total geographical areas. It is surrounded by Imphal West District in the North, Churachandpur District in the South, Imphal East and Thoubal District in the East. It occupies an area of 53,000 hectare and population of 2,08,368 (2001 census) and is situated at a distance of 27km from the state capital, Imphal. The following figure 1 shows the specific study site.

METHODOLOGY:

1. **Methodology applied in map study:** The research is studied on the spatio-temporal change detection through satellite imagery. ERDAS IMAGINE version 8.7, standard geographic imaging software is used for the map study (ERDAS, 1999).

1.1 Acquisition of data (satellite image): For the procurement of satellite image Landsat-5 and Landsat-7 is used Table 1 shows the satellite data used for the study.

Table 1: Satellite data used for the study

Sr. No.	Landsat type	Data type	Date of acquisition
1.	**Landsat-5**	TM	05-02-1988
2.	**Landsat-7**	ETM+	21-01-2003

1.2 Importing of data into system and generation of subset: The satellite data required for the project is downloaded on to the system. Sub-setting of the required image was generated through following procedure:

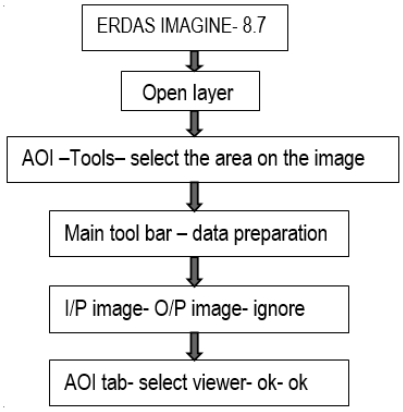

Figure 2: Flowchart showing importing of data and generation of subset

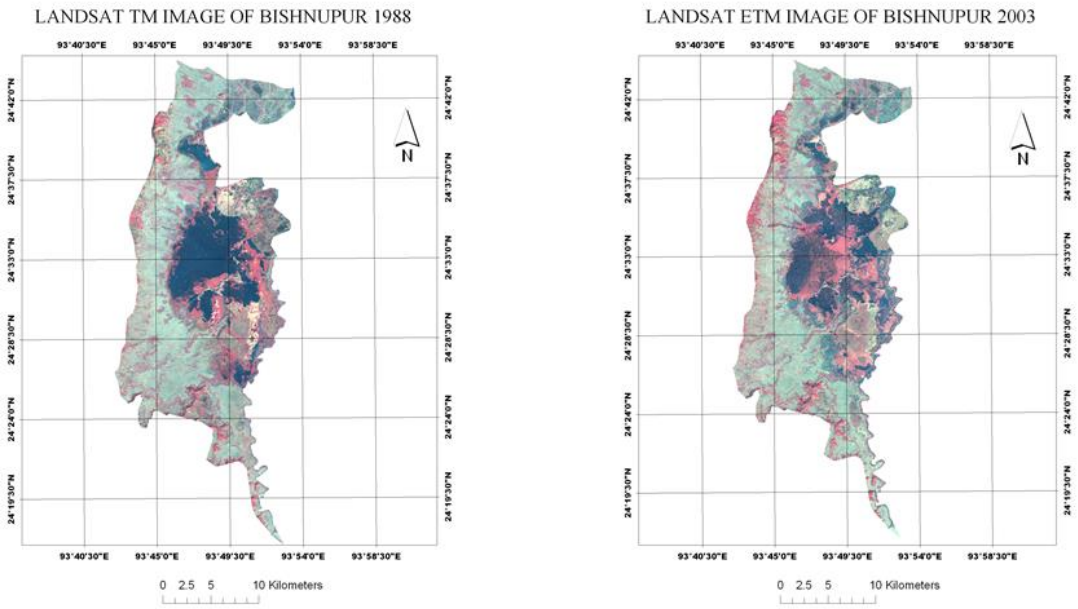

Figure 3: Satellite images of Bishnupur District for the year 1988 and 2003 respectively

1.3. Geometric Rectification of Raw Data: Rectification is the process of projecting the data onto a plane and making it conform to a map projection system. Assigning map coordinates to the image data is called georeferencing.

This is normally required prior to the main data analysis and extraction of information. Radiometric corrections include correcting the data for sensor irregularities and unwanted sensor or atmospheric noise, and converting the data so they accurately represent the reflected or emitted radiation measured by the sensor. Geometric corrections include correcting for geometric distortions due to sensor- earth geometry variations and conversion of the data to real world coordinates system Geographic Lat/Long WGS 84 Datum and Zone 46N of the earth's surface.

1.4. Classification of image: Image classification is defined as the extraction of spectrally non-overlapping differentiated classes or themes; land use and land cover categories, from geometrically rectified digital satellite data. The task of digital classification is to assign or label each pixel of the remote sensing image to one of the several possible objects on earth- say water, frost, snow etc. that is, to a specific class. The separability between the classes depends more on the right combination of the spectral bands than just the number of bands used for classification.

Digital Image Processing:

In today's world of advanced technology where most remote sensing data are recorded in digital format, virtually all image interpretation and analysis involve numerous procedures including formatting and correcting of the data, digital enhancement to facilitate better visual interpretation, or even automated classification of targets and features entirely by computer.

Most of the common image processing functions available in image analysis systems can be categorized into the following four categories:

- **Preprocessing**- Preprocessing operations; sometimes referred to as image restoration and rectification, are intended to correct for sensor and platform specific radiometric and geometric distortions of data.
- **Image Enhancement**- Enhancements are used to make it easier for visual interpretation and understanding of imagery. The advantage of digital imagery is that it allows us to manipulate the digital pixel values in an image.
- **Image Transformation**- It typically involves the manipulation of multiple bands of data, whether from a single multispectral image or from two or more images of the same area acquired at different times. Either way, image transformations generate "new" images from two or more sources, which highlight particular features or properties of interest, better than the original input images.
- **Image Classification and Analysis**- A human analyst attempting to classify features in an image uses the elements of visual interpretation to identify homogeneous groups of pixels which represent various features or land cover classes of interest.

The common classification procedures can be broken down into two broad subdivisions based on the method used: Supervised classification and unsupervised classification. The supervised classification techniques were used to categorize the vegetation and land cover categories. In this, the analyst identifies in the imagery homogenous representative samples of the different surface cover types (information classes) of interest. These samples are referred to as training areas. The selection of appropriate training areas is based on the analyst's familiarity with the geographical area and their knowledge of the actual surface cover types present in the image. Thus, the analyst is "supervising" the categorization of a set of specific classes. The numerical information in all spectral bands for the pixels comprising these areas is used to train the computer to recognize spectrally similar areas for each class. The computer uses a special program or algorithm (of which there are several variations), to determine the numerical "signatures" for each training class. Once the computer has determined the signatures for each class, each pixel in the image is compared to these signatures and labeled as the class it most closely "resembles" digitally. Thus, in a supervised classification we are first identifying the information classes, which are then used to determine the spectral classes, which represent them. To perform supervised classification, the flowchart is given in Figure 4.

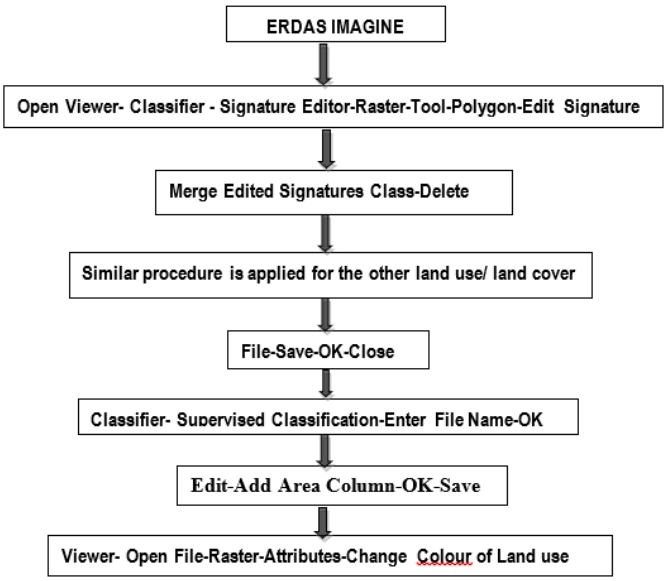

Figure 4: Flowchart to perform supervised classification

1.5. Development of a Classification Scheme: Based on the prior knowledge of the study area for over 10 years and a brief reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area (Table 2). The classification scheme developed gives a rather broad classification where the land use land cover was identified by a single digit.

Table 2: Landuse/ land cover classification scheme

Code	Land use/Land cover
1	Dense forest
2	Open forest
3	Agricultural lands
4	Water bodies
5	Scrub lands
6	Settlements
7	Wetlands
8	Water logged areas

1.6. Pre field visual interpretation of Satellite Imagery and Reconnaissance Survey: The pre field visual interpretation was done with existing imageries using various elements of image interpretation viz., tone, texture, size, shape, location, pattern, association etc. Different land covers and cultural features were demarcated as polygons. The doubtful areas for specific locations were marked for field checks. Reconnaissance Survey of the area was done for getting patterns of vegetation and other land features in the area. Major vegetation types and other land cover characteristics were covered and identified on both toposheets and imagery. Observations

were made for the variation of tonal pattern and textural patterns of FCCs. Traverses were made along the roads, major drainages, hilltops, and valley, and inside forested area for collecting ground truth. Existing literature study and interaction with forest department and local research institutes were also done for information on scientific line.

1.7. Accuracy assessment

The classification performance is evaluated by training area confusion matrix (Error matrix) to obtain over all classification accuracy. The step involving in an accuracy assessment are shown in Figure 5.

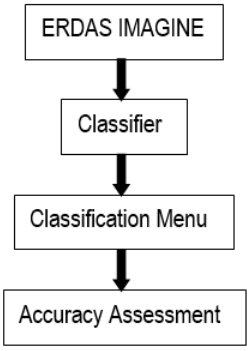

Figure 5: Steps involved in Accuracy Assessment

For the whole present map study, the flowchart shown in figure 6 is adopted.

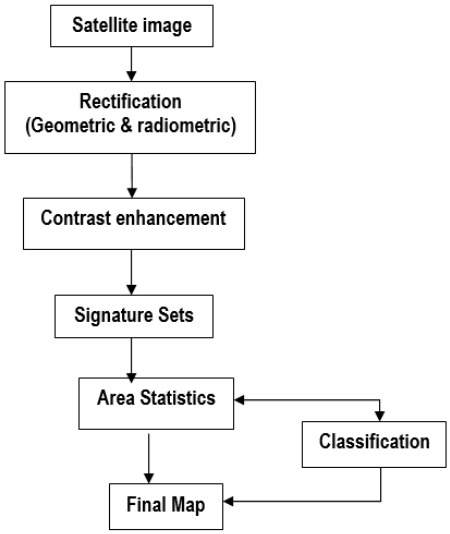

Figure 6: Flowchart of the methodology applied in map study

2. Methodology used for Water Analysis: Water samples were collected from the Manipur River, the Khuga River and Loktak Lake during dry seasons in winter period, 2009 and tested for physical qualities and chemical contents. 1.5-liter polypropylene bottles were used for water sample collection. Prior to sample collection, all bottles were washed with dilute acid followed by distilled water and were dried in an oven. Before taking final water samples, the bottles were

rinsed three times with the water to be collected. The sample bottles were labeled with date and sampling source. Fifteen sampling points were selected. To observe the colour of given water sample some ml of water is taken in a beaker an observed through the naked eye. Temperature is determined with the help of a thermometer. Both the temperature and pH of the given samples are taken with the help of ph analyser (Labindia phan pH Analyser). The conductivity, turbidity, salinity and determination of total dissolved solids are determined with Deluxe water and soil analysis kit.

The measurement values of the analytical equipment (Deluxe water and soil Analysis Kit) are given below: -

- pH – 0 to 14.00 pH
- Conductivity- 0.00 to 19.99 mS
- TDS – 0.00 to 50.00 ppt
- Salinity – 0.0 to 50.00 ppt
- Turbidity – 0 to 1000 NTV
- DO – 0.00 to 19.99 ppm
- Temperature – 0.00 to 60°C

For determining the biological parameter, MPN (most-probable number) test is done. The indicator, most commonly used, is a group of microbes of the family *Escherilia coli* called "coliforms" which are normally found in digestive tracts of warm-blooded animals.

The following is the **requirements and procedure for MPN test**.

Requirements:

a) Autoclave for sterilization
b) Bacteriological incubator
c) Culture tube
d) Duran tubes
e) Sample bottle
f) Graduated pipettes
g) Measuring flasks
h) Test tubes
i) Fermentation tubes
j) Cotton

Procedure:

I. Lactose broth is prepared by dissolving 3g of beef extract, 5gof lactose and 5g of peptose in 1 litre of distilled water.
II. Three sets of cultured tube are properly sterilized and cleaned.
III. 10ml of lactose broth is poured in each of the tube and Duran tube or fermentation tube is inserted in inverted position and plugged with cotton. Then is sterilized in the autoclave.
IV. For sterilization all the test tubes are autoclaved at a pressure of 15 kg/cm.sq for 1 to 1 and ½ hours. It is then cooled.
V. 10ml of each of the water sample is inoculated in 5 of the above test tubes, 1ml each in next tubes and 0.1ml in the remaining tubes. Fresh cotton is plugged into them.

VI. All the test tubes are incubated in bacteriological incubator at a temperature of 37 degree Celsius for 24hrs.

VII. After 24hrs, the tubes are then taken out. Gently shake the tubes and examined for any gas bubbles formed (gas bubbles will appeared inside the inverted tube). Number of air bubbles is to be counted.

