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Limnology

Volume II

Editors

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PREFACE

We are delighted to publish our book entitled "Limnology Volume II". This book is the compilation of esteemed articles of acknowledged experts in the fields of limnology providing a sufficient depth of the subject to satisfy the need of a level which will be comprehensive and interesting. It is an assemblage of up to date information of rapid advances and developments taking place in the field of water science, biodiversity, environmental science and allied subjects. With its application oriented and interdisciplinary approach, we hope that the students, teachers, researchers, scientists and policy makers in India and abroad will find this book much more useful.

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, Nigave Khalasa 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

CONTENT

WATER QUALITY MANAGEMENT IN AQUAPONICS SYSTEM

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Abstract:

The aquaponics system is the culture of fish and vegetable plants in the combined circulatory aquatic environment in that water quality plays an important role in the yield of the system and in the present study important water quality was evaluated to enhance the efficiency of an aquaponics system. This research was conducted in two different treatments which contain rohu and tilapia with tomato plants in 10 replications and simultaneously important water quality parameters including air temperature (°C), water temperature (°C), pH, dissolved oxygen (mg/l), electrical conductivity (mS/cm$^{-1)}$, total hardness (mg/l), total alkalinity (mg/l), ammonia (mg/l), nitrate (mg/l) and nitrite (mg/l) were analysed. The findings of the present study show the range of air temperature from 25.30 to 29.80 °C, water temperature from 25.45 – 27.86 °C and 25.85 - 27.83 °C, pH 7.39 – 7.63 and 7.40 – 7.64, dissolved oxygen 5.46 – 6.0 mg/l and 5.45 – 6.0 mg/l), electrical conductivity 222.38 – 229.63 mS/cm^{-1} and 220.75 – 228.75 mS/cm^{-1}, total hardness 578.25 – 635.75 mg/l and 581.25 - 633 mg/l), total alkalinity 110.5 – 118 mg/l and 107.25 – 119.75 mg/l, ammonia 0.001 – 0.003 mg/l and 0.001 – 0.002 mg/l, nitrate 0.05 – 0.07 mg/l and 0.05 – 0.07 mg/l and nitrite 0.03 – 0.05 mg/l and 0.04 – 0.06 mg/l) in T_1 and T_2 respectively. These water quality parameters were compared with optimum values referred to by different authors and found suitable for cultivation in the system.

Keywords: Aquaponics system, Water quality, Temperature, Ammonia and Nitrate

Introduction:

Water quality is an important requirement not only for aquatic production but also for agricultural production and it also helps to maintain high-quality and profitable products, which will have an impact on human health and wealth. Aquaculture is the potential and most important to improve the food and nutrition status of human beings and contribute to the economic components at all levels from household to the national level (Filipski and Belton, 2018) and changes in water quality will affect the development, growth, reproduction, and even mortality of cultured species (Barker *et al.*, 2009). However, food production resources are decreasing daily due to the overuse of water resources, resulting in water shortages (NFDB, 2009). A huge amount and appropriate quality water are required for aquaculture practices, so an innovative food production system like aquaponics would help utilize the nutrition level of natural aquatic ecosystems and viable options to save land and water (Taufik, 2012). Aquaponics is the combination of culture systems including aquaculture and plant cultivation in water circulation using the nutrients from aquaculture effluents to survive the plants (Zidni, 2013; Yildiz *et al.*, 2017; Goddek *et al.*, 2019). It is one of this century's most important and efficient environmentally sustainable farming methods (Somerville *et al.*, 2014; Oladimeji *et al.*, 2020). Plants may grow in the absence of soil by using natural fertilizers produced by nitrifying bacteria during the nitrification process. The nutrient-rich fish water is used for plant growth, while the plants serve as biofilters for water purification (Estim and Mustafa, 2010). The nitrogenous contents in the simple form are converted by plants, fishes, and bacteria which help to grow these food components (Rockey, 2006; Tyson *et al.*, 2011). Similarly, the importance of water quality in aquaponics management was described by Hasan *et al.*, (2017), Stiadi *et al.*, (2018) and Osman *et al.*, (2021). The dissolved nutrients and water quality are essential for fish survival and plant growth. The main objective of the current work was to determine and compare different water parameters in floating raft aquaponics systems for better growth of fish and plants.

Material and Methods:

The study was carried out in circular fiber tanks (400 liters) for 60 days at the aquaponics unit at the Department of Aquaculture, College of fisheries (MPUAT), Udaipur. The research work was conducted in 2 groups considered T_1 and T_2 and stocked by 10 specimens (fingerlings) of *Labeo rohita* and *Oreochromis mossambicus* in 10 replications respectively. Similarly, these tanks were planted with 10 numbers of tomato (*Solanum lycopersicum*) plants by raft system. The water sample was collected every week and the following water quality parameters were analyzed to follow the standard method of APHA (2005).

1. **Air temperature:** The assessment of air temperature is helpful to provide information about the surrounding environment of the operational area.
2. **Water temperature:** It is an important parameter for the growth of the selected fish species as well as plants because all biological and physiological activities of these living components depend on temperature.
3. **pH:** The pH in an aquaponics system becomes too close to or above 7.2, the plants because the absorption of the nutrients by plants is affected in the system, resulting in nutrient shutdown and the plant’s withering, leaf curl, yellowing, stunted growth, and

failure to produce growth or blossoms similarly, the fishes also prefers the neutral pH of water in the system

4. **Dissolved oxygen:** It is considered a life gas and very much important to keep fish breathing and to increase nitrification.
5. **Electrical conductivity:** It shows the nutrient concentration in the system and the amount of water-borne nutrients for the plants.
6. **Total hardness:** It influences the pH of water but the buffering capacity of the water is the more important pH factor. This buffering capacity acts as an invisible sponge that soaks any acid or base in the system.
7. **Total alkalinity:** Alkalinity is an important parameter for both of designer and operations of systems. To compensate for acid produced by bacteria, any aquatic system that depends on bacteria for nitrification requires some form of ability to neutralize capacity. Alkalinity also keeps the pH stable and reduces in the fish.
8. **Ammonia:** It is produced by excretion and exists in two forms i.e. unionized ammonia (NH_3) and ammonium ion (NH_4^+), which are added together to form total ammonia nitrogen. Unionized ammonia is the most toxic form to fish. Temperature and pH influence the form of ammonia.
9. **Nitrate:** It is the end product of nitrogen oxidation, which is also produced by bacteria. Nitrates are toxic to fish only in large quantities. This amount is determined by the fish species.
10. **Nitrite:** It is the second form of nitrogen found in an aquaponics system; it is rather toxic to fish and is produced by nitrifying bacteria oxidizing ammonia.

Result and Discussion:

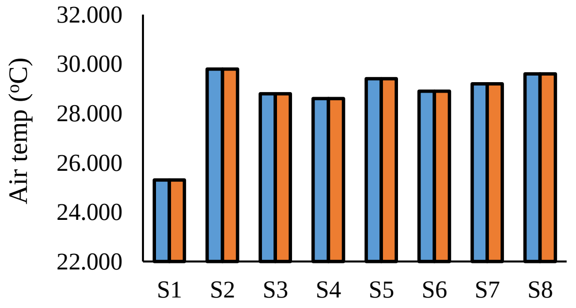
Water quality is critical for fish health and growth as well as for plants also. The water physicochemical properties of both treatments in floating raft aquaponics systems were investigated and are shown in Table (1) and Figures (1).

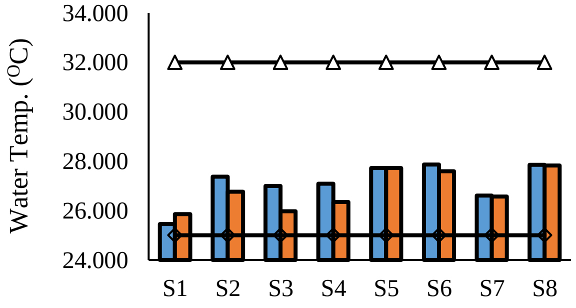
During the study, the minimum air temperature of 25.30°C was recorded and a maximum of 29.80°C was recorded. The water temperature is the single most important factor which affects the welfare of fish because the behavior, feeding, growth, metabolic rates, and reproduction of all fishes depend on temperature. Bore well water was used as a source of water. During the study period, the minimum was 25.45°C and the maximum was 27.86°C in rohu rearing tanks (T_1). Similarly, it ranged, from 25.85 – 27.83°C in tilapia rearing tanks (T_2). The observed range of temperature is suitable for fish because it was within the range of optimum temperature (24 - 32°C) for aquaculture practices (Bhatnagar *et al.*, 2004). Nelson (2008) also reported suitable a range of temperature 25.2 to 28.3°C for tilapia in the aquaponics system.

Table 1: The water quality parameters in the experimental period

Parameters	Tre.	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	Opt. Val.
Air Temp (°C)	T_1	25.30	29.80	28.80	28.60	29.40	28.90	29.20	29.60	-
	T_2	25.30	29.80	28.80	28.60	29.40	28.90	29.20	29.60	
Water temp (°C)	T_1	25.45	27.38	27.00	27.09	27.73	27.86	26.61	27.85	25.0-32.0[a]
	T_2	25.85	26.76	25.98	26.35	27.73	27.59	26.56	27.83	
pH	T_1	7.51	7.43	7.61	7.39	7.56	7.56	7.49	7.63	6.5-8.4[a]
	T_2	7.45	7.48	7.60	7.40	7.57	7.50	7.50	7.64	
D.O. (mg/l)	T_1	5.60	5.85	6.00	5.68	5.53	5.48	5.46	5.49	5.0 - 10.0[a]
	T_2	5.55	6.00	6.00	5.60	5.53	5.45	5.48	5.45	
E.C. (mS/cm^{-1})	T_1	229.38	222.38	225.50	225.88	225.38	225.00	227.13	229.63	205 - 211[b]
	T_2	227.88	220.75	222.38	225.38	225.38	228.50	226.13	228.75	
TH (mg/l)	T_1	629.50	635.75	578.25	589.00	632.25	583.25	613.50	632.25	30-180[c]
	T_2	621.50	626.50	581.25	599.75	632.25	586.00	611.13	633.00	
TA (mg/l)	T_1	118.00	112.25	110.75	111.50	110.50	110.75	116.00	112.25	50.0-300.0[c]
	T_2	119.75	112.75	107.25	111.25	110.50	114.50	110.50	113.25	
Ammonia (mg/l)	T_1	0.001	0.001	0.001	0.002	0.003	0.002	0.001	0.002	0.0-1.0[c]
	T_2	0.001	0.001	0.002	0.001	0.002	0.001	0.001	0.001	
Nitrate (mg/l)	T_1	0.05	0.07	0.06	0.06	0.06	0.05	0.06	0.06	0.1-3.0[c]
	T_2	0.06	0.06	0.05	0.06	0.06	0.06	0.07	0.07	
Nitrite (mg/l)	T_1	0.04	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.0-0.5[c]
	T_2	0.04	0.04	0.05	0.05	0.05	0.04	0.05	0.06	

[a]Shah (2010), [b]Stone *et al.*, (2013) and [c]Bhatnagar and Devi (2013)





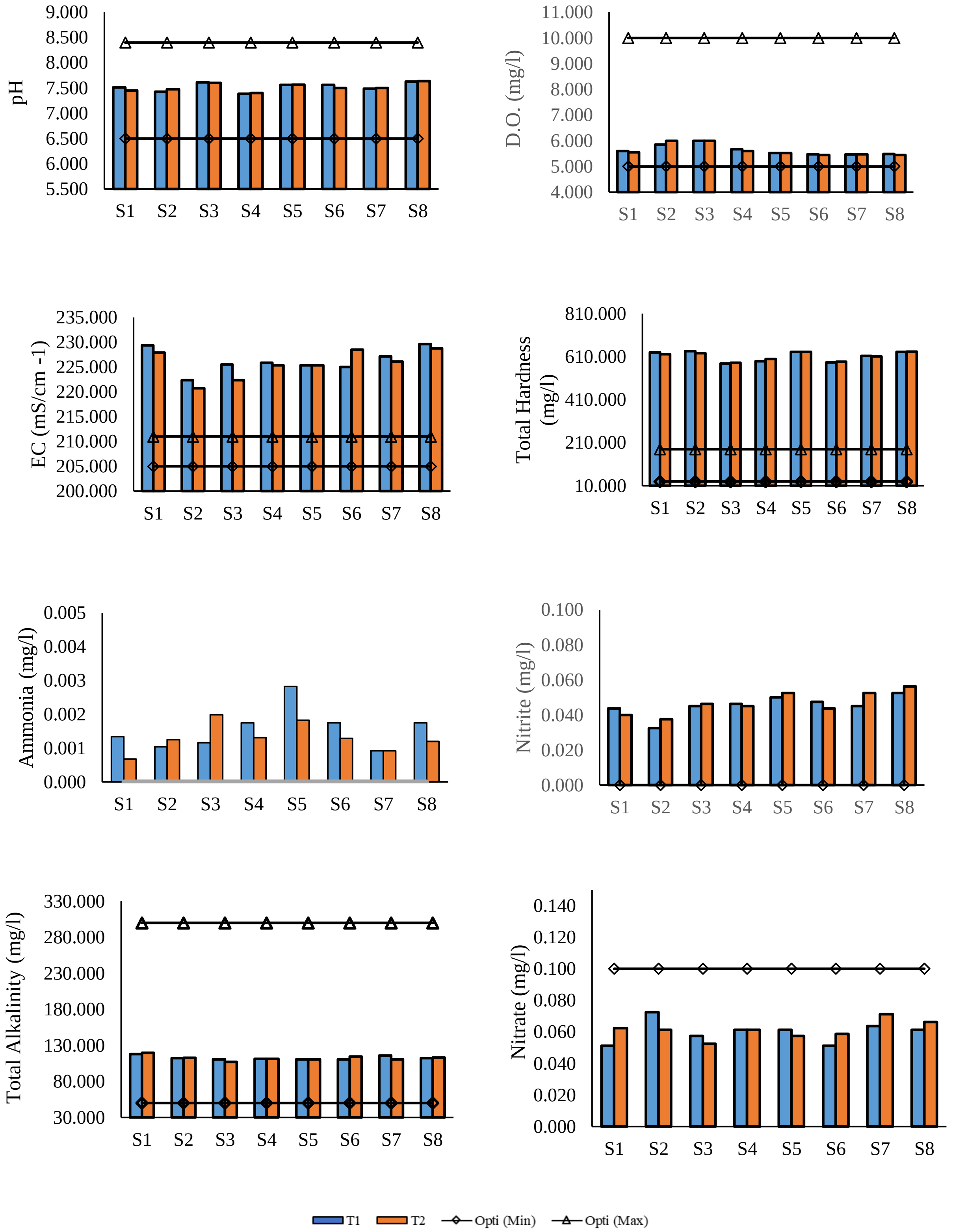


Figure 1: Important water quality parameters in floating raft aquaponics system during study

The pH is a measurement of whether water is acidic or basic. In rohu rearing tanks (T_1) it ranges from 7.39 – 7.63 and in tilapia rearing tanks (T_2) pH range was a minimum of 7.40 and a maximum of 7.64. Santhosh and Singh (2007) reported suitable range of pH for fish culture is between 6.7 and 9.5 and Chen *et al.,* (2006) also stated that the range of pH (7.0 - 9.0) is optimum for nitrification and helps to release the nitrogenous nutrients from the fish waste.