VIII. To find out the presumptive MPN, given statistical table is used.

IX. If the air bubbles are not formed within 24hrs than those tubes are kept for another 24hrs for confirmation test and after 48hrs number of positive tubes are counted again.

X. If no bubbles are formed in 48hrs than the water sample is free from bacteria.

RESULTS AND DISCUSSION:

1. **Landuse pattern:** The land use pattern in the study area is classified into eight categories, namely agricultural fields, settlements, water bodies, wetlands, dense forest, open forest, scrub lands and water-logged area.

   1.1. Agriculture: Agriculture is the predominant class in Bishnupur district. It occupies almost all the parts of the district. There are two broad farming systems prevailing in the district such as shifting cultivation which is the traditional agriculture practice in the hilly region, whereas a more settled form of agricultural is practiced in the remaining part of the district. In 1988, the agricultural land was 39.02% of the total land use, which has been, reduced to 36.95% in 15 years i.e., 2003 (Table 3.1 and 4.1).

   1.2. Settlements: There are many rural and urban settlements in the district. Further human dwellings are found in the floating vegetation (Phumdis) in small huts where they reside mainly for fishing activities. Apart from the people living in the close vicinity of the lake, people are also residing at hill villages. These people mainly practiced shifting cultivation. Settlement area in 1988 was 6.56% of the total land use. It is increased to 8.85% after 15 years i.e., 2003. It showed that an area of about 1200 ha is encroached by these activities (Table 3.1 and 4.1).

   1.3. Water bodies: Loktak Lake serves the main water body of this district. The five major rivers with indirect catchments area of 7,157 km^2 (2,763.3 sq mi) are the Imphal (also called the Manipur River), the Iril, the Thoubal, the Sekmai and the Khuga. The other major streams which drain into the lake and which bring in lot of silt are the Nambul, the Nambol, the Thongjaorok, the Awang Khujairok, the Awang Kharok, the Ningthoukhong, the Potsangbam, the Oinam, the Keinou and the Irulok. Water bodies in 1988 were 14.16% of the total land use. It is reduced to 10.04% after 15 years i.e. 2003 (Table 3.1 and 4.1).

1.4.Wetlands: The Loktak Lake is the largest pat (local language- wetland) within the district comprising 61% of the identified wetland regime. Wetlands support a rich biodiversity and are great cultural importance to the people of Manipur. Wetlands in 1988 were 11.65% of the total land use. It is increased to 16.35% after 15 years i.e., 2003 (Table 3.1 and 4.1).

1.5.Forest: A small portion of dense forest and open forest of this district constitutes about 6.76% and 15.33% respectively in 1988. These forests are reduced to 3.62% and 14.79% respectively in 2003 (Table 3.1 and 4.1).

The image of two periods i.e., 1988 and 2003 is analyzed and its area and percentage of land use are shown in the following tables and figures (Table 3.1, 4.2 and Fig. 3.1, 4.1).

Table 3.1: Area Statistics of different Landuse/ Land cover classes in the year 1988

Landuse/ Land cover class	**Area (ha)**	**Percentage Area (%)**
Dense Forest	3585.10	6.76
Open Forest	8124.33	15.33
Agricultural lands	20683.00	39.02
Water bodies	7504.87	14.16
Scrub lands	638.24	1.20
Settlements	3476.24	6.56
Wetlands	6176.67	11.65
Water logged Area	2812.49	5.31
Total	**53000**	**100**

Table 4.1: Area Statistics of different Landuse/ Land cover classes in the year 2003

Landuse/Land cover class	**Area (ha)**	**Percentage Area (%)**
Dense Forest	1917.83	3.62
Open Forest	7837.90	14.79
Agricultural lands	19581.94	36.95
Water bodies	5321.26	10.04
Scrub lands	1411.79	2.66
Settlements	4687.91	8.85
Wetlands	8665.81	16.35
Water logged Area	3575.77	6.75
Total	**53000**	**100**

As per the above tables it is clear that agriculture is the predominant one constituting 20683 ha and 19581 ha in 1988 and 2003 respectively. There is a slightly decrease in 2003 as there is a rapid growth of human population and scrublands. 2% of the settlements has increased in 2003 and 1.5% as that for scrublands. Forest areas have also decreased in 2003 mostly for dense forest, they are scattered and are found in the northwestern part and small fractions in

southern part of the district. Some of these parts are barren and denuded, primarily due to shifting cultivation that is practiced.

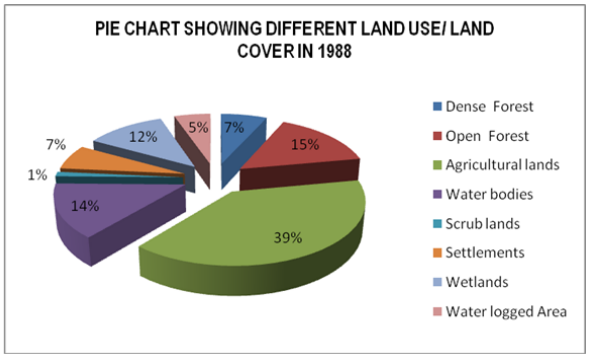

Figure 3.1: Pie chart showing different land use/ land cover in 1988

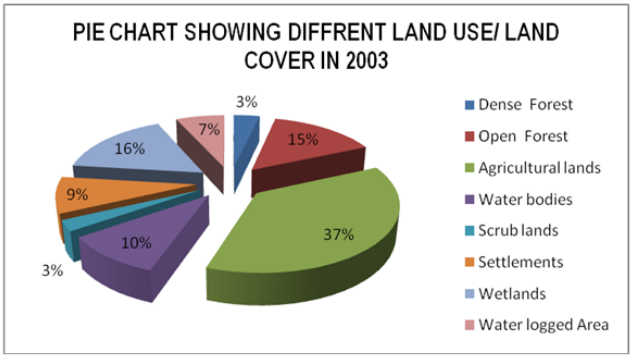

Figure 4.2: Pie chart showing different land use/ land cover in 2003

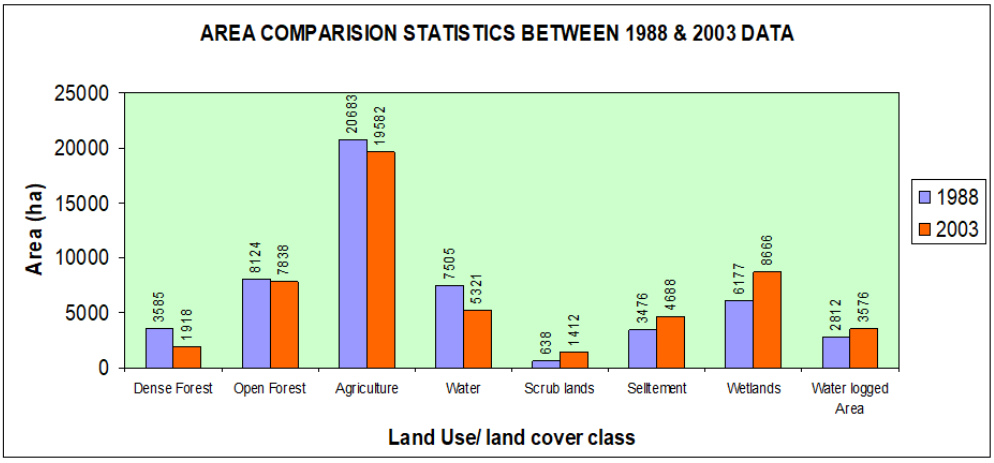

Figure 5: Area comparison statistics between 1988 and 2003

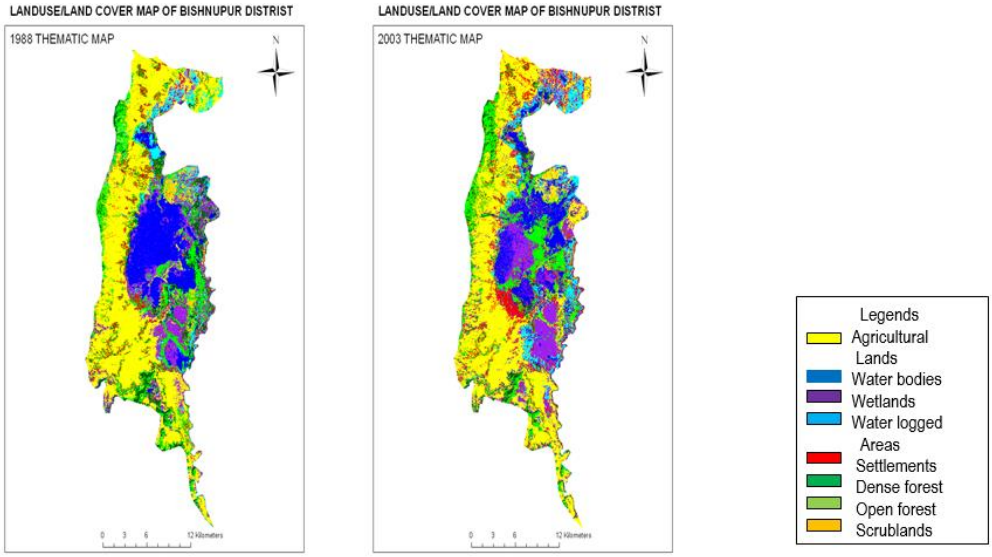

Figure 6: Comparison Map showing the Land use/ Land cover of Bishnupur District, Manipur between the year 1988 and 2003

Table 5: Result of accuracy assessment report of the image 1988

Class name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Wetlands	4	5	4	100.00%	80.00%
Dense forest	1	4	1	100.00%	25.00%
Open Forest	14	11	10	71.43%	90.91%
Waterlogged Area	5	3	3	60.00%	100.00%
Water	9	9	9	100.00%	100.00%
Scrub lands	1	1	1	100.00%	100.00%
Settlements	4	3	3	75.00%	100.00%
Agriculture	12	14	12	100.00%	85.71%
Total	50	50	43		

Overall Classification Accuracy = 86.00% Overall Kappa Statistics = 0.8289

Table 6: Result of accuracy assessment report of the image 2003

Class name	Reference Totals	Classified Totals	Number Correct	Producers Accuracy	Users Accuracy
Open forest	10	10	9	90.00%	90.00%
Dense forest	0	0	0	---	---
Settlements	5	3	3	60.00%	100.00%
Waterlogged Areas	3	3	3	100.00%	100.00%
Water bodies	6	5	5	83.33%	100.00%
Wetlands	10	10	9	90.00%	90.00%
Agricultural land	15	19	15	100.00%	78.95%
Scrub lands	1	0	0	---	---
Open forest	10	10	9	90.00%	90.00%
Total	50	50	44		

Overall Classification Accuracy = 88.00% Overall Kappa Statistics = 0.8470

Changes in the landuse pattern: Findings of the present study revealed that there is increase in area under the land use / land cover like Settlements (1211 ha), Water logged area (766 ha), Wet land (2489 ha) and scrub land (773 ha). However, the land cover that were changed/encroached for the above categories are Dense and open forests, water bodies and Agricultural lands. Maximum (2081 ha) area of water bodies were losses or changed to wetlands/water logged area. An area of about 2000 ha forest have been loosed in 15 years' time span in the district. This

needs an urgent attention of the planners and managers for its sustainable management or minimizes its further degradation/loss (Table 7).

Table 7: Changes in different Land use/ Land cover from 1988 to 2003

Land use/Land cover class	Area (ha) during 1988	Area (ha) during 2003	Net Change (ha)
Dense Forest	3585.10	1917.83	(-) 1668
Open Forest	8124.33	7837.90	(-) 287
Agricultural lands	20683.00	19581.94	(-) 1102
Water bodies	7504.87	5321.26	(-) 2081
Scrub lands	638.24	1411.79	773
Settlements	3476.24	4687.91	1211
Wetlands	6176.67	8665.81	2489
Water logged Area	2812.49	3575.77	766

2. **Water quality:** Water samples were collected from the Manipur River, the Khuga River and Loktak Lake during winter seasons and tested for physical and chemical parameters. The important water quality parameters, such as Color, Odour, Temperature, pH, DO, TDS, MPN analysis and Salinity etc. were analyzed. Results are shown in the following table 8.

Table 8: Table showing results of water analysis

Tests done	Loktak Lake	Khuga River	Manipur River
Colour	Lt. green (very clear)	Lt. green (clear)	Lt. green (clear)
Temperature (°C)	21.6	21.8	21.9
Turbidity	19.6	6.4	8.4
pH	6.59	7.19	6.81
Conductivity (mS)	0.04	0.11	0.11
TDS(ppt)	0.01	0.07	0.06
Dissolved Oxygen	6.7	6.4	6.5
MPN Analysis	35	7.4	19

2.1. Color, Odour and Temperature: The river water should be colorless. The colour of Khuga River and Manipur River are light green and they are clear. As for the lake, it is very clear. The river water should be odorless. Samples collected from the rivers as well as from the lake are odorless. In the case of temperature, standard for sustaining aquatic life is 20-30 (^{0}C) and as it was winter all the sample complies with the national standard (Table 8).

2.2.TDS: The total dissolved solids for Loktak Lake, Manipur River and Khuga River was found to be 0.01ppt, 0.06ppt and 0.07ppt, respectively. The standard values range from 0.00 to 19.99ppt. Thus, it seems to be not polluted as per TDS is concern (Table 8).

2.3.DO: In the case of dissolve oxygen (DO), standard for sustaining aquatic life is 4 mg/L, whereas for drinking purposes it is 6 mg/L. DO value of Loktak Lake, Manipur River and Khuga River along our particular reach gives the value of 6.7, 6.5 and 6.4 respectively. Dissolved oxygen values for all the three water bodies seems to be at higher side thus there will be no adverse impact on aquatic life while it is not fit for drinking purposes (Table 8).

2.4. pH, Turbidity and Conductivity: pH is the indicator of acidic or alkaline condition of water status. The standard for any purpose in-terms of pH is 6.5-8.5; in that respect the value of Loktak Lake, Manipur River and Khuga River are 6.59, 6.81 and 7.19 respectively. The turbidity values are 19.6, 6.4 and 8.4, respectively. In case of conductivity, there is not much of conductance in Loktak Lake with the value of 0.04mS. And for Manipur River and Khuga River are 0.11mS and 0.11mS, respectively (Table 8).

2.5.MPN: As for MPN analysis 35 per 100ml of the water sample is found in Loktak lake, 19 per 100ml of the water sample is found in Manipur River and that of Khuga River is 7.4 per 100ml of the water sample (Table 8).

To achieve the objectives of this research study, satellite remote sensing data were collected and interpreted with the help of ERDAS GIS software using various techniques. Landsat 5 & 7 imagery having TM and ETM+ sensor data were used. And to analyse the major constituents by different parameters of surface water, the major lentic water bodies i.e., Khuga River and Manipur River and Loktak Lake of the district were collected.

The results of the classified images of Bishnupur District revealed that the area is under different types of land use where agricultural land is a predominant one followed by wetlands, water bodies, water logged areas, settlements, dense forest, open forest and scrubland. Agricultural land is the predominant class where shifting cultivation (in the hills) and settled agriculture is practiced. It is reduced to 36% in 2003 from 9% in 1988. In case of settlements, Meiteis mostly inhabited the district and 14% of the valley population resides in and around the Loktak Lake. It is increased to 8.85% in 2003. Loktak Lake serves the main water body of the district as well as that of the state. Major as well as streams discharged themselves in the lake. Water bodies in 1988 constitute 14.16% of the total land use and it reduced to 10% after 15years i.e., 2003. Wetlands support a rich biodiversity and are great importance to the people of Manipur. *Cervus eldi eldi* locally called as Sangai thrives in these wetlands. Keibul Lamjao National Park, which is located at Southern part of the lake, is the natural habitat of these animals. Wetland areas are increased to 16% in 2003.

Water analysis of various parameters assessed includes pH, temperature, colour, odour, and TDS, conductivity, turbidity and MPN analysis. From the above analysis, it results that these water bodies are fit for drinking but it should be taken after treatment and it can be used for irrigation and ecological purposes. A comprehensive analysis or more research water quality from different zones of these water bodies is necessary and has to make awareness among the people.

CONCLUSION:

For sustainable utilization of the land ecosystems, it is essential to know the natural characteristics, extent and location, its quality, productivity, suitability and limitations of various land uses. In order to improve the economic condition of the area without further deteriorating the bio environment, every bit of the available land has to be used in the most rational way. This requires the present and the past land use/ land cover data of the area. Keeping above in account, the current work is taken up in Bishnupur District of Manipur.

The results of the study suggest that the analysis of sequential satellite data offers means of extraction of information on land use/land cover. In fact, for shorter intervals satellite data are very helpful for the detection of land use/land cover changes, due to repetitive coverage at very short intervals. It can be clearly seen from the above study that there is a considerable increased in wetlands area. The main reasons behind it are its location, construction of Ithai Barrage on Manipur River, deforestation and shifting cultivation in the catchment area, which promotes soil erosion resulting in the increased in siltation. The problem has been further aggravated due to prolific growth of floating vegetation from the nutrients brought down by the rivers and non-continuity outflow of water, encroachments in the lake through assemble of fishing farms using phumdis (floating intermass of vegetation), roads and settlements. So, to overcome these weaknesses there is need a to conserve and protect these wetlands and as well to protect the surviving forest areas by implementing strategies like Joint Community Base programmes, reduction of jhum cultivation in hill villages, integrated farming as well as in lakeshore villages, economic utilisation of phumdis, reducing dependence on forests for fuelwood, reducing pressure on lake fisheries. And a comprehensive or more research of water quality from different zones of the above-analysed three water bodies i.e., Loktak Lake, Khuga River and Manipur River is necessary. Overall management with community participation to protect and to conserve should be implemented.

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ANALYSIS THE EFFECT OF SODIUM CARBONATE AS AN ADDITIVE ON BONDING PROPERTIES OF MAGNESIUM OXYCHLORIDE

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ABSTRACT:

Non-hydraulic Magnesium oxychloride cement has numerous advantages over typical Portland cement, including quick setting, strong fire resistance, reduced thermal conductivity, higher abrasion and chemical resistance. Magnesium oxychloride cement is attracting a lot of research attention because of its energy-saving and environment friendly properties. Despite its numerous benefits, its commercial application is limited due to its low early strength and poor water resistance. A parametric study was conducted to investigate the effect of Sodium carbonate on the bonding properties of Magnesium oxychloride. Incorporation of different proportions of Sodium carbonate in Magnesia cement gradually increases the setting periods and improves compressive strength of the product.

KEYWORDS: Magnesium oxychloride, Sodium carbonate, Setting periods, Compressive strength, Moisture ingress, Weathering effects, Linear changes, etc.

INTRODUCTION:

Magnesia cement has been attracted attention for many years due to their properties and potential applications. It is also known as Sorel cement (Sorel, 1867; Beaudoin and Ramachandran, 1977; Chandrawat *et al.*, 2011). It is non-hydraulic cement and formed by mixing powdered Magnesium oxide (MgO) gauged with Magnesium chloride ($MgCl_2.6H_2O$). This reaction is exothermic, hence Dolomite is used as an inert filler to reduce thermal shocks in the cement and increase soundness of the product.

$$MgO + MgCl_2.6H_2O \longrightarrow MOC + Heat$$

(Deformation and expansion)

$$MOC + Heat + Inert\ filler \longrightarrow MOC + Inert\ filler^*$$

(Intact structure)

(MOC = Magnesium oxychloride cement)

(Inert filler = Dolomite ($MgCO_3$/$CaCO_3$)

It has many superior properties compared to ordinary Portland cement. It has high fire resistance, low thermal conductivity and good resistance to abrasion and is unaffected by oil, grease and paints (Urwongse and Sorrell, 1980; Bensted and Barnes, 2002; Shand, 2006; Liska and Al-Tabbaa, 2008; Li *et al.*, 2010; Schollbach and Pöllmann, 2011). It is also distinguished by high bonding, quick setting time and does not require humid curing (Hubbell, 1937; Sorrell and Armstrong, 1976; Chuanmei and Dehua, 1995; Özer *et al.*, 2007; Zongjin and Chau, 2007). This cement has attracted much research interest due to energy saving and environmental protection considerations. For example, the production of lightly burnt Magnesium oxide used in magnesia cement requires much lower calcination temperatures than used for Portland cement, greatly reducing energy consumption (Li *et al.*, 2010; Schollbach and Po¨llmann, 2011). The major commercial and industrial applications of magnesia cement are industrial flooring, fire protection, grinding wheels and lightweight wall panels, but it is also used for rendering wall insulation panels, interior plaster and decorative panels (Beaudoin and Ramachandran, 1975; Shand, 2006; Liska and Al-Tabbaa, 2008). The setting and hardening of magnesia cement takes place through solution reaction (Urwongse and Sorrell, 1980). Four main reaction phases in the ternary magnesia cement system are found: $2Mg(OH)_2.MgCl_2.4H_2O$ (phase 2), $3Mg(OH)_2.MgCl_2.8H_2O$ (phase 3), $5Mg(OH)_2.MgCl_2.8H_2O$ (phase 5) and $9Mg(OH)_2.MgCl_2.5H_2O$ (phase 9) (Hubbell, 1937; O¨ zer et al., 2007; Sorrell and Armstrong, 1976; Zongjin and Chau, 2007). Phase 3 and Phase 5 are more prominent phases. Magnesia cement has many beneficial engineering and mechanical properties, but it has poor water resistance, resulting in significantly decreased strength of the hardened paste in water, thereby limiting its engineering applications. Many investigations into the water resistance of magnesia cement have thus been carried out (Chuanmei and Dehua, 1995; Chau *et al.*, 2009; Chandrawat *et al.*, 2011; Sglavo *et al.*, 2011), but there are only a few reports available worldwide on magnesia cement concrete. The object of the study was to determine the effect of Na_2CO_3 on setting periods, moisture ingress, weathering effect, compressive strength and linear changes of Sorel's cement. The anionic part of Sodium carbonate reacts with active lime and other harmful impurities and forms inactive insoluble phase. Thus the harmful effects of these impurities on the quality of Magnesium oxychloride cement are minimized.

EXPERIMENTAL DETAILS:

MATERIALS

The raw materials used in the study were Magnesium oxide, Magnesium chloride and Dolomite powder.

1. Magnesium oxide: Commercial grade Magnesia (lightly calcined) was used in this study. The analysis of Magnesite powder is:-SiO_2=8.51%, CaO=2.80%, MgO=82.70%, Fe_2O_3=0.12%, Al_2O_3=0.98%, LOI=4.40%.
2. Magnesium chloride ($MgCl_2.6H_2O$): Magnesium chloride used in the study was Grade 3 of Indian Standard: 254 – 1973, with following characteristics: Colorless, crystalline, hygroscopic crystals, Highly soluble in water, Magnesium chloride hexahydrate minimum 95%, Magnesium sulfate, calcium sulfate and alkali chlorides (NaC1) contents were 4%.
3. Dolomite (Inert filler): Commercial grade dolomite was used in this study. The chemical composition of Dolomite is SiO_2=5.06%, CaO=29.40%, MgO=19.50%, Fe_2O_3=0.82%, Al_2O_3=0.23%, LOI=44.50%, $CaCO_3$=52.50%, $MgCO_3$=40.95%, Brightness=93.00%, Whiteness=95.30%.

Preparation of gauging solution

Magnesium chloride solution was prepared in water. Flakes of Magnesium chloride were transferred into plastic containers to which potable water was added to prepare concentrated solution. This solution was allowed to stand overnight so that insoluble impurities settle at the bottom. The supernatant concentrated solution was filtered by suction pump and taken out in other glass container and well stirred after each dilution before determining the specific gravity. Concentration of the solution is expressed in terms of specific gravity on Baume scale (^{o}Be).

Preparation of dry-mix composition

Dry-mixes were prepared by mixing lightly calcined magnesite (magnesia) and dolomite (inert filler) in the ratio of 1 : 0, 1 : 1, 1 : 2, and 1 : 3 by their weight.

METHODS

All the experiments were carried out on the Magnesium oxychloride's best cementing composition (MgO: Dolomite is in 1:1 proportion and the density of the gauging solution is 24^0Be) under the same temperature (30^0C) and humidity conditions (above 90 percent). The effects of Sodium carbonate on Magnesium oxychloride cement were investigated with different percentages of Sodium carbonate (0%, 5%, 10%,15% & 20%) in the following experiments.

1) **Setting Time Investigations:** The effect of Sodium carbonate on setting characteristics of Magnesium oxychloride cement was studied by admixing Sodium carbonate in the dry mix in varying proportions. The quantity of additive was calculated by weight of Magnesia. Wet mixes were prepared by gauging 1:1 dry mixes (by weight of Magnesia and Dolomite) having different quantities of additive with Magnesium chloride solution of 24^0 Be. The volume of gauging solution was kept constant for each lot of dry-mix. Standard procedures were adopted

according to IS Specification to determine standard consistency, initial and final setting times by using Vicat needle apparatus. Findings are summarized in Table1.

2) **Weathering Investigations:** Setting time investigation blocks were used for this test. Weights of the trial blocks were measured after different time interval (24 hrs, 7 days, 30 days and 45 days) with the help of standard chemical balance. The weight of blocks may increase or decrease with time due to different weathering effects. Results are recorded in Table 2.
3) **Moisture Ingress Investigations:** Soundness of the product can be ascertained by this test. After 2 months of curing in identical conditions, setting time investigation blocks were exposed to steam/ boiling water in identical conditions for at least 30 hours. The effect is noted after an interval of five hours. Moisture ingress and soundness are inversely proportional. Results are shown in Table 3.
4) **Compressive Strength Investigations:** Trial blocks of 70.6 mm x 70.6mm x 70.6mm side and 50cm^2 surface area were prepared for the investigation and these were cured for 28 days under identical conditions of temperature and humidity and then these were tested on universal testing machine. Results are summarized in Table 4.
5) Linear Change Investigations: Trial blocks were prepared from standard sized moulds (200mm x 25 mm x 25 mm) and these blocks were kept under 90% relative humidity and 30± 2^oC temperature for 24 hrs. The initial length of the trial blocks can be determined by the micrometer scale. These blocks were cured for 28 days under identical conditions and then the length was measured. This is the final length of the beams. Difference between initial and final length tells the linear change. The greater the change the lesser will be the soundness of the product. Results are recorded in Table 5.

RESULTS:

Table 1 represents the effect of Na_2CO_3 on setting periods of Magnesium oxychloride cement. It is observed that initial as well as final setting periods of Magnesium oxychloride cement increases with increasing quantity of additive. When ratio of additive increases, the amount of MgO decreases in the matrix (eq ii & iv). Also carbonate ions react with diavalent cations, which results in the formation of insoluble and inactive phase of their carbonates (eq iii & iv).This decreases the active quantities of MgO available in the matrix. Such situation retards the setting process.

The effect of Na_2CO_3 as an additive on weathering characteristics is shown in Table2. Incorporation of Na_2CO_3 reduces the weight of the trial blocks with time up to 30 days of observation period. This is attributable mainly to the uncombined free moisture present in the

matrix which slowly evaporates with time causing decrease in weights. Observations recorded on the 45th day reveal almost insignificant increase in. This shows that major reactions involved in cement formation are almost over by that period. Minor increase in weights may be explained due to rehydration or carbonation (eq vi).