The dissolved quantity of gaseous (O_2) in the water is referred to as dissolved oxygen. At the time of the experiment, the minimum value of dissolved oxygen was 5.46 mg/l and the maximum value was 6.0 mg/l in rohu rearing tanks (T_1). While in tilapia rearing tanks (T_2) 5.45 mg/l minimum and 6.0 mg/l was the maximum range noted. According to Sallenave, (2016), DO level in aquaponic systems depends on the fish species and it should be kept at or above 5 ppm. Similarly, Bhatnagar and Singh (2010) and Bhatnagar *et al.,* (2004) suggested that a Dissolved oxygen level >5 ppm is essential to support good fish production.

The pen-type digital meter was used to determine the range of electrical conductivity. Electrical conductivity was noted with a minimum range of 222.38 mS/cm^{-1} and a maximum range of 229.63 mS/cm^{-1} in rohu rearing tanks (T_1). Similarly, in tilapia rearing tanks (T_2) the minimum and maximum values of electrical conductivity were 220.75 mS/cm^{-1} and 228.75 mS/cm^{-1} respectively. The observed conductivity was compared with the prescribed limit of conductivity by Bhatnagar and Devi (2013) and found suitable for fish farming. Stone and Thomforde (2004) also reported that 100 to 2000 mS/cm^{-1} electrical conductivity containing water is suitable for fish growth.

The total hardness of calcium and magnesium might correspond to total hardness. It is an irreversible measure of the mineral content in a boiling water sample. The minimum value was 578.25 mg/l and the maximum value was 635.75 mg/l in rohu rearing tanks (T_1). Similarly, in tilapia rearing tanks (T_2), the minimum value of total hardness was 581.25 mg/l while the maximum was 633.0 mg/l. Although the observed values of total hardness were much high than the recommended values of 75-150 ppm Bhatnagar *et al.,* (2004) for fish culture which shows that the experimental water was hard water (>300 mg/l).

The total water base quantity in mg/liter of calcium carbonate equivalent refers to total alkalinity. During the period of research, in rohu rearing tanks (T_1) the minimum and maximum 110.5 mg/l and 118 mg/l respectively were noted. In tilapia rearing tanks (T_2) the minimum value was 107.25 mg/l and the maximum value was 119.75 mg/l. The recommended range of total alkalinity for aquaculture is 80–200 ppm Bhatnagar *et al.,* (2004) which shows that total alkalinity was in favor and suitable for fish growth. It is also reported that total alkalinity in the water exceeding 300 mg/l has no negative effects on the fish Buttner *et al.,* (1993).

During the experiment period, narrow changes were noted at the ammonia level. The minimum value of ammonia was 0.001 mg/l and the maximum value was 0.003 mg/l in rohu rearing tanks (T_1). Similarly, it ranged from 0.001 – 0.002 mg/l in tilapia rearing tanks (T_2) which is much lesser than the recommended values of 1.00 mg/l Nijhof and Bovendeur (1990) and 0.17-3.87 mg/l Caldini *et al.*, (2015) for aquaculture production which shows that the water of aquaponics system during the present study is non-toxic and safe for the fish survival.

Nitrate was observed at 0.05 mg/l minimum and the maximum was 0.07 mg/l in rohu rearing tanks (T_1). In the same way in tilapia rearing tanks (T_2) the minimum value was 0.05 mg/l while the maximum was 0.07 mg/l. Santhosh and Singh (2007) said the favourable range of (0.1 mg/L to 4.0 mg/L) in fish culture water.

According to Swann (1997), in aquaponic, the conversion rate is quick so the nitrite level was founded to be low into the permissible limit (0.5 mg/L). In rohu rearing tanks (T_1) the value of nitrite with minimum and maximum ranges of 0.03 mg/l and 0.05 mg/l respectively was noted. In tilapia rearing tanks (T_2) the minimum value was 0.04 mg/l and the maximum value was 0.06 mg/l.

Conclusion:

In this, the management of water quality certainly helps to enhance the fish and vegetable production in the floating raft aquaponics system. It also can be concluded that the growing environment of an aquaponics system is favorable for bacteria for nitrification and nitrification processes that help to produce the nutrients for plant growth.

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PLANKTONIC INDICATORS: A POTENTIAL APPROACH FOR EVALUATING WATER QUALITY

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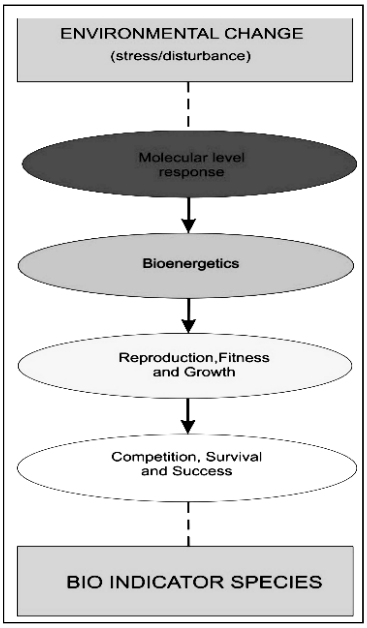
Abstract:

Bioindicators are specific living species or communities that, by their presence, absence, frequency, and abundance at a specific place, reveal information about the surrounding physical and/or chemical environment. They are used to screen the health of a natural environment. Globally environmental pollution has become one of the most serious problems and unsafe contaminants in drinking water have led to many health issues followed by mortality. A reliable and affordable method for analyzing water quality can safeguard the life of the masses. The current review presents the use of planktons as a bioindicator for evaluating water quality, emphasizing them as a potential method compared to the conventional physical and chemical parameters. The study suggests the use of planktonic indicators as supplementary methodologies in determining the health condition of water bodies.

Introduction:

Drinking clean water is a fundamental human right on a worldwide scale (WHO, 2004). AGI (Acute Gastrointestinal Disease) affects 4 billion people globally each year, and poor sanitation and hazardous water supply are too responsible for 88% of those cases (WHO, 2004). According to Jain *et al.* (2010), and Tank and Chandel (2010), drinking water with a nitrate content of greater than 45 mg L^{-1} has harmful consequences on human health, including methemoglobinemia and gastric carcinoma. Too much fluoride can cause dental fluorosis or skeletal fluorosis, the latter of which is a debilitating condition that affects many regions of the world.



To give a comprehensive spectrum of data for effective water management, the quality of water should be evaluated using physical, chemical, and biological parameters. However, such study requires considerably more time and resources than the study of biological parameters, which is globally accepted (Iliopoulou-Georgudaki *et al.*, 2003). As our water bodies serve a variety of functions, they must be managed skilfully. Rapid and trustworthy monitoring methods are necessary to determine the state of water bodies.

Biological indicators, also known as bioindicators, are specific species or communities that, by virtue of their existence, absence, frequency, and abundance at a specific place, reveal information about the surrounding physical and/or chemical environment. The capacity of each species' to thrive under certain water chemistry parameters is the basis of each species' or community's function as a bioindicator. Some species have clear biological needs, their presence and relative abundance in streams can serve as a proxy for both historical and current water-quality conditions.