Effect of Na_2CO_3 on moisture ingress characteristics of Magnesium oxychloride cement is represented in Table 3. Incorporation of Na_2CO_3 increases water tightness of the product. Inactivation of harmful impurities like active lime (eq iii & iv), formation of inert solid phases like basic Magnesium carbonates (eq viii) etc. contribute to water tightness.

Table 4 shows the effect of Na_2CO_3 on compressive strength of Magnesium oxychloride cement. Compressive strength is improved by the incorporation of additive. It is noted that strength decreases with increasing proportion of additive. Small proportion of the additive inactivate harmful impurities like active lime (eq iii & iv). In such a situation compressive strength of the trial blocks is found to increase initially. With subsequent addition of the additive, compressive strength is found to decrease sharply as the chances of formation of strength giving composition decreases and also due to the porous structure of the cement blocks on account of the evolving CO_2.

Effect of Na_2CO_3 on linear changes is noted in Table 5. Incorporation of Na_2CO_3 causes contraction in the linear beams to some extent. This can be accounted on the basis of the conversion of expansive or bulky materials (oxides and hydroxides) into compact crystalline phase (carbonates) (eq ii, iv & vii).

The above discussion can be interpreted on the basis of the following chemical changes :-

$CaO+H_2O \longrightarrow Ca(OH)_2$ ----------(i)

$MgO+H_2O \longrightarrow Mg(OH)_2$ ----------(ii)

$Ca(OH)_2+Na_2CO_3 \longrightarrow CaCO_3 + 2NaOH$ ----------(iii)

Inactive Insoluble phase

$Mg(OH)_2+Na_2CO_3 \longrightarrow MgCO_3 + 2NaOH$ ----------(iv)

Inactive Insoluble phase

$MgCl_2+2NaOH \longrightarrow Mg(OH)_2 +2NaCl$ ----------(v)

$MO+H_2O/CO_3 \longrightarrow M(OH)_2/CO_3$ ----------(vi)

Increase in weight

$Na_2CO_3+MgCl_2 \longrightarrow MgCO_3 + 2NaCl$ ----------(vii)

$XMg(OH)_2+YMgCO_3+ZH_2O \longrightarrow XMg(OH)_2.YMgCO_3.ZH_2O$ ---(viii)

Basic Magnesium Carbonate

(Solid phase non setting)

$3Mg(OH)_2+MgCl_2+8H_2O \longrightarrow 3Mg(OH)_2.Mg\ Cl_2.8H_2O$ --------(ix)

Magnesium oxychloride cement

(3.1.8 Form)

$5Mg(OH)_2+Mg\ Cl_2+8H_2O \longrightarrow 5Mg(OH)_2.Mg\ Cl_2.8H_2O$ --------(x)

Magnesium oxychloride cement

(5.1.8 Form)

(Strength giving composition)

Table 1: Effect of Na_2CO_3 on Setting Characteristics of Magnesium oxychloride cement

Sr. No.	% of Na_2CO_3 in Dry-mix composition	Setting Time	
		Initial (min.)	Final (min.)
1	0%	62	202
2	5%	70	447
3	10%	79	482
4	15%	87	502
5	20%	121	537

Table 2: Effect of Na_2CO_3 on Weathering Characteristics of Magnesium oxychloride cement

Sr. No.	(% of Na_2CO_3 in dry-mix composition)	Weight of blocks in gm after			
		24 hrs	7 days	30 days	45 days
1.	0%	257.06	253.39	253.09	251.07
2.	5%	258.17	248.57	247.25	243.41
3.	10%	246.08	235.27	229.94	230.30
4.	15%	244.45	230.79	229.04	226.07
5.	20%	243.01	226.38	225.44	224.06

Table 3: Effect of Na_2CO_3 on Moisture Ingress Characteristics of Magnesium oxychloride cement

S. No.	(% of Na_2CO_3 in dry-mix composition)	Trial blocks kept in boiling water for					
		0-5 hrs	5-10 hrs	10-15 hrs	15-20 hrs	20-25 hrs	25-30 hrs
1.	0%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
2.	5%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
3.	10%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
4.	15%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
5.	20%	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.

N.E. = No Effect

Table 4: Effect of Na_2CO_3 on compressive strength of Magnesium oxychloride cement

Sr. No.	(% Na_2CO_3 in Dry-mix composition)	Compressive Strength in Kg/cm^2
1	0%	263.55
2	5%	374.77
3	10%	358.73
4	15%	320.66
5	20%	280.58

Table 5: Effect of Na_2CO_3 on linear changes of Magnesium oxychloride cement

Sr. No.	(% of Na_2CO_3 in dry-mix composition)	Length of beams (mm)		Change in length (mm)
		Initial	Final	
1.	0%	200.00	199.970	0.020
2.	5%	200.00	199.934	0.064
3.	10%	200.00	199.887	0.113
4.	15%	200.00	199.875	0.126
5.	20%	200.00	199.847	0.122

CONCLUSIONS:

1) Na_2CO_3 increases setting periods in all proportions within the experimental limits.

2) Incorporation of Na_2CO_3 improves water tightness and strength of the cement.

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POTENTIAL OF KAIROMONES IN RECRUITING PARASITOIDS: A MINI REVIEW

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ABSTRACT:

The past few decades have seen a rise in interest in biological control by taking advantage of natural enemies due to the negative effects of hazardous substances on the environment and life. Natural enemies of pests hang on variety of chemical signals including kairomones for foraging, i.e., looking for food sources and oviposition sites in the nature. Chemical cues called kairomones facilitate interspecific interactions beneficial to the species that receive them. Economic loss and the detrimental consequences of insect herbivory can be reduced through pest management strategies that increase the effectiveness of natural enemies. Kairomone-based lures are utilized to improve biological control methods by luring and retention of natural enemies and management of the pest in an environmentally friendly manner. There are different sources for kairomones utilized by beneficial entomophages in reaching their target host. Kairomones can be of herbivore induced plant volatiles (HIPVs), herbivore released and natural enemy released. Parasitoids have their own ingenious methods to differentiate host kairomones and non-host kairomones. The present chapter mainly covers the role of the kairomones in attracting parasitoids towards host and use of kairomones in increasing the efficiency of parasitoids in the agricultural field.

KEYWORDS: Kairomones, Parasitoids, biological control, environmental safety

INTRODUCTION:

Major biotic constraints for agricultural production are weeds (33%), insects (26%) and diseases (20%) and others (10%) (Kumar *et al.,* 2021). But large number of chemicals used are insecticides, accounts nearly 65% of total pesticides consumption (Devi *et al.,* 2017). Lot of these insecticides are hazardous and greatly associated with human health and environment. Moreover, larger quantity of insecticides are used by the farmers then recommended at the field level. Excessive use of insecticides results in major problems like resistance, resurgence and residues. Use of biocontrol agents manage the pest population below the Economic Injury Level (EIL) with no side effects. Success of pest management by the natural enemy depends on herbivore location and establishment. Foraging natural enemies largely depends on the various chemical cues for host recognition. Most exploited chemical cues are the kairomones.

Kairomones

Kairomones are the type of semiochemicals, released by one species beneficial to the individual belongs to other species. Role of kairomones is well studied since 1960's, in limitation of pest population in natural ecosystem by recruiting natural enemies (Dyer, 2007). There are evidences showing that the volatile compounds released from the herbivore attacked plant, acts as attracting signals to beneficial entomophages towards host plant. Once the natural enemies reach the target host, they use different cues to find different stages of pest. Host volatile plays an important role in the both success and extent of parasitization. Such case is seen in the parasitization of eggs of *Helicoverpa armigera* by the adults of *Trichogramma chilonis Ishii*. High rate of parasitization by this parasitioid was observed when *H. armigera* used tomato as a host than other hosts (Tandon and Bakthavatsalam, 2007). Thus, the kairomones specific to natural enemies can be exploited for conservation and increased abundance. Kairomones when sprayed in the field manipulate the behavior of natural enemies and increase their efficiency of parasitization.

Types of kairomones

Evolutionary and ecological studies mainly focused on how natural enemies find the host. There are four phases in the location of host by parasitoids, such as host habitat finding, host finding, host recognition and host acceptance (Vinson, 1976).

Parasitoids search the plant community for the host plant during foraging by using a variety of resource-indicating odours, then the target host, and finally select and accept the host. Schematic illustration of how parasitoids and predators utilize the kairomones during foraging is given in **Fig 1.**

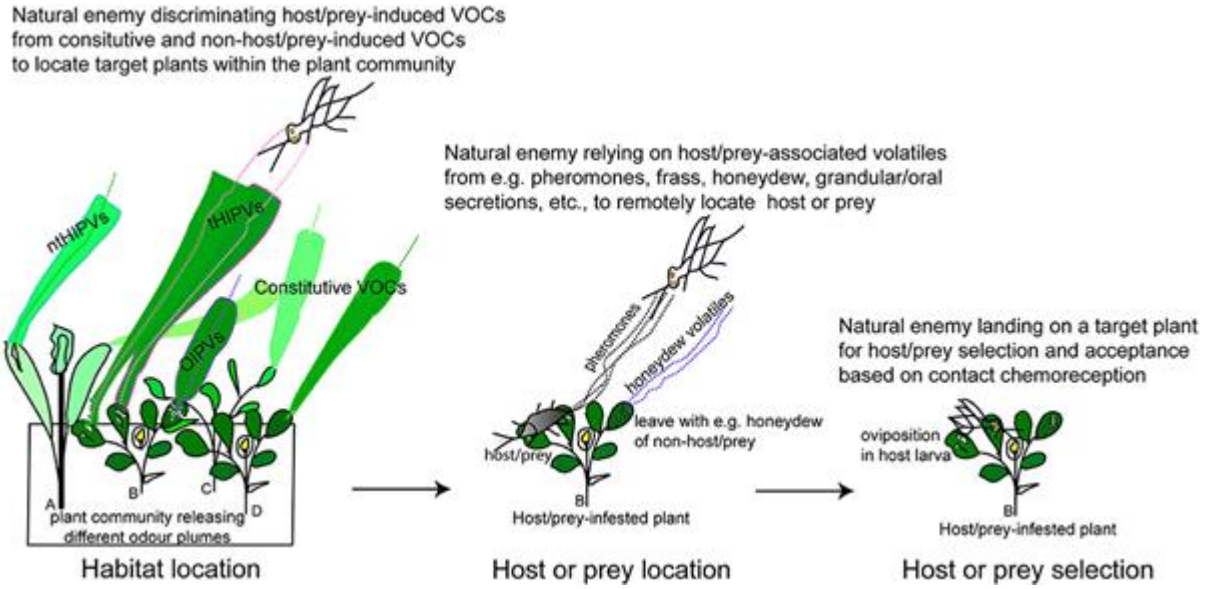

Figure 1: Schematic illustration of how parasitoids and predators utilize the kairomones during foraging (Ayelo *et al.*, 2021). (ntHIPVs- non-target herbivore-induced plant volatiles; tHIPVs-target hervore-induced plant volatiles; OIPVs-oviposition-induced plant volatiles; VOCs-volatile organic compounds).

Different sources of kairomones utilized by parasitoids during foraging

1. Host habitat finding using herbivore induced plant volatiles

Foraging activity of parasitoids is tedious task. Parasitoids initially find infested host plant in search of herbivore. Host plant releases volatile compounds when stressed by herbivores. These volatile compounds are called as herbivore-induced plant volatiles (HIPVs). A schematic illustration of how plants react to herbivores given in the **Fig 2.** Tandon and Bakthavatsalam have been reported that when tomato infested by *H. armigera,* a set of volatiles from fruit such as Linalool-L and heptadecane attracted *T. chilonis*, an egg parasitoid of *H. armigera* (Tandon and Bakthavatsalam, 2007). Similarly, *Allium porrum* released a set of volatile compounds, when infested with *Acrolepiopsis assectella*. Major compounds found were thiosulfonate dipropyl, disulfide and propylpropane, thiosulfinate and propyl propane. These compounds attracted the *Diadromus pulchellusm*, parasitoid of *A. assectella* (Lecomte and Thibout, 1986). When octadecanoic acid released in higher quantities from the rice plant attracted and increased the oviposition of different species of *Trichogramma* (Rani and Kurra, 2012). It has been reported that many compounds including monoterpenes, alkane hydrocarbons, diterpenes and sesquiterpenes in tomato fruit and leaf were involved in increased parasitization of egg of *H. armigera* by *T. chilonis* (Tandon and Bakthavatsalam, 2007).

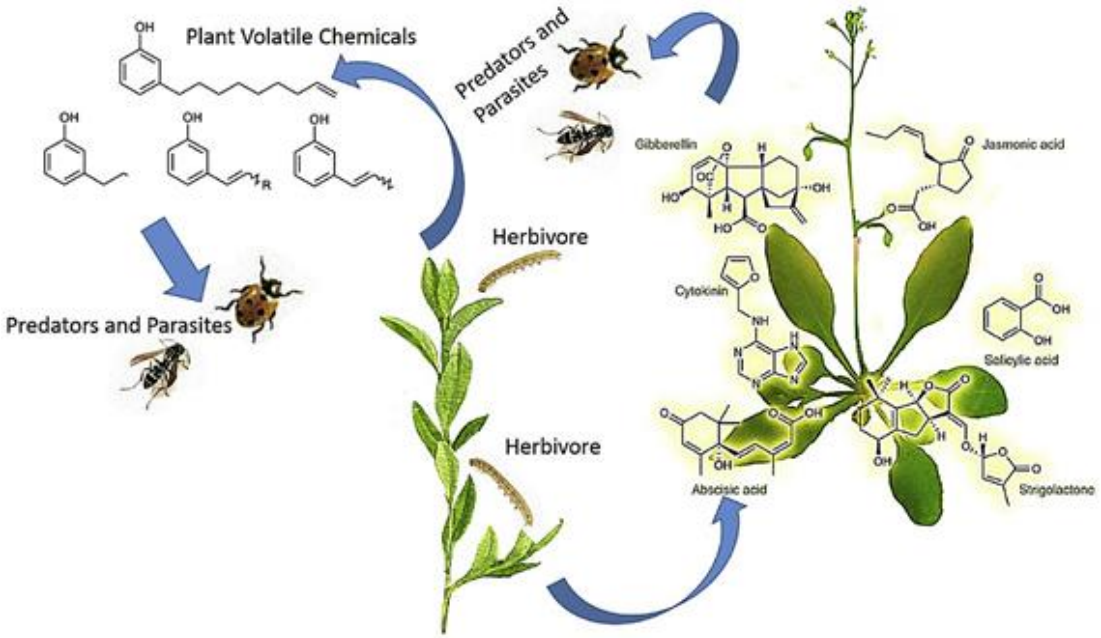

Figure 2: A schematic illustration of how plants react to herbivores (Murali-Baskaran *et al.*, 2018)

Not only do plants emit volatile chemicals in response to herbivore eating, but also in response to oviposition. These are called as oviposition induced plant volatile (OIPVs). Volatile compounds were released due to oviposition by *Diprion pini* on alpine tree and *Xanthogaleruca luteola* on elm tree attracted the *Chrysonotomysia ruforum* and *Oomyzus gallerucae*, respectively (Hilker *et al.,* 2000; Meiners and Hilker, 2006).

Different parts of the plant release the volatile compounds acts as kairomones to parasitoids. Chemical combinations found in floral extracts from genotypes with high susceptibility may also attract natural enemies. The cotton plant provides the best illustration of this, as extra floral nectaries serve as the main source of kairomones for ichneumonids, braconids and trichogrammatids engaged in the management of cotton budworms and boll worms. Moreover, these extra floral nectaries act as source of energy as it contains high quantity of sugars and amino acids and thus improves the lifespan of parasitoids (Pemberton and Lee, 1996). It is very well known that crop plants are infested by different species of herbivores. These herbivores can be target or non-target hosts for parasitoids (Vos *et al.,* 2001). Plants infested by the insects with different modes of feeding determines the types of defense signalling pathways (either JA or SA alone, or both) to get activated. Chewing insects activate the JA pathway (Danner *et al.,* 2018) and sucking insects like whiteflies activate the SA pathway (Zhang *et al.,* 2013) and sting bugs activates both SA and JA (Giacometti *et al.,* 2016). The qualitative and quantitative differences exist in the plant volatiles from JA- vs. SA inducers (Danner *et al.,*

2018). These differences may affect the attractiveness of parasitoid towards the host. One such example is the *Cotesia marginiventris* (Cresson) (Hymenoptera: Braconidae) attracted to maize plant when infested by an JA-inducer, *Spodoptera littoralis* (Boisduval) (Lepidoptera: Noctuidae) alone then when infested along with *Euscelidius variegatus* (Kirschbaum) (Hemiptera: Cicadellidae) an SA-inducer (Erb *et al.*, 2010). Hence the parasitoids recognize the target host based on the differences in the chemical volatiles secreted by the host plant.

2. Host finding using herbivore released kairomones

The volatile compounds released from the herbivore are species specific acts as important source of communication to parasitoids. Different types of compounds from the herbivore, such as fatty acids, hydrocarbons and proteins enhance the host reaching capacity of beneficial entomophages (Murali-Baskaran *et al.,* 2018). The use of such compounds to boost entomophages efficacy has been reported by many researches (Brown *et al.,* 1970; Whittaker and Feeny, 1971).

Pheromones released from the insects acts as source of kairomones to natural enemies. (Z)-11-hexadecenyl is a major component in sex pheromone of *Helicoverpa assulta* (Guenée) (Lepidoptera: Noctuidae) acts as kairomone in the attraction of *T. chilonis*.

Apart from pheromones, herbivore by-products such as honeydew, larval frass, grandular secretions of larva and adult also act as kairomones to natural enemies. Allyl isothiocyanate, a volatile substance from larval frass of *Plutella xylostella* attracted its natural enemies *T. chilonis* and *Cotesia plutella* (Ayelo *et al.,* 2021). Wing scales, abdominal tips and excretions of female *Helicoverpa zea* are the sources of kairomones of two parasitoids *Trichogramma. pretiosum* Riley and *Trichogramma evanescens*. It has been reported that parasitization of *T. evanescens* was found higher on the eggs when placed on scales of adults (Lewis *et al.,* 1975).

Increased parasitization was observed with different blends of (Z)-7-hexadecenal, hexadecanal, aldehydes, (Z)-11-hexadecenal and (Z)-9-hexadecenal (Lewis *et al.,* 1972, 1982). Chemicals released during calling activity also acts as kairomones. Such case is found in the females of *O. nubilalis* (Hübner) (Lepidoptera: Crambidae), where virgin females released the chemicals during calling activity intensified the searching capacity of parasitoid *Trichogramma brassicae* Bezd. (Frenoy *et al.,* 1992). Whole body extracts of females of *Earias vittella* and *H. armigera* acted as kairomones and attracted *T. chilonis* and *T. chilonis, C. zastrowi sillemi* respectively (Maruthadurai and Archana, 2011; Parthiban *et al.,* 2016 b). Whole body extracts from the males and females affect the efficiency of attraction of natural enemies. Whole body extracts of female *Corcyra cephalonica* greatly attracted the *C. zastrowi sillemi* and *T. chilonis* then whole-body extracts of male because of high concentration of hydrocarbons (Parthiban *et*

al., 2015a). Concentration of these hydrocarbons affects the efficiency of parasitoids but don't strictly increase with increase in concentration. Pentacosane, a hydrocarbon acts as kairomone to *T. chilonis*, whose efficiency decreased with increase in concentration from 200 to 500 ppm (Paul *et al.,* 2002).

3. Host recognition and acceptance using kairomones from herbivores

For oviposition or feeding, natural enemies must choose the target herbivore species and life stages. Since it determines the forager's and its offspring's survival, this foraging behaviour stage is critical. Herbivore contact kairomones are non-volatile, species specific. Parasitoids rely on these kairomones for host recognition either by probing and antennating (Vinson, 1998; Bénédet *et al.,* 2002). The major source of contact kairomones can be body surface larva, nymph, adult, wings scales, egg shells, oral secretions of larvae (Afsheen *et al.,* 2008; Kaiser *et al.,* 2017). O-caffeoylserine, which was extracted from the body surface of *Phenacoccus herreni* Cox & Williams (Homoptera: Pseudococcidae) and which strongly triggered drumming behaviour, serves as an illustration of this against the parasitoids *Aenasius vexans* Kerrich (both Hymenoptera: Encyrtidae) and *Acerophagus coccois* Smith (Calatayud *et al.,* 2001). The acceptance of hosts by parasitoids is also influenced by hydrocarbons obtained from herbivores. For example, *Trissolcus basalis* Wollaston (Hymenoptera: Scelionidae) uses a cuticular contact kairomones called non-adecane fromstink bug host, *Nezaria viridula* (L.) (Hemiptera: Pentatomidae) and discriminate between female and male (Colazza *et al.,* 2007). It has been further reported that *Trichogramma basalis* and *Telenomus podisi* preferred the hydrocarbons from target host *N. viridula,* and *Euschistus heros* respectively that other species (Gomes-Lagôa *et al.,* 2019). Frass is reported as one of the important sources of kairomones to parasitoids. Nearly 100% of ovipositor probing by parasitoids was observed due to frass (Usha Rani, 2014). Kairomones from cuticular extraction also plays an important role in attraction of parasitoids. Cuticular extraction from the scales of both the sexes of *Corcyra cephalonica* attracted the *T. japonicum* and *Trichogramma brasiliensis* (Paul *et al.,* 1997). Both attraction and enhanced oviposition of parasitoids were observed when cuticular extraction contains a mixture of hydrocarbons such as hexacosane, heneicosane, tetracosane, pentacosane, pentadecane, and, eicosane. Differences in the composition of the main hydrocarbons in the mix extract may be the cause of the parasitoid selective reactions to the hydrocarbons of their target hosts (Gomes-Lagôa *et al.,* 2019). In the process of co-evolution between host and its parasitoids enabled the plant parasitoids to recognise the host based on the chemical stimuli associated with the target herbivore (Peri *et al.,* 2013).

Role of kairomones in biological control of pest in the field

In biological control natural enemies are employed for the management of pests (Ayelo *et al.,* 2021). Adoption of biocontrol is considered as one of the best alternatives to the synthetic pesticides as it is environmentally safe (Gay, 2012). Cases of successful and failure in biocontrol of pests have been reported. One of the successful examples is control of red scale insect *Aonidiella aurantii* in citrus orchards by the parasitoid *Aphytis melinus* (Moreno and Luck, 1992). Main reasons for failure of the biolocontrol of pests is the poor host recognition and emigration of pesticides (Heimpel and Asplen, 2011). Very well familiar that natural enemies depend on the number of chemical cues including kairomones in all the activities during foraging. So, use of kairomones in the field can increase the host searching capacity and retention in the field. Some successful examples field application of kairomones against parasitoids are described below

Application of HIPVs and OIPVs in the field recruited the natural enemies against various species of herbivores have been reported in different experiments and very well reviewed by Ayelo et al., 2021. Methyl salicylate (MeSA), a volatile compound released when stressed by herbivore naturally. When this MeSA applied in the using dispersers in the soyabean and cranberry field resulted in the attraction and retention of natural enemies (e.g., Rodriguez-Saona *et al.,* 2011; Mallinger *et al.,* 2011). When kairomone formulation based on kaolinite-clay used in the tomato filed highest parasitism of *T. chilonis* was observed nearly upto 48% where in the control plot it is only 17% (Paramasivam and Paul, 2005). Nearly 78% of parasitism of *T. chilonis* was observed when the kairomonal mixtures are impregnated into the rubber septa (Bakthavatsalam and Tandon, 2006). Application of by-products of herbivores also found to have positive impact in attraction of natural enemies. Spraying of kairomones made from *Cnaphalocrocis medinalis* frass on rice plants in the field boosted *Apanteles cypris* parasitization on *C. medinalis* by 15–25% (Hu and Chen, 1987). It has been reported that fields sprayed with molasses (3 %) along with kairomones caused an increase in parasitization of *Meteorus rubens* on *Agrotis ipsilon* (Zaki *et al.,* 1997). Increase in efficiency was observed when parasitoids are released in the filed after the application of kairomones. In the rice field, when the three kairomones such as n-hexadecanoic acid (200ppm), n-octadecanoic (500ppm) and octadecane (500ppm) applied individually from 39 DAT- 60DAT, followed by release of *T. japonicum* reduced the damage by yellow stem borer (YSB), *Scirpophaga incertulas.* Highest reduction in damage by YSB was observed with application of octadecane at 500ppm (Murali-Baskaran *et al.,* 2021).

CONCLUSION:

The key to effective biological control is to attract and establish the natural enemies in the target sites. The numerous positive instances provided above imply that there is much scope for kairomone application in biocontrol. Thus, during the past several years, the application of kairomones has been seen as an innovative strategy for luring in and keeping natural enemies in the target area. The use of kairomones in the field requires a great deal of investigation. Further research can be focussed on identification and synthesis kairomones specific to target natural enemies. Studies on identification of genes responsible for kairomones can be of greater importance in the near future. So that transgenic crops using the trait responsible for kairomone production can be developed which attracts the natural enemies and control the pest in the initial stage itself. This can considerably reduce the use of pesticides, which promotes environmental safety.

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INDIA'S GREEN PROVISIONS: GREEN WAYS FOR GREEN ENVIRONMENT

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ABSTRACT:

In recent times, environmental degradation such as ozone layer depletion, global warming and climate change and loss of biodiversity are one of the major and serious issues the entire world is facing. Deforestation, environment pollution, killing of animals and using the natural resources excessively have become natural and regular phenomena that have brought the threat to annihilation of all living beings on earth because trees, water, air, soil and other natural resources are fundamental requirements for survival of all forms of life. This paper deals with the status of forests in India from ancient to modern periods and various environmental protection law or Acts and policy made by Indian Government for protection and improvement of environment as constitutional responsibility of every Indian citizen. Additionally, the Indian constitutional aspects related to environmental protection kept in reference while formulating and launching the welfare scheme "JanVan yojana" for people of Jharkhand by state government. Ancient Indian texts like *Arthasastra* and *Vedas* reflected the concepts of forest ecology and conservation in a sustainable manner. In the Indus valley civilization, several characteristics of the city planning and social structure showed environmental awareness. The sacred groves (*Tapovana*) of India were rich in biodiversity and ecological wealth, which mentioned in ancient Indian documents like *Abhigyan Shakuntalam.* In the Medieval period, during the Mughal period large portion of forests was cleared because forests provided shelter to dacoits, anti-social elements and insurgents for tactful administration. Though they also contributed in forest conservation by establishment of gardens, green parks, Central and provincial headquarters, Public places. In modern India, environmental Jurisprudence has gone a

long way in acquiring a very seminal importance leaving behind the engraved British Juristic notions as out dated and insufficient. Unfortunately in the initial phase of judicial response to the problems of environment has been of insensitivity and apathy towards environmental issues and problems. In 1865, the first Indian Forest Act was passed by the Supreme Legislative Council in England, which paved the way for exploitation of forest resources followed by a Forest Policy was formulated in 1884 by the British Government for promoting the general well being of the people and, preserving climate and physical conditions of the country. The Indian Forest Act, 1927, was passed to consolidate the existing laws relating to forests, the transit of forest produce and the duty leviable on timber and other forest produce. After independence in 1947, India was experiencing an acceleration of forest loss, and appeared increasingly unable to provide for rural, subsistence needs. Therefore, India's new National Forest Policy was evolved and declared on 12th May 1952. In 1972, United Nations Conference on the Human Environment in Stockholm, Sweden, was the first-ever UN conference with the word "environment" and provided the first global set of principles for future international cooperation on environmental issue. To comply with the principles of the Stockholm Declarations, the Government of India, by the Constitution 42nd Amendment Act, 1976 made the express provision for the protection and promotion of the environment. In the 7th Schedule by the 42nd Amendment, the subject 'forests' originally was in the State list moved to the concurrent list. Keeping all these constitutional laws and acts in views, the state Government of Jharkhand in 2016 has launched a scheme "Jan Van Yojana" with some objectives and components. The component of the yojana will ultimately leads in the balance of environment by increasing the green cover, conservation of the underground water, reduce soil erosion, reduction in greenhouse gases, increase farmer's income as well as employment generation. Therefore, it can be concluded that the proper implementation of the yojana will fulfill the constitutional law made for maintaining the environment and right for clean environment for humanity.