Kolenati (1848) and Cohn (1853) made the first discussion on the ability of freshwater species to reflect changes in environmental circumstances towards the middle of the 19th century (Bellinger and Sigee, 2010). After this, the type of pollution began to receive attention in the middle of the 19th century. Cohn (1853) noted that the biota in polluted waters was different from those in unpolluted waters, Kolenati (1848) observed the presence of Trichoptera in Bohemia, Moravia, and the southern part of Silesia. Kolkwitz and Marsson (1908) developed the first technique for classifying species according to how sensitive they are to oxygen deprivation or a high organic load. According to Nygaard (1949), phytoplankton association might serve as a gauge of contamination. The phrases "biomonitoring" and "bioindication" are sometimes used interchangeably, however, they have different implications in the scientific world. In comparison to biomonitors, which accurately measure responses (e.g., decreases in lichen diversity or chlorophyll content indicate the presence and severity of air pollution), bioindicators qualitatively evaluate biotic responses to environmental stress (e.g., the presence of lichen indicates poor air quality). Temperature, oxygen content, pH, and biotic interactions between species all affect the tolerance range (ecological optimum) that determines the presence of planktonic organisms in the natural environment (Paturej 2006). Numerous environmental conditions, both human and non-anthropogenic, have an impact on the presence of species in the ecological niche's multidimensional space. Compared to common and uncommon species, bioindicators are more tolerant to environmental change. This tolerance gives them the capacity to be sensitive to environmental change while still having the endurance to resist some fluctuation and represent the overall reaction of the biotic community (Holt and Miller 2011).

Populations develop strategies through time to enhance growth and reproduction (i.e., fitness) in the presence of a particular set of environmental conditions. An individual's physiology and/or behaviour may be negatively impacted outside of their environmental tolerance zone, decreasing their overall fitness. Reduced fitness can thus change the group as a whole and disturb population dynamics. A bioindicator species' capacity to accurately reflect the state of the ecosystem is attributed to their moderate environmental tolerance.

Characteristics of good bioindicators

A species should exhibit a variety of traits to be regarded as an useful bioindicator, according to research by Phillips (1977), Stocker (1980), Phillips (1980), Conti and Cecchetti (2001), Bellinger and Sigee (2010), and Holt and Miller (2011). (i) When the condition is even repairable, a species or combination of species must exhibit quantifiable reaction (sensitive to the disturbance or stress), and the response quickly reflects the response of the entire population, community, or ecosystem. (ii) Well understood life cycle, reasonably stable despite mild climatic and environmental change, and taxonomically well-documented. (iii) Can be consistently recognised using common laboratory tools and is simple and inexpensive to survey.

In addition to this, the indicator should have a broad temporal and geographical distribution, including distribution within the study region (rare species are not ideal). Additionally, it is advantageous if the species are well-known to the general public, significant economically or commercially, and previously collected for other uses.

Advantages of bioindicators

The use of bio indicators reflects overall water quality by integrating the effects of various stress factors over time, as opposed to traditionally conducted chemical assays and directly measured physical parameters of the water (such as ambient temperature, salinity, nutrients, pollutants, available light, and gas levels). Contaminants can also exist in really low amounts. To identify such tiny amounts, laborious tests requiring very sensitive equipment at exorbitant costs are necessary. In comparison to the expense of evaluating toxicant pollution, routine monitoring of biological communities is often trustworthy and reasonably affordable. Prior to the impacts of the pollutants beginning, bio indicators of pollutants are helpful in forecasting the quantity and degree of pollutants (early warning system). Sharma and Jindal (2012).

The capacity of bio indicators to detect indirect biotic impacts of pollutants, which many physical or chemical tests are unable to, is another advantage of their usage. For instance, adding more phosphorus to a lake would improve some species' development and reproduction (Khan and Ansari, 2005). Chemical measures, however, might not fully capture a drop in species variety or how competitive exclusion may affect the development and reproduction of other species. Additionally, a large number of diverse species' reactions (e.g., some species may grow while others decline) might mask a strong bio indication signal. The situation is somewhat comparable to invading species that reduce ecological variety and encourage monoculture. In these situations, we can only concentrate on a subset of the biota or a single species to convey the tale while integrating all the direct and indirect consequences of a disturbance (Holt and Miller, 2011). Monitoring is now more cost-effective and physiologically relevant thanks to this focused strategy. Additionally, one issue with chemical and physical measurements is that they often oversimplify a complex response that is present in these habitats with a diversity of species, whereas bio indicators rely on the intricate workings of ecosystems and use a representative or aggregated response to present a dynamic picture of the state of the environment.

Phytoplanktons

Phytoplanktons, also known as microalgae (in the narrow sense), are phototrophic microorganisms with basic nutritional needs that make up the majority of the planet's primary producers, including both prokaryotes (cyanobacteria) and eukaryotes (green algae). The foundation of an ecosystem's nutrient cycle is phytoplankton, an essential primary producer. Numerous publications suggest that one, more, or all algal assemblages might be employed as indicators of water quality (Mohapatra and Mohanty, 1992). However, the situation is rather paradoxical in both polluted and clean water bodies. While clean water bodies sustain a wide range of algae species, contaminated water supports only a few number of tolerant organisms, with one or two species predominating (Rai *et al.* 2008).

Table 1: Phytoplanktons that can withstand pollution.

Recorded genera/ species	Habitat	Water status	Reference
Microcystis sp.	Ponds	Eutrophic	Ganapati, 1960
Asteronella sp., Fragilaria sp., Melosira sp., Stephanodiscus sp.,	Various habitats	Eutrophic	Hutchinson, 1967
Pandorina sp., Scenedesmus sp.	Drain	Sewage pollution	Verma *et al.* 1978
Chlorella vulgaris, Ankistrodesmus falcatus	River	Paper and Sewage waste	Paramasivam and Sreenivasan, 1981
Cyclotella sp., Cymbella sp., Gomphonema sp., Melosira sp., Nitzschia sp.	Canal water of river	Eutrophic	Abubacker *et al.*, 1996

Anabaena aequalis, Oscillatoria angusta, Nitzschiabilobata,	Shallow ponds	Sewage/organic pollution	Ahmad, 1996
Microcystis aeruginosa	Pond	Eutrophic	Gaur, 1997
Microcystis sp., Stigeoclonium sp.	Lake	Polluted	Swaranlatha and Rao, 1998
Nitzschia palea, Synedra sp., Navicula cryptocephala	Flowing small stream	Polluted	Bhatt *et al.*, 2001
Euglena acus, Euglena oxyuris	River	Eutrophic	Sampoorani *et al.*, 2002
Ulva lactuca	Bay	Sewage polluted	Rogers, 2003
Microcystis aeruginosa, Anabaena flos-aquae	Reservoirs	Polluted	Vardaka *et al.*, 2005
Navicula cryptocephala, Nitzschia palea, Synedra ulna	River	Sewage pollution	Jindal and Vatsal, 2005
Navicula cryptocephala, Nitzschia palea, Synedra ulna	Urban river	Polluted	Ghavzan *et al.*, 2006
Eudorina elegans, Eudorina unicocca	Municipal lake	Eutrophic	Kemka *et al.*, 2006
Oscillatoria sp., Frafellaria sp., Chlorococcum sp.	Urban lakes	Eutrophic	Kumari *et al.*, 2008
Phacus caudate, Euglena sp., Chlamydomonas globosa	Water bodies	Polluted	Rai *et al.*, 2008
Anabena sp., Microcystis sp., Aphanizamenon sp.	Reservoir	Polluted	Hulyal and Kaliwal, 2009
Closterium acerosum, Closterium dianae, Closterium lineatum	Perennial ponds	Polluted	Rajagopal *et al.*, 2010a
Achnanthus brevipes, Gomphonema parvulum, Cymbella tumida	Estuaries	Polluted	Shruthi *et al.*, 2011
Ankistrodesmus falcatus, Chlorella vulgaris, Chlamydomonas sp.	River	Polysaprobic	Jindal and Sharma, 2011
Microcystis aeruginosa, Anabaena bergii	Reservoir	Polluted	Katsiapi *et al.*, 2011