KEYWORDS: Forest, Ancient to modern period, Indian Constitutional Law, JanVan Yojana, Jharkhand

FOREST:

The word "forest" or "forests" is derived from the old Latin word "*foris*", which means outside. In later Latin this became "*forestis silva*" which literally meant "wood outside". The Oxford English Dictionary defines forests as, "An extensive tract of land covered with trees and undergrowth, sometimes intermingled with pasture (in proper names also a district formerly

forest but now cultivated); and the trees growing in such a tract". A forest is best defined as an ecosystem or assemblage of ecosystems dominated by trees and other woody vegetation.

According to United Nations Food and Agriculture Organization (FAO)[1], A forest is defined as "Land with tree crown cover (or equivalent stocking level) of more than 10 % and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. May consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground; or open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 %. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 % or tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention or natural causes but which are expected to revert to forest".

At present, in India, there is no clear nationally-accepted definition of 'forest'. States are responsible for determining their definition of forests. The prerogative of the states to define forests stems from a 1996 Supreme Court order called the T.N. Godavarman Thirumulkpad versus the Union of India judgment, where the debate over defining a forest came to the fore. One of the aspects of the judgement is related to the meaning of the word "forest". In the judgement, the Supreme Court interpreted that the word "forest" must be understood according to its "dictionary meaning". This description covers all statutorily recognized forests, whether designated as reserved, protected or otherwise.

Forests in Ancient period

The hymns in Atharva Veda (12.1.11) and (12.1.35) supposed to have been composed at around 800 B.C., somewhere amidst deep forests based on Conservation Principle "Let thy hills and snowy mountains, let thy forest-land, O earth, be pleasant; upon the brown, black, red, all-formed, fixed earth, the earth guarded by Indra- I, unharassed, unsmitten, unwounded, have stood upon the earth"[2] and Utilization and Regeneration Principles "What of thee, O earth, I dig out, let that quickly grow over; let me not hit thy vitals nor thy heart, O cleansing one"[3], respectively. The book *Arthasastra* written by Chanakya (the minister of Chandragupta Maurya, 321-297 BC) is a treatise on government and economics of ancient India describe the importance was given on the protection and management of forests, gardens, orchards as these all were considered as sources of revenue, besides being of recreational spots[4].

Around 10,000 years ago, mankind began to establish permanent settlements by adopting an agrarian way of life leads to the population expansion vastly. During Vedic period Hindu tradition describes three basic categories of forests *viz.,* Mahavan, the great natural forest where

all species of life find shelter; Tapovan, where one could contemplate as the sages did and seek after truth and Shrivan, the forest which provided prosperity[5]. In *Vrikshayurveda's* chapter "Bijotpatti Kanda" describes the forest ecosystems. Forests were referred by different names like "atavi", "bipina", "gahana", "kanana", "bana", "aranyani" etc. The books described forests where trees, shrubs, creepers and grasses grow naturally. Classification and characterization of woodlands were done according to their location and natural surroundings[6].

The Indus Valley Civilization (Bronze Age civilization; 3300-1300 BC) shows several characteristics of the city planning and social structure showed environmental awareness but it was the environmental change which was probably the main reason behind the fall of this civilization. In many coins and seals in Harappa there were a variety of animals including elephants, rhinoceroses and tigers. But at present, there is no forest area in Harappa and Mahenjodaro, which can indicate the changes in climatic conditions. However, in the seal of "Pashupati", a man was encircled with animals proved that they often went to the forest to spend a part of their life[7]. Natural resources is observed that they have been degrading since 5000 B.C. and the unprecedented pace of their erosion is the root cause for the present environmental uncertainties. The over-exploitation of natural resources by an ever growing population has resulted in various problems, such as land degradation, vegetation loss, pollution and so on. Such problems need to be addressed seriously using traditional knowledge, a proven treasure for natural resource management as the main basis. One of the major concerns in this endeavor is to rehabilitate the degraded and vulnerable land and water resources characterized by soil erosion, soil acidity, salinity, alkalinity, water logging, water depletion, water pollution etc, and also to ensure a sustainable livelihood support for the rural population in the country.

Forests in Medieval period

In the Medieval period, during the Mughal period (1526-1700) large portion of forests was cleared because forests provided shelter to dacoits, anti-social elements and insurgents. Frequent change of political bodies coupled with the pressure of burgeoning population and livestock, clearance for agriculture led to large scale destruction. The only abiding feature was that some forests were reserved for game- hunting, gardens and recreation. They did not have any definite policy to protect the forests or wildlife. Forest meant not more than wooded lands for mughals where they could hunt and properties which yielded some revenue. There was no restriction on cutting of trees except 'Royal trees' which enjoyed patronage from being cut except upon a fee. Though there have been instances of establishment of nature parks, gardens and fruit orchards by the Mughal rulers around their palaces and banks of rivers as well as canal bank plantations were also started in some regions.

Additionally, the religious policy of Akbar based on principle of complete tolerance also reflects concern for protection for birds and beasts in so much so as endeavors were taken during his reign to stop their unnecessary killing. In the sunned of emperor Akbar it is directed "that on both sides of the canal down of Hissar, trees of every description, both for shade and blossom be planted so as to make it like the canal under the tree in paradise and that the sweet flavor of the rare fruits may reach the mouth of every one, and that from those luxuries a voice may go forth to travelers calling them to rest in the cities where their every want will be supplied". Subsequently, however, destruction and mismanagement of forests started with the invasion of India by foreign powers. The tempo of deforestation and wanton destruction which increased during the mughal period reached its peak during the British regime.

From Abu'l Fazl and other sources of the Mughal period it is assumed that in spite of the reclamation of land for agriculture many parts of India, particularly Eastern India were still heavily forested and contained wild animals. It ought to be remembered that direct statements can often be supplemented by inferential evidence derived from information such as on locations of hunting grounds or haunts of wild animals. These incidental details tell us much about the extent of forest and even of forest types. For example, wild elephants obviously indicate the proximity of a dense forest while wild cheetahs imply the presence of grass lands and scrub[8-10]. Since five thousand elephants were kept in Emperor Akbar's establishment alone[11], and his nobles were ordered to maintain another 7,709 elephants under the conditions of the personal or Zat ranks[12], it is obvious that there were dense forests in India in Mughal period.

Forests in Modern period

The advent of British rule significantly changed the perception of environment in India. The early days of British rule marked large-scale plunder of natural resources from India. Forest resources were the major casualties. The first Indian Forest Act(1865) was passed by the Supreme Legislative Council in England, which paved the way for exploitation of forest resources in a legitimate manner. In 1884, a Forest Policy was formulated by the British Government with the objectives of promoting the well being of the people and, preserving climate and physical conditions of the country[13].

The Indian Forest Act 1927

The Indian Forest Act, 1927, was a very comprehensive Act including all earlier amendments and major provisions of the Acts enacted before 1927[14]. It was passed with an objective to consolidate the existing laws relating to forests, the transit of forest produce and the duty leviable on timber and other forest produce. It also consists of the procedure followed in cases of declaring the area to be a reserved, protected or a village forest. The Act is divided into

13 chapters with a total of 86 sections ranging from the definition of various forests to the penalties that are to be levied on the violation of the provisions of the Act. The term 'forest' has a wider ambit when it comes to its definition as it includes private lands, lands for pasture, cultivable lands etc. and so the Supreme Court is yet to assign a particular interpretation and thus the Act is silent on the definition of a forest or a forest land. This Act established reserved forests, protected forests and village forests.

Although the Act aimed towards the forest conservation and its forest produce duties, it failed miserably in meeting its objective. The essence of the Act was lost when the Government regained the control of these forests so that the revenue can be generated from the forest produce. Eventually, the Act could not serve its purpose that is to avoid the exploitation as earlier the people were exploiting the forests and now it was the government in power to regulate and prohibit the usage of the lands. The Forest Act, requires amends in matters where the focus should be shifted towards conservation and enrichment of sustainable use of the forest resources to safeguard the ecological stability as was proposed in the amendment bill of 2019 for bringing changes in the Act of 1927.

The Forest Policy 1952

After independence in 1947, India was experiencing an acceleration of forest loss, and appeared increasingly unable to provide for rural, subsistence needs. Therefore, the need for a new forest policy was felt. Thus, to incorporate the changed conditions, the Board of Forestry, Government of India, formulated a national forest policy in consultation with the State governments. A resolution No. 13-1/52F was adopted and India's new National Forest Policy was evolved and declared on 12th May 1952[15].

Stockholm Convention & Declaration, 1972[16]

The 1972 United Nations Conference on the Human Environment in Stockholm, Sweden, was the first-ever UN conference with the word "environment" in the title. It provided the first global set of principles for future international cooperation on environmental issue. Stockholm began a new era of global cooperation to search for solutions to reconcile economic development and environmental management and paved the way for the concept of sustainable development. The conference acclaimed man's fundamental right to adequate conditions of life in an environment of a quality that permitted a life off dignity and well-being.

At Stockholm Conference, Mrs. Gandhi, the then Prime Minister of India, emphasized on the preservation of natural resources of the earth including the air, water, land flora and fauna and ecosystem for the benefits of present and future generations through careful planning or

management and estimated the nation's commitment to safeguarding and protecting the environment.

42nd Amendment Act, 1976

To comply with the principles of the Stockholm Declarations, the Government of India, by the Constitution 42nd Amendment Act, 1976 made provision for the protection and promotion of the environment, by the introduction of Article 48-A and 51- A(g) which form the part of Directive Principles of State Policy and the Fundamental Duties, respectively[17]. In Article 48-A: By Constitution (42nd Amend) Act, Sec.10 (w.e.f. 3.1.1977) Protection and improvement of environment and safeguarding of forests and wild life: "The State shall endeavour to protect and improve the environment and to safeguard the forest and wildlife of the country". In Article 51-A(g): By Constitution (42nd Amend) Act, Sec.11 (w.e.f. 3.1.1977) "It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures". Thus the Indian Constitution makes two fold provisions i.e. it gives directive to the State for the protection and improvement of environment and the citizens owe a constitutional duty to protect and improve natural environment.

The constitutional changes effected in the 7th Schedule by the 42nd Amendment Act, 1976 is a milestone steps, in the direction of the protection of environment. The subject 'forests' originally was in the State list as entry 19, resulted into no uniform policy by the State so as to protect the forests. By placing the item 'forest' now in the concurrent list by the entry 17-A, along with the State, Parliament has acquired a law making power[18].

Forest Conservation Act (1980)[14]

This Act was again not subservient to the needs of the tribes, though it aimed at changing the existent commercialization of forest. The Forest Conservation Act 1980 provided for: i) the strict restriction of wanton destruction of forests for developmental purposes by the State Governments and ii) People were restricted from changing the forestland or any section of land for agriculture or other productive purposes. The Forest Conservation Act 1980 was further amended in 1988.

National Forest Policy 1988[5]

The Government of India in 1980 set up the Ministry of environment and Forests and the government has adopted the new National Forest Policy in 1988. For the first time in the history of forest legislation, this policy focused its attention on increasing the forest over in the country through effective means like afforestation programmes and social forestry. The forest policy of 1988 has tried to uphold the tribal needs and at the same time maintain the ecological balance

and meet the economic needs of the villagers residing in the forest area. Forest legislation has today come a long way ever since the British showed their first interest in forestry, which was undoubtedly dictated by imperialist consideration. The overall needs of the rural communities in general and tribal in particular have not actually taken centre stage in all these legislations and the goals of forestry legislations both in the colonial and post-colonial period have not been realized.

Indian Forest (Amendment) Act's 2019[18]

The Indian Forest Act, 2019, was envisaged as an amendment to the Indian Forest Act, 1927, and an attempt to address contemporary challenges to the country's forests. The amendment defines community as "a group of persons specified on the basis of government records living in a specific locality and in joint possession and enjoyment of common property resources, without regard to race, religion, caste, language and culture". Forest is defined to include "any government or private or institutional land recorded or notified as forest/forest land in any government record and the lands managed by government/community as forest and mangroves, and also any land which the central or state government may by notification declare to be forest for the purpose of this Act." The amendment has increased the focus to "conservation, enrichment and sustainable management of forest resources and matters connected therewith to safeguard ecological stability to ensure provision of ecosystem services in perpetuity and to address the concerns related to climate change and international commitments". The amendments say if the state government, after consultation with the central government, feels that the rights under FRA will hamper conservation efforts, then the state "may commute such rights by paying such persons a sum of money in lieu thereof, or grant of land, or in such other manner as it thinks fit, to maintain the social organization of the forest dwelling communities or alternatively set out some other forest tract of sufficient extent, and in a locality reasonably convenient, for the purpose of such forest dwellers". The amendment also introduces a new category of forests - production forest. These will be forests with specific objectives for production of timber, pulp, pulpwood, firewood, non-timber forest produce, medicinal plants or any forest species to increase production in the country for a specified period. The proposal to amend the Indian Forest Act was rejected after a consultative meeting of all stakeholders, including representatives of political parties, civil society organizations and officials.