Zooplanktons

Zooplanktons are tiny aquatic organisms that cannot move or can only swim relatively slowly. Although zooplankton are not dependent solely on nutrients to exist and are influenced by the quantity and quality of bacteria, algae, and other detritus in a reservoir, its trophic condition may have an impact on this community's diversity, shape, size, and productivity. By forming a connection between primary producers and higher trophic levels, they play a significant role in the food chain. The nano phytoplankton is the dominating component in oligotrophic habitats with higher water clarity, lower nutrient concentrations, and electrical conductivity, permitting high abundances of herbivorous zooplankton (i.e., filter feeders like calanoids and big cladocerans) (Xu *et al.*, 2001). While in eutrophic environments, higher levels of nutrients and detritus promote the growth of bacteria and protozoa, vital sources of food for small filter-feeders like rotifers and small-bodied cladocerans (bosminids). Furthermore, cyclopoids are favoured by the preponderance of colonial and filamentous cyanobacteria since they may feed on these algae thanks to their raptorial habit and employ micro-zooplankton as a food source (Brito, 2011).

Table 2: Zooplanktons that can withstand pollution.

Recorded genera/ species	Habitat	Water status	Reference
Brachionus angularis	Lake	Eutrophic	Gannon and Stemberger, 1978
Chydorus sp.	Freshwater reservoirs	Eutrophic	Mahajan, 1981
Eristalis tenax larva	Rivers	Sewage waste	Paramasivam and Sreenivasan, 1981
Epistylis sp.	Lake	Eutrophic	Pace, 1982
Brachionus angularis	Lakes and ponds	Polysaproboic condition	Sladecek, 1983
Keratella sp.	Freshwater tanks	Organic pollution	Goel and Chavan, 1991
Moina sp.	Himalayan lakes	Polluted	Jha and Barat, 2003
Arcella vulgaris, Difflugia sp., Brachionus angularis	Himalayan lakes	Eutrophic	Wanganeo and Wanganeo, 2006
Anuraeopsis fissa, Brachionus angularis, Filinia longiseta	Coastal lake	Eutrophic	Paturej, 2006
Keratella sp., Brachionus sp.	Urban lake	Eutrophic	Kumari et al., 2008
Moina sp., Ceriodaphnia sp.	River	Eutrophic	Ferdous and Muktadir, 2009

Monostyla sp., Keratella sp., Lapadella sp., Leydigia sp.	Perennial pond	Eutrophic	Rajagopal et al., 2010b
Paramoecium caudatum, Oxytricha ovalis, Oxytricha oblongatus, Holophyra simplex, Cyclidium glaucoma	Rain fed lake	Eutrophic	Sharma et al., 2010
Aspidisca sp., Bodo sp., Brachionus angularis, River Polysaprobic Jindal and Sharma Colpoda sp., larvae of Chironomus sp., Eristalis tenax	River	Polysaprobic	Jindal and Sharma, 2011

Conclusion:

Bioindicators' many advantages have definitely surpassed its drawbacks. To assess the health of a certain ecosystem, bioindicators may be used at a variety of scales, from the cellular to the ecological level. They combine knowledge on alterations in population density, community makeup, and ecological processes, as well as information about the biological, physical, and chemical elements of our world. When it comes to management, bio indicators help us decide what is and is not biologically sustainable. Bio markers, however, are not without flaws. As a result, our knowledge of the fundamental mechanisms of change may be complex since populations of indicator species may be affected by factors other than the disturbance or stress (such as illness, parasitism, competition, or predation). No one species has the ability to accurately detect every sort of stress or disturbance in every habitat. Appropriate bioindicator species or groups of species must be chosen based on the particular habitat, the species present, and local disturbances.

When it comes to management, bioindicators let us determine what is and is not biologically sustainable. Based on the findings of the current study, it is advised that planktonic indicators can and should be used as supplementary methodologies in determining the health condition of water bodies.

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SPATIAL AND TEMPORAL INVESTIGATION OF WETLAND IN SOUTHSOUTH ZONE OF NIGERIA

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Abstract:

Satellite-based analysis of wetland is an effective alternative to the costly ground-based surveys. The aim of this study is to conduct a spatial and temporal investigation of wetland of Southsouth zone of Nigeria using Time-series satellite datasets. For this study, MODIS–NDVI datasets covering Southsouth zone of Nigeria were acquired for 2000, 2010, and 2020. This was followed by image reprojection to WGS 84 and clipping of the study area. Also, the clipped images were classified and change detection was conducted. The result is a map and statistics wetlandof Southsouth zone of Nigeria.

Keywords: Coastal, LULC, satellite data, water, wetland change

Introduction:

Wetlands are terrestrial or semi-terrestrial ecosystem characterized with low drainage quality, and slow water body filled with soil. They are areas where water is present at or near the soil surface all year or varying periods of the year (Obiefuna *et al.*, 2013). Generally, wetlands are natural or artificial, and permanent or temporary water bodies made of marsh, fen, peatland, or water. Their water is static or flowing, fresh, brackish, or salt, and covers marine water area with depth of which at low tide does not exceed six meters (Ramsar Concenction, 1994).

Wetlands resource directly or indirectly support life in certain environment and occur in all places ranging from the tundra to the tropics. It encompasses rivers, reefs, lakes, tidal flats, artificial reservoirs, rice field (Rebelo *et al.*, 2009) and others. They are considered to be immensely important portion of the global ecosystem even though they cover only about 6 % of the Earth's surface (Toyra and Pietroniro, 2005). Of course, wetlands have general functions and values which significantly recognize the uniqueness of its environment (Nwankwoala, 2012). They play significant ecological roles including biodiversity management, regulation of watershed hydrology, fishery health, coastal protection, and carbon sequestration (Wright and Gallant, 2007); Barbier *et al.*, 2011). Carbon sequestration by wetland, especially within the coastal environment can significantly aid climate change mitigation. Coastal wetland carbon is found in coastal vegetated ecosystems, such as mangroves, tidal marshes, and sea grasses, where it is stored in soils, above- and belowground biomass, litter, and dead wood (Howard *et al.*, 2014). Carbon sequestration rates for tidal saline wetlands and mangroves are globally estimated to be 44.6 TgC/year, and the release of greenhouse gases from these wetlands are minimal (Chmura *et al.,* 2003). Furthermore, other important functions of wetland include flood storage and distribution, retention of sediments and nutrients, aquifer recharge, water quality improvement, aesthetic and educational benefits (Kindscher *et al.,* 1998; Chmura *et al.,* 2003), waste water treatment and recycling, and provision of breeding and rearing ground for natural habitats, animals and aquaculture resources (Nwankwoala, 2012). Wetlands also provide various multiple ecosystem services such as buffers zone, and important resource for humans and animals (Verones *et al.,* 2013).