Jan Van Yojana, social forestry on private land: salient features

In year 2016, the Government of Jharkhand has launched a welfare scheme "Jan Van Yojana" [20]. The major objectives of the scheme is to increase the green cover and maintain the environmental balance, conservation of the underground water by plantation, to reduce the

pressure on notified forest by planting the trees in the private land, to increase the farmers income as well as to increase forest cover in the state by peoples participation[21]. Under the scheme, there is a provision of planting timber plant species *viz.* Rosewood, Teak, Ghamhar, Mahogany, Clonal Eucalyptus and Acacia with 3 m x 3 m plant to plant distance for block plantation on the ridge at a distance of 2 m x 2 m in 30 cm x 30 cm pits. Whereas, fruit crop plant species *viz.* Kalmi Mango, Guava, Gooseberry, Litchi, Jackfruit and Beal are planted in a pit of 60 cm x 60 cm at a distance of 5 m x 5 m only in block plantation fashion. The plantation is made in block plantation or linear afforestation on the ridge of the field. In one acre of land a total of 445 plants of timber and 160 fruit plants can be planted. For a single beneficiary the minimum limit of planting area is 0.5 acres and the maximum limit is 50 acres. 75% of the cost incurred over the plantation and maintenance of the planted trees are borne by the State Government/Forest Department for the first 3 years of the plantation.

Constitutional Justification of Jan Van yojana

India's constitution has recognized the value of maintaining and managing environment from the very beginning. Accordingly, protection and improvement of environment is a constitutional responsibility cast on every Indian citizen, the state government and the central government. Under the constitution, three important subjects concerning environment namely, water, land and gas are placed in state list of seventh schedule of the constitution as item 17, 18 and 25 and moved 'forest' in the concurrent list from the state list. Under article 48, protection and improvement of environment has been identified as state responsibility. This article provides that the state shall endeavour to protect and improve the environment and to safeguard the forest and wildlife of the country. "The quality of environment has an important bearing on the right of life under article 21 relating to fundamental rights"[22].

Under article 249, Parliament can legislate on the matters of "national interest". Two major and vital environmental laws namely, The Air [Prevention and Control of Pollution] Act of 1981 and The Environmental [Protection] Act 1986, has been enacted under these constitutional provisions. Article 51A (g) imposes a fundamental duty of the Indian citizen to protect and improve the natural environment including forests, lakes, rivers and wildlife. The constitution enjoins upon the state to secure a social order for the promotion of the welfare of the people in which justice, social, economic and political shall inform all the Institutions of national life (article 38). It also requires the state and the citizens to protect and improve the natural environment (article 48A and 51A). These provisions cover aspect both of development (and livelihood) as well as protection and development of environment and natural resources. Eleventh schedule of the constitution is added by 73rd Amendment Act, this schedule has 8

entries (2, 3.6.7, 11, 12, 15 and 29) providing for environmental protection and conservation. Further, the 73rd and 74th Amendments gave constitutional backing to democratic decentralization and community-based natural resource management and so has the Panchayats (Extension to the scheduled Areas) Act, 1996.

Keeping all these constitutional laws and acts in views, the state Government of Jharkhand has launched a scheme "Jan Van Yojana" with five major objectives to increase the green cover, maintain the environmental balance, conservation of the underground water by plantation, to reduce the pressure on notified forest by planting the trees in the private land as well as to increase the farmers income. The component of the yojana i.e. plantation of fruit and timber yielding plants species on private land of the approved beneficiaries, will ultimately leads in the balance of environment by increasing the green cover. The plantation of different ascribed plant species will also helpful in the conservation of the underground water, reduce soil erosion, reduction in greenhouse gases, increase farmer's income by increasing the scope of fruit and timber yielding industries as well as in employment generation. Therefore, it can be concluded that the proper implementation of the yojana will fulfill the constitutional law made for maintaining the environment and right for clean environment.

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PHYTOREMEDIATION – A SUSTAINABLE WAY TO RECLAIM MINED OUT LAND IN JHARKHAND

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ABSTRACT:

Mining is an inevitable requisite for the modern industrialization and urbanization.The physical, chemical and biological characteristics of the soil is changed irreversibly by the mining processes, and therefore, the revegetation of minedout areas through natural process takes a very long time and poses a major problem because nutritionally it becomes a recalcitrant medium for plant growth. Jharkhand is one of the leading states of India in the mining of coal and various other raw minerals. But the dark side of this prideful condition is that it has led to the deforestation and loss of the floral and faunal biodiversity leading to the deterioration of the ecosystems and environment as a whole. We have reviewed various methods of bioremediation techniques and the plants as the source of remediation for reclaiming and restoring mined out lands in Jharkhand.

KEYWORDS: Jharkhand, remediation, mining, reclamation

INTRODUCTION

Over centuries, human industrial, mining and military activities as well as farming and waste practices have contaminated large areas of the world with high concentrations of heavy metals and organic pollutants. In addition to their negative effects on environment and other natural resources, these sites pose a great deal of threat to public health, because pollutants can enter food through agricultural produce or leach into drinking water.

With the development of industrialization and urbanization, the abundance of heavy metals in the environment has increased enormously during the past decades, which raised significant concerns throughout the world (Suman et al., 2018; Ashraf et al., 2019). Heavy metals are classified as a group of metallic chemical elements that have relatively high atomic weights, atomic numbers as well as high densities. The common heavy metals/metalloids are

cadmium (Cd), mercury (Hg), lead (Pb), arsenic (As), zinc (Zn), copper (Cu), nickel (Ni), and chromium (Cr).

Different Mining Methods and their Impact on Environment

- **Open Pit Mining**

Open-pit mining is one of the most common forms and as well as one of the most damaging ways of mining. Miners hollow out a section of land, digging down to form an extractable area and extract valuable raw minerals.

Figure 1: Open pit mining (source: get-green-now.com)

The large pits are left behind in the earth and can be a cause of contamination for the groundwater with chemicals used in the mining process. If rehabilitation and restoration of the land is not done, it will remain vulnerable to further soil erosion and scattering of topsoil which is definitely not suitable for plant or animal life. Without human intervention and action, it may take years or decades for the land to become usable again.

- **Underground Mining**

Underground mining is the process where miners form tunnel beneath the Earth's surface to extract mineral deposits, is lesser used method than open-pit mining and has relatively smaller extent of an impact on the physical nature of the surface. However, this doesn't mean that underground mining doesn't have an effect on the environment. In fact, itsimpact on environment is quite large.

With this mining method, rocks and minerals are exposed to the surface from tunnels underground. There, toxic chemicals in the waste material can escape into the environment and local water channels if not properly and carefully disposed of. Underground mines can alleviaterisk of subsidence on the surface i.e., the land above begins to sink, usually when

underground supports collapse in closed or inactive mines. This can damage buildings, destroy infrastructure and harm the surface environment.

Underground mining can also sometimes lower the water table of the area. If miners need to dig through an aquifer or water-covered layer of earth, water will need to be pumped out of the mine for work to continue. This dewatering can dry up springs, cut off rivers thereby degrading the local ecosystems.

Some studies even suggest that while underground mining typically has less of a surface impact than the open-pit process, it may have a regressive effect on the environment overall.

- **Other Mining Methods**

Some mining techniques — like in-situ leaching uses acid and water to remove minerals from a site without significantly disturbing the surface. These processes have much less environmental impact as compared to the previous techniques. In-situ mining techniques can use less water than open-pit mining and underground mining, and also diminish the risk of releasing ore dust into the atmosphere.

However, even low-impact mining techniques like in-situ mining aren't free from consequences. The strong acids used to break down ore and rocks can add on to the acidification of the surrounding environment. The acids can also dissolve the other metals and radioactive isotopes in these ores during the leaching process, both of which can contaminatethe nearby water sources.

Jharkhand- the mining hub of India

Jharkhand is located in the eastern part of India having abundant treasure of natural resources. The state shares its borders with five states namely West Bengal in the east, Uttar Pradesh and Chhattisgarh in the west, Bihar in the north and Odisha in the south. In India, Jharkhand is one of the leading states in terms of economic growth. At current prices, Jharkhand's gross state domestic product (GSDP) stood at Rs. 3.63 trillion (US$ 48.63 billion) in 2021-22E. Jharkhand is one of the richest mineral zones in the world harbouring 40% and 29% of India's mineral and coal reserves, respectively. Due to its large mineral reserves, mining and mineral extraction are the major forms of industries in the state. Mineral production (excluding fuel minerals, atomic minerals and minor minerals) in the state contributed Rs. 10,172.47 crore to the economy (US$ 1.38 billion) in FY21 (until January 2021).

Jharkhand is rich in mineral resources viz. coal (27.3% of India's reserves), iron ore (26% of India's reserves), copper ore (18.5% of India's reserves), uranium, mica, bauxite, granite, limestone, silver, graphite, magnetite and dolomite. Jharkhand has the sole state status in India to produce coking coal, uranium, and pyrite. The State occupies 1st position in coal

reserves, 2nd position in Iron (25.7% of the total hematite reserves), 3rd position in copper ore reserve and 7th position in Bauxite reserve, signifies its status as mineral rich state. Limestone, Dolomite, Manganese, Mica, China Clay, Graphite, Soap stone, Fire Clay, Coal Bed Methane, Uranium, Phosphorite, Apatite, Quartz, Feldspar, Gold and Pyroxenite are in the list of other important minerals which are available in huge quantities in State and provide raw materials for various industries.

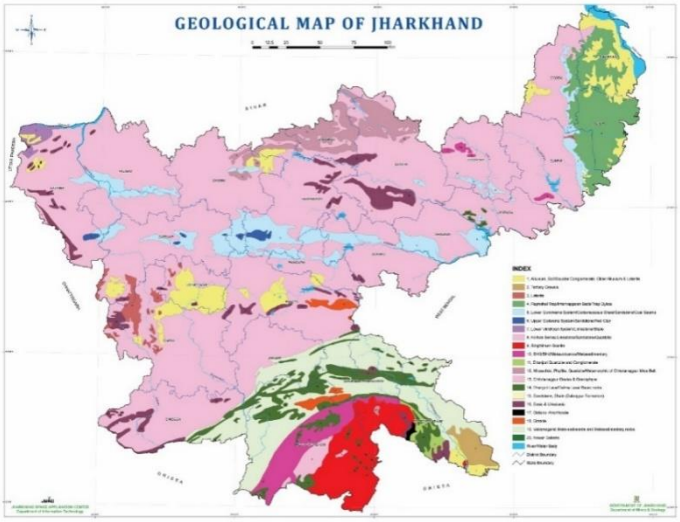

Figure 2: Geological map of Jharkhand (Department of Mines & Geology, GoJ)

To make mining possible, several forests are clearedup for the purpose leading to deforestation. The vegetation is cleared in order to build the mining facility and laying required infrastructures. These forests are home to several organisms and animals.With the act of deforestation, these organisms and animals lose their natural habitat.So, they start migratingto a new habitat in order to survive.However, most organisms and animals do not respond very well this change and end up losing their survival capability. The biodiversity of the region is lost in this process. A number of smaller plants and creepers that grow with the support of the trees also disappear due to deforestation. Every single forest in the world is a biosphere of its own. It is impossible to create a biosphere artificially as the various processes and inter- dependence of organisms is too complicated to replicate. In addition, mining causes a lot of pollution (air, water, land) as a lot of chemical waste spread and accumulate due to various processes involved. This waste is released into water bodies, rivers and sea. The chemical composition of the soil also changes in the mining area which becomes converted into a desert- like environment where growth of anything is impossible.

A Sustainable Mining Attractiveness Index (SMAI) developed by a Delhi based Centre for Social and Economic Progress (CSEP) has revealed that the best performing districts in terms

of mining activities among the 24 districts of Jharkhand ranked lowest on environment parameter while the lowest ranked districts in terms of mining ranked among the top 10 on the environment pillar. This fact points that mining is an inevitable evil in a state like Jharkhand and steps should be taken to restore environmental health which ticks every box of parameters of healthy environment.

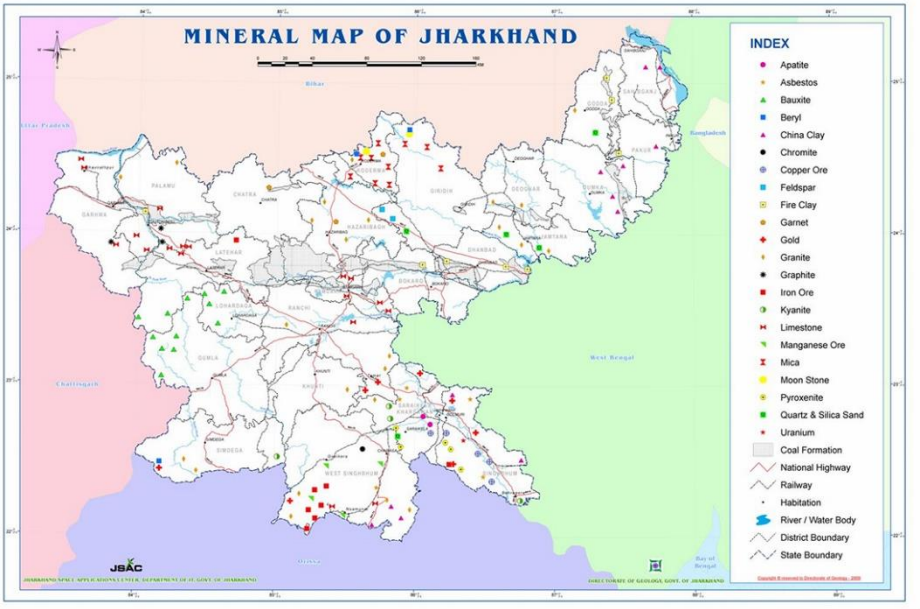

Figure 3: Mineral map of Jharkhand ((Department of Mines & Geology, GoJ)

The index, which is in alignment with the principle of environmental and social responsibility in mining emphasised in the National Mineral Policy 2019, indicate the need to push the drive for community development and environmental conservation, especially in the context of numerous controversies surrounding the mining sector.