The most recent estimate of global inland and coastal wetland area is in excess of 12.1 million km^2, an area almost as large as Greenland (Ramsar Convention, 2018). Similarly, Africa is endowed with abundant wetland resources covering about 10 % of her land (Davidson *et al.*, 2013). The wetlands resources in the Sub-Saharan Africa consists of the coastal wetlands, inland basins, river, valleys and floodplains, all of which are estimated to cover an area of about 2.4 million km^2. Also, Nigeria presently has 11 sites designated as Wetlands of International importance with a surface area of 10, 767 km^2. However, other important wetlands in Nigeria that are not accounted for also exist.

Despite all the values of wetlands, its functions are continually declining due to intensive anthropogenic activities, climate change and decreasing biodiversity (Eppink *et al.*, 2004; Han *et al.,* 2015). The global extent of wetland has declined between 64-71% in the 20th century and this constitutes a significant threat to wetland biodiversity (Davidson, 2014). Also, mismanagement of Nigeria's wetland has negatively affected its hydrology and water resources status. As a consequence, there is degeneration of all the potential resources and all the benefits expected of the wetland ecosystem. The reason is that wetlands which naturally recharge and protect both the surface and groundwater resources are being unscrupulously degraded at an alarming rate (Uluocha and Okeke, 2004).

Conflicts regarding wetland usage frequently arise among stakeholders including diverse nature conservation interests, farmers, land and water planners and engineers. Thus, governmental and non-governmental bodies interested in biodiversity, wetlands, and sustainability of resources initiated a Multilateral Environmental Agreement (MEA) in 1971 (at

Ramsar, Iran). The motives behind the convention are the wise use approaches to wetlands, conservation of wetlands and designation of wetland sites as a very important and internationally recognized environmental habitat (Gardner, and Davidson, 2011).

Conservation of wetland ecosystem begins with the identification of the wetland's location, distribution, size and type. Yet, the conventional approach involving field survey or the manual visual interpretation of aerial photographs have limited the spatial or temporal coverage, consume a large amount of human resources and are tough to undertake. Thus, satellite images with their unique characteristics including multi-temporal, multispectral, repeated and synoptic view (Ozesmi and Bauer, 2002) can be used for wetland mapping and change detection (Han *et al.,* 2015) with an improved result. With the rapid development of remote sensing technology, abundant remote sensing data are available for wetland mapping, including the freely available Landsat images, and the moderate resolution imaging spectroradiometer data (Rundquist *et al.,* 2001). Recent technological advances in space observation have facilitated the collection of very detailed images that can characterize large areas of wetlands with high spatial resolution. Optical multispectral images afford maps of natural environments (Stenzel *et al.*, 2014) while RaDAR data, which are not sensitive to cloud cover, make it possible to monitor dynamics of wetlands (Marechal *et al.,* 2012). Thus, Earth observation data represent a potentially practical and economically feasible tool for extracting functional descriptors of wetlands. The same time, advancements in Earth Observation coupled with ground analyses have provided opportunities for identifying, describing and mapping the distribution of wetlands at a range of scales from local to global (Lehner, and Do¨ ll, 2004). The Ramsar Convention on wetlands has long recognized the need to develop techniques that can fill gaps in baseline inventory and has supported the development and application of inventory techniques including the application of remote sensing and GIS (Davidson and Finlayson, 2007; Rosenqvist *et al.,* 2007). However, the methods by which wetlands have been identified or classified using global datasets varies and the results have often been incompatible or inconsistent (Finlayson *et al.,* 1999). Consequently, some major gaps apparently exist in wetland inventory. Also, efforts to assess the global extent and condition of wetlands and the estimates of the rate of wetland loss are incomplete or based on unsubstantiated assertions. Furthermore, there have great effort on community-based assessment of wetlands in the study area, yet, there is no study to our knowledge that covers the entire zone. Therefore, this study is significant to the scientific community and for decision making.

Materials and Methods:

Study area:

The Southsouth area of Nigeria fall between longitudes 5° 00’ and 9° 30’ E of Greenwich Meridian, and latitudes 4° 00’ and 7° 45’ North of the Equator (figure 1). It is made up of six Nigerian States including Akwa-Ibom, Bayelsa, Cross River, Delta, Edo and Rivers. The National Population Census put the population of the Southsouth States of Nigeria at 21,014,655.

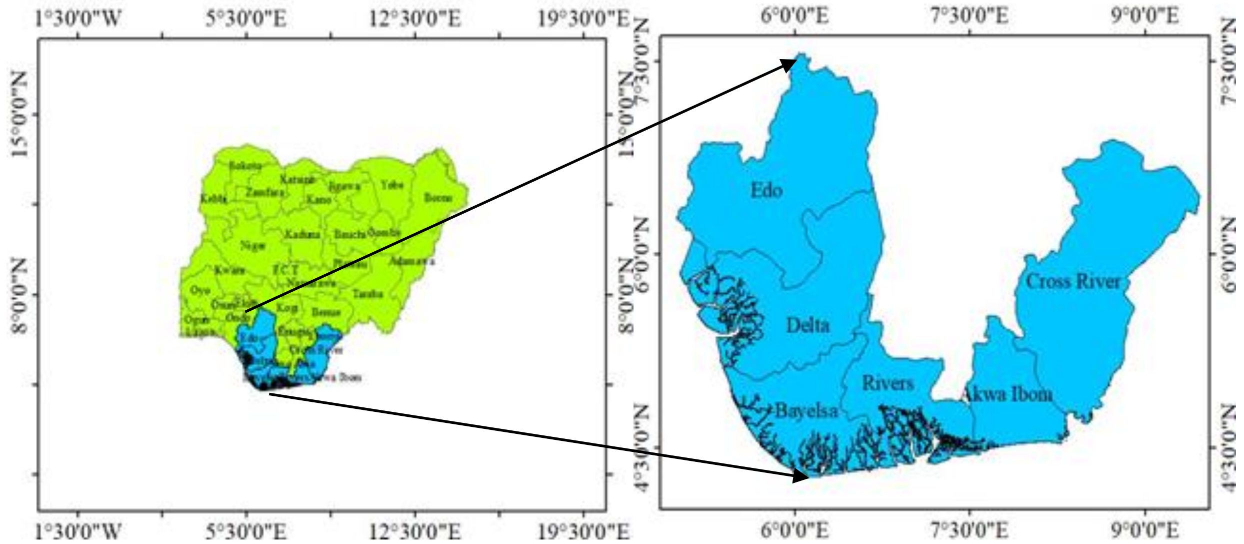

Figure 1: Inset map of Nigeria showing Southsouth Nigeria

Southsouth Nigeria is blessed vast amounts of resource wealth and thus, it provides the economic mainstream of the country. Yet, it suffers from environmental problems especially due to oil spillage, which have contributed to undermining traditional agriculture, fishing and livelihood strategies on which communities outside the petroleum sector rely.

Typically, the region consists of mangrove, lowland rainforest freshwater forest and aquatic ecosystem that provide services to the indigene of the region and to the West African economy at large. The zone harbours several biodiversity, and it is characterized by low-lying sedimentary basin drained by the Niger River with several crisscrossed rivers, streams, creeks, creeklets that emptied into the Atlantic Ocean through the estuaries.

MODIS–NDVI Datasets:

Investigating and monitoring Land use and land cover using remote sensing requires images of different epoch. Thus, a time series of 16–day composite MODIS (Moderate Resolution Imaging Spectroradiometer) 500 m spatial resolution NDVI datasets (MOD 13A1) covering the study area (h18v08) was acquired from the earth observing system data gateway.

The imageries collected for the analysis are in three epochs over a period of 20 years from 2000 to 2020 at 10 years interval.

The satellite data was preprocessed and a subset covering the study area was extracted to limit the analysis to the area of interest. Furthermore, original NDVI values were converted to index values ((-0.2 to 0.9) by multiplying the image by a scale factor of 0.0001.

Delineation of wetlands their change analysis:

Using ISODATA clustering algorithm, unsupervised classification was conducted on the satellite data. The wetland was extracted from the NDVI image by setting threshold values for wetlands. A spatial distribution map of wetlands was derived, and simple arithmetic was used to determine the area, trend, direction and percentage of change of the wetlands. Descriptive statistics were used to explain the values of wetland change and the percentage change in the wetland per epoch under consideration.

Results and Discussion:

Spatial extent of wetland in the study area:

The wetland spatial extent of wetland in the study area is presented in figure 2a, 2b, and 2c, for 2000, 2010, and 2020 respectively. The maps includes all wetlands as defined by the Ramsar definition – lacustrine, riverine, palustrine, opencast mines and other less abundant types. Identified wetland types include depressions, channeled valleys, floodplains, seeps and dams.

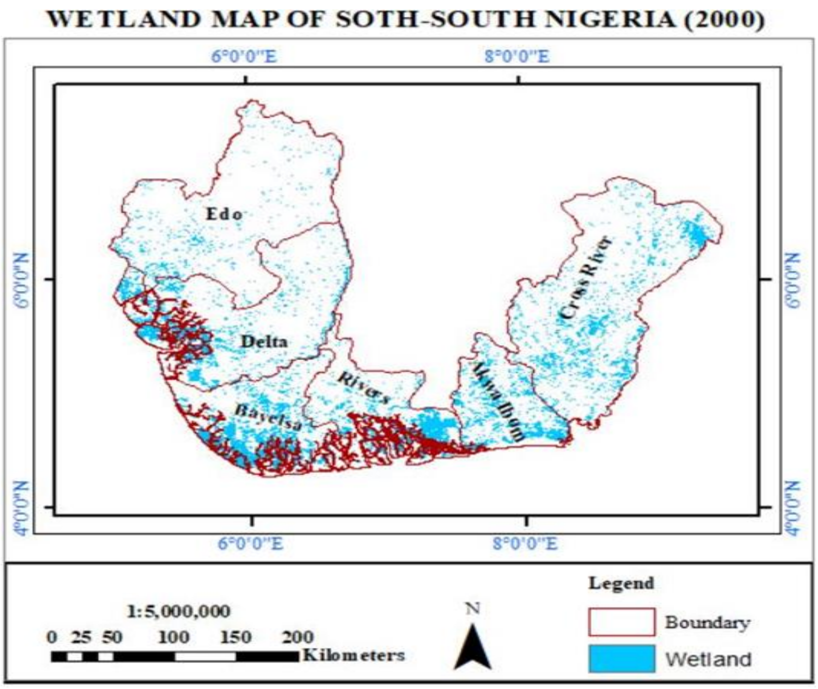

Figure 2a: Wetland map of Southsouth Nigeria for 2000

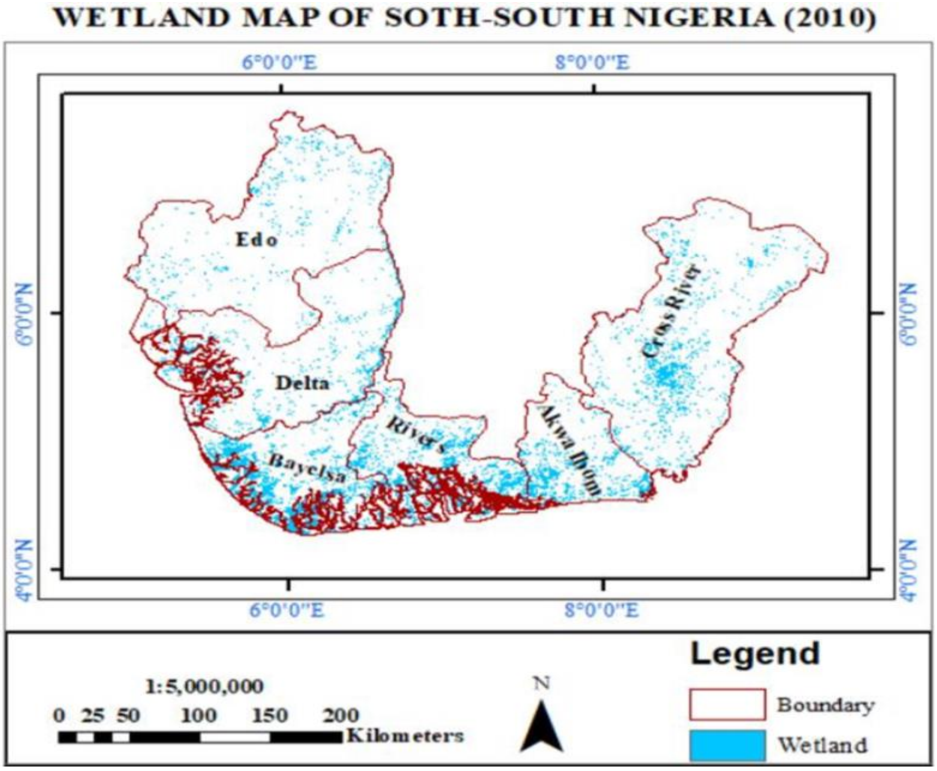

Figure 2b: Wetland map of Southsouth Nigeria for 2010

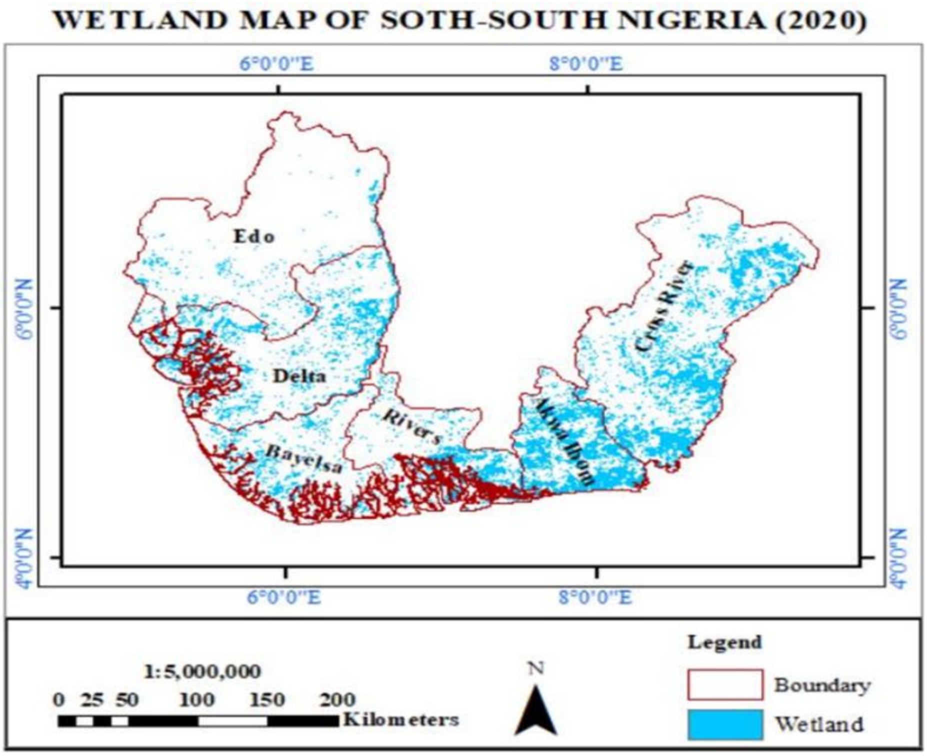

Figure 2c: Wetland map of Southsouth Nigeria for 2020

Furthermore, tables 1 and 2 shows the statistics of the spatial distribution of the wetland among the various states within the study area. From table 1, it can be seen that the total wetland area in the catchment for 2000, 2010, and 2020 are 14.102 km^2, 9.910 km^2, and 16.635 km^2 respectively. Also, wetland in 2000 as presented in the table show that the largest and smallest wetlands are in Bayelsa and Edo States with extent of 3.123 km^2 (22.1 %) and 0.984 km^2 (7.0 %) respectively. Likewise, Bayelsa and Edo States have the largest and least wetland in 2010 with areal extent of 2.696 km^2 (27.2 %) and 0.804 km^2 (8.1 %) respectively. But, in 2020, the largest wetland is located in River State with a total of 5.259 km^2 (31.61 %) while the wetland in Edo State still remain the smallest with a total spatial coverage of 0.822 km^2 (4.94 %).

Table 1: Spatial coverage (in km^2) and percentage of wetland in the study area

	2000		**2010**		**2020**	
States	**Coverage**	**%**	**Coverage**	**%**	**Coverage**	**%**
A/ Ibom	1.814	12.9	1.113	11.2	3.509	21.09
Bayelsa	3.123	22.1	2.696	27.2	1.491	8.96
C/ River	2.928	20.8	1.855	18.7	5.259	31.61
Delta	3.049	21.6	1.378	13.9	3.602	21.65
Edo	0.984	7.0	0.804	8.1	0.822	4.94
Rivers	2.204	15.6	2.064	20.8	1.952	11.73
Total	**14.102**	**100**	**9.910**	**100**	**16.635**	**100**

Table 2: Spatial change (in km^2) and percentage change of wetland in the study area.

	2000-2010		**2010-2020**	
States	**Change**	**%**	**Coverage**	**%**
A/ Ibom	-0.701	16.7	2.396	35.6
Bayelsa	-0.427	10.2	-1.205	-17.9
C/ River	-1.068	25.5	3.406	50.6
Delta	-1.671	39.9	2.224	33.1
Edo	-0.180	4.3	0.018	0.3
Rivers	-0.140	3.3	-0.112	-1.7
Total	**-4.187**	**100**	**6.727**	**100**

Furthermore, table 2 provides the changes that occur in the wetland for each state between 2000 and 2010, and from 2010 to 2020. All the states experienced decrease in the wetland from 2000 to 2010, with the highest reduction of -1.671 km^2 (39.9 %) in Delta State while the lowest decrease of -0.140 km^2 (3.3 %) occurred in River State. Between 2010 and 2020, Bayelsa and River States experience reduction while the other States show increase in their wetland.

Conclusion:

The impact of climate change, anthropogenic activities such as cultivation, settlement and mining are contributing immensely to wetland degradation in the Southsouth zone of Nigeria. These activities on wetlands are expected to increase due to demand for more land for settlement, the need for more cultivated land to feed a growing population, and urbanisation. Therefore, there is need for improved management of wetland by both the communities and the environmental policy-makers.

Priorities in wetland management should focus on strengthening the assessment, monitoring and restoration of wetlands. This study reveal that remote sensing afford good options to map and monitor wetlands as they have the capability to provide information over wide areas at equal time intervals. Remote sensing technique provides fast, accurate and economic method for extraction of wetlands. It has overcome the drawbacks of old traditional method like field survey, which is not only time consuming but also hard to undertake. Besides, remote sensing allows the possibility of mapping physically unreachable areas. The wetland map and land-use change assessment on wetlands can help to underscore the wetland depletion, its attendant vulnerability and it serves as a guide to land-use practices that have a direct and indirect effect on wetlands.