Figure 4: Mined out area

PHYTOREMEDIATION- Sustainable way for reclaiming mined out land

Phytoremediation term is derived from two generic terms including ‘phyto’ means plant and ‘remediation’ means reversing or stopping environmental damage. Phytoremediation is not a term for single methodology but an assembly of technologies, using a group of plants for remediation of soils, water, sludge which get sediment with different types of inorganic and organic contaminants.

Phytoremediation comprises technologies that make use of higher plants to clean up and revegetate contaminated sites (Pulford and Watson, 2003; Adriano *et al*., 2004; Robinson *et al*., 2009). Many techniques and applications are included in the term phytoremediation, which basically differ in the process utilized by the plants to remove, immobilize, or degrade contaminants from the surroundings.For example, the process in which plants are used to extract inorganic or organic contaminantsfrom soil and water and store them in harvestable tissue is called phytoextraction, rhizoextraction,or phytofiltration. Similarly, the technique in which plants are used to remove contaminants through volatilization is called phytovolatilization (Moreno *et al*., 2005). In phytostabilization, inorganic contaminants such as heavy metal (loid)s in the soil are immobilized, thereby minimizing their transport and accumulation in water or dust. This technology may enhance the degradation of organic contaminants such as pesticides and hydrocarbons via microbialactivity associated with the plant roots that aids to the transformation of these contaminants into nontoxic forms (Berti and Cunningham, 2000).

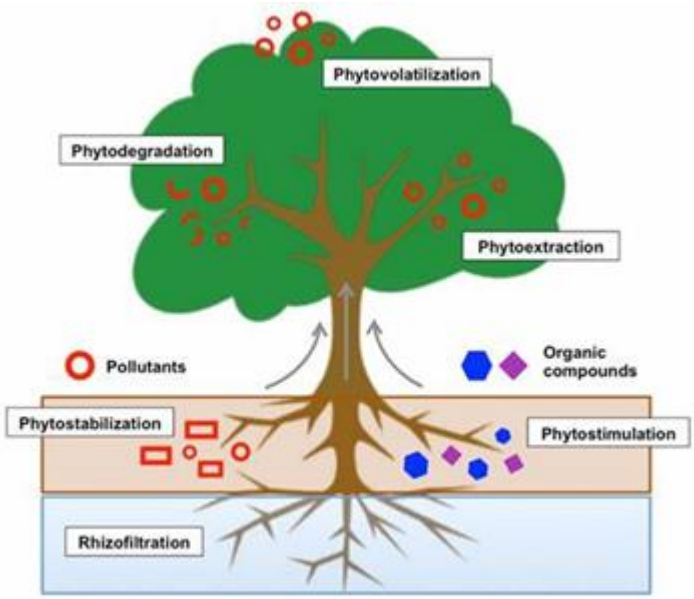

Figure 5: Various techniques of phytoremediation

Phytoremediation is an emerging, costeffective, sustainable, and environment friendly technology that uses plants and associated microorganisms to clean up pollution of soil, water,

and the atmosphere. This technology provides passive protection using vegetation barriers, cleaning of soil and water through pollutant extraction and harvest, and pollutant degradation and volatilization.

Currently the quality of soil has been degraded remarkably due to continuous utilization of huge and irrational quantities of synthetic fertilizers and agricultural malpractices. In addition, other factors such as natural disasters and industrialization are also responsible for dispensing toxic metals into the soil and thus degrading its quality (Raven and Leoppert, 1997). Both organic and inorganic pollutants are culprits for the deterioration in the health of soil. Among organic pollutants, trichloroethylene, herbicides (Burken and Schnoor, 1997), explosives such as trinitrotoluene (Hughes *et al.,* 1997), hydrocarbons (Schnoor *et al.,* 1995) and fossil fuels and methyl tertiary butyl ether are the leading polluting agents (Hong *et al.,* 2001).

Phytoremediation has turned out to be a transpiring technology that has overshadowed earlier utilized physical and chemical technologiesfor soilreclamation, particularly because of its economic, industrial and commercial benefits.Phytoremediation is an eco-friendly, cost-effective in situ bioremediation method by which plants can accumulate, sequester, or degrade contaminants from soil by their innate capabilities. Phytoremediation methods have been successful in remediating contaminated industrial environments (Macek *et al.,* 2000; Suresh and Ravishankar, 2004).

RECLAMATION PROJECTS IN JHARKHAND

- The opencast mine in Jharkhand at Piparwar was once the largest coal-producing mine in the state and had devastated the local ecology. Now, after about 30 years of mining operations, the state-run Central Coalfields Limited (CCL), is ready to carry out reclamation and restoration process in a part of the original mining area, to make it suitable for public use.

  Of the total leasehold area of 1,120.25 hectares, the quarry area of the mines was 540 hectares. Out of these 540 hectares, reclamation work is being done in about 272 hectares area which includes plantation of tree species in the majority of this area, development of a small eco-park (*KayakalpVatika*) and establishment of a few water bodies.

  Environmental experts welcomed the reclamation process so far done but had cautioned and stated that the company should go for a proper plantation process involving local species.
- In Lohardaga district, the company HINDALCO recently completed some of the mining leases at Pakhar and Bagru plateaus and started back filled process with laterite, morrum

and normal soil layer at the top. Both of these plateaus are situated just 30 to 35 kms away from the district head quarter Lohardaga. After backfilling the mine areas, rehabilitation and restoration through afforestation activities will be carried out and finally handover to the concern owners.

As per the direction of Indian government's environment ministry, mining companies will be required to carry out re-grassing in the mined-out areas to make them suitable for the growth of flora and fauna once the mining activity is complete. The said direction of the Ministry of Environment, Forest and Climate Change (MoEFCC) came after a Supreme Court order earlier this month, on January 8, 2020. The decision has now become part of the conditions specified by the ministry while giving forest clearance.

The environmental impact of seed sowing of the grass species would be the stabilization of the soil through their root formation. Grasses have fibrous roots, which binds the soil and their sod forming tendencies eventually produce a layer of organic soil with good amount of humus. Germination of grasses is very useful in restoring the slopes of mine areas since it stabilizes soil, preserves soil moisture and may compete with and restrict weedy species. This initial cover must be an aid to the development of diverse, self-sustaining plant communities.

PLANT SPECIES THAT CAN BE USED FOR REMEDIATION

Figure 6: *Leucaena leucocephala* (Subabul)

1. ***Leucaena leucocephala*** **(Subabul)**

Various researches have shown that*Leucaena* could be a possible tool in biological remediation of coal and metal mine tailings, tannery and dye pollutants, waste oil pollutants, lagoon ash, fly ash, textile waste, and heavy metal contaminated soils (Cheung et al. 2000;Gupta et al. 2000;Song et al. 2005;Bisht et al. 2011;Jayanthy et al. 2014;Edwin-Wosu and Nkang 2016;Ssenku et al. 2017).It can be used to uptake, store, and to some degree, tolerate heavy metals such as arsenic, lead, chromium, cadmium, and nickel (Rout et al. 1999;Iqbal and Shazia

2004;Song et al. 2005;Shafiq et al. 2008;Sakthivel and Vivekanandan 2009;Dias et al. 2010;Ho et al. 2013;Adanikin and Kayode 2019).*Leucaena leucocephala* is a **small fast-growing mimosoid tree** native to southern Mexico and northern Central America (Belize and Guatemala) and is now naturally found in the tropics including parts of Asia. Common names include jumbay, white leadtree, river tamarind, ipil-ipil, tan tan, and white popinac.

2. **Indian mustard *(Brassica juncea L.) Info: Brassica juncea (L.) Czern.* – Indian Mustard**

Figure 7: *Brassica juncea* L. (Indian mustard)

Brassicaceae species have been found to be really useful in accumulating certain metals while producing high quantities of biomass in the process, and Indian mustard is the crown of this group and is a known metal hyperaccumulator (Kaur, 2018).It can remove three times more Cd than others, reduce 28% of Pb, up to 48% of Se, and it is effective against Zn, Hg and Cu as well (Chang *et al.*, 2005).

3. **Indian Grass (*Sorghastrum nutans*) (*Sorghastrum nutans* (L.) Nash)**

Figure 8: *Sorghastrum nutans* (Indian Grass)

Indian grass is one of the nine members of the Gramineae family identified by Phyto Pet (Bioremediation of Aquatic and Terrestrial Ecosystems), as capable to remediate petroleum

hydrocarbons. The list includes other grasses like Common buffalo grass or Western wheatgrass, leading the ranking.

Other species

Zizyphus jujuba, Pongamia pinnata, Acacia catechu, Acacia nilotica and Azadirachta indica, Syzygium cumini, Madhuca indica,T. bellirica and T. arjuna

It has been observed that the presence of leguminous forb, *Stylosanthes hamata*, and grasses *Pennisetum pedicellatum* and *Heteropogon contortus* in the experimental plots on flat and slopy areas of coal mining areas enhanced the natural colonization of a large number of plant species. (a) Trees and shrubs: *Butea monosperma*, *Melia azedarach*, *Woodfordia fruticosa*, *Grevea sp.*, and *Calotropis procera*, (b) Herbs and Grasses: *Hyptis suaveolens*, *Clitoria sp., Alternanthera sessilis, Ageratum conyzoides, Blumea oxyodonta,Desmodium triflorum, Apluda mutica, Abutilon graveolens, Sonchus oleraceus, Tephrosia purpurea, Alysicarpus longifolius, Phyllanthus varigatus, Aristida adscensionsis, Aristida cynatha, Vernonia cinerea, Launaea nudicaulis, Eragrostis tenella, Cynodon dactylon, Bothriochloa pertusa, Cyperus compressus, Evolvulus alsinoides, Tridax procumbens, Echinops echinatus, Aneilema nudiflorum, Saccharam munja*, etc. (Jha et al. 2000)

A combination of the various techniques of phytoremediation can be utilized for the reclamation and restoration of the mined-out land in a phase- wise manner. Use of native species should be emphasized for the process so that the ecologywhich was found previous to the mining can be restored. In addition, inoculation of plants with biological amendments such as arbuscular mycorrhizal fungi and improvement through genetic modifications (transgenic species) has also emerged as an effective remediation strategy for heavy metal contaminatedsoils. In aquatic environments, rhizo-filtration can provide a suitable alternative for uranium remediation.With the recent developments, phytoremediation has the potential to become an integral part of the management of contaminated environment and restoring it back to the level which is required for human and other life forms' survival in a sustainable way.

Table 1: Typical plants used in various phytoremediation application

(Source: Jerald L. Schnoor, Technology Evaluation Report (Oct 1997, Ground-Water Remediation Technologies Analysis Center)

Application	Media	Contaminants	Typical Plants
Phytotransformation	Soil,Groundwater, Landfill leachate, Land application of wastewater	Herbicides (atrazine, alachlor) Aromatics (BTEX) ·Chlorinatedaliphatics (TCE) ·Nutrients (NO3-, NH4+, PO43-) · Ammunition wastes (TNT, RDX	Herbicides (atrazine, alachlor) ·Aromatics (BTEX) ·Chlorinated aliphatics (TCE) ·Nutrients (NO3-, NH4+, PO43-) ·Ammunition wastes (TNT, RDX
Rhizosphere Bioremediation	Soil, Sediments, Land application of wastewater	Organic contaminants (pesticides, aromatics, and polynuclear aromatic hydrocarbons [PAHs])	Phenolics releasers (mulberry, apple, osage orange); ·Grasseswith fibrous roots (rye, fescue, Bermuda) for contaminants 0-3 ft deep; · Phreatophyte trees for 0-10 ft; · Aquatic plant
Phytostabilization	Soil, Sediments	· Metals (Pb, Cd, Zn, As, Cu, Cr, Se, U) · Hydrophobic Organics (PAHs, PCBs, dioxins, furans, pentachlorophenol, DDT, dieldrin)	Phreatophyte trees to transpire large amounts of water for hydraulic control; · Grasses with fibrous roots to stabilize soil erosion; · Dense root systems are needed to sorb/ bind contaminants
Phytoextraction	Soil, Brownfields, Sediments	· Metals (Pb, Cd, Zn, Ni, Cu) with EDTA addition for Pb Selenium (volatilization)	Sunflowers · Indian mustard · Rape seed plants · Barley, Hops ·Crucifers · Serpentine plants ·Nettles, Dandelions
Rhizofiltration	Groundwater, Water and Wastewater in Lagoons or Created Wetlands	· Metals (Pb, Cd, Zn, Ni, Cu) ·Radionuclides (137Cs, 90Sr, U) · Hydrophobic organics	Aquatic Plants: - Emergents (bullrush,cattail, coontail, pondweed, arrowroot, duckweed); Submergents-(algae, stonewort, parrot feather, Eurasian water milfoil, Hydrilla)

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