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IMPACT OF CLIMATE CHANGE ON AQUATIC HABITAT

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Abstract:

The environment is constantly changing nowadays due to various types of variations in climate. The renowned climatologist and researchers all around the world specially discuss the climate change that affects aquatic habitats. The atmosphere is a layer of gases around the Earth. It protects the Earth's surface from the sun's harmful rays and contains the oxygen we breathe. The sun's rays shine on our planet and warm the surface of the Earth. Heat then radiates from the surface. Scientists have shown conclusively that greenhouse gases trap some of this heat in the atmosphere. Over the history of the Earth, this 'greenhouse effect' has helped keep the planet warm enough for life to flourish. The temperature of the air at the planet's surface has risen rapidly, especially over the last fifty years. We know this through records from thousands of weather stations across the world, satellites, and ocean data from ships and buoys. The scientific evidence is clear that these changes are not being driven by long-term natural climate cycles. Instead, their main cause is global warming and the human activities that cause it. Global warming is the primary cause of what we now refer to as "climate change."

Keywords: Atmosphere, Temperature, Global warming, Climate change

Introduction:

Climate change refers to a shift in average weather conditions, including measures such as temperature, humidity, rainfall, cloudiness, and wind patterns – and changes in the frequency or severity of these conditions. The observed shifts associated with recent climate change are likely to have been brought about through both direct and indirect (changes to species interactions) effects of climate. The Earth's climate has changed throughout its history, in cycles that occur over very long periods.

Today we tend to use the phrase "climate change" to refer to the very rapid changes in the climate that we have seen over the past 50 years or so. The scientific evidence is clear that these changes are not being driven by long-term natural climate cycles. Instead, their main cause is global warming and the human activities that cause it.

The environment is constantly changing nowadays due to various types of variations in climate. The renowned climatologist and researchers all around the world specially discuss the climate change that affects aquatic habitats. The aquatic habitats consist of marine water bodies and freshwater bodies. Aquatic life includes aquatic plants and animals. Climate change can impact aquatic through sea level and temperature rise, changes in monsoon patterns, and extreme weather conditions having both direct and indirect impacts on aquatic animals. It directly acts upon the physiological behavior and growth pattern of organisms. Indirectly it affects the productivity, structure, and composition of aquatic ecosystems. Changes in seasonal patterns of precipitation and runoff will alter the hydrological characteristic of aquatic systems. The productivity of inland freshwater and coastal wetland ecosystems will be significantly altered by an increase in water temperatures. Aquatic plants like submerged and emergent wetland plant communities are affected due to climate change. Especially sea grasses submerged freshwater plants, and tidal marsh plants. The submerged plants are mostly affected by temperature changes and indirect impacts on water clarity. The vulnerability of freshwater ecosystems against climate change is very high. Climate change will cause a decrease in fish production. Coral reefs are greatly affected due to increased temperatures, acidity, etc. The aquatic habitats including both freshwater and marine water habitats need to be preserved sustainably. The changes in climate and seasons impact the flora and fauna in many ways.

What impacts of climate change are we already seeing?

Climate change has profound implications for people and the natural world. Impacts of climate change that we are already seeing include:

- **Changes in extreme heat**

Higher average temperatures mean heat waves are now more frequent – and tend to be hotter when they occur. Some of the extreme heat waves that we are now seeing would have been highly unlikely without the recent warming of the planet. The increased temperatures also make events such as the forest fires that have been happening recently in Australia more likely and more intense. Parts of the world, such as in the Mediterranean and Central and West Africa, are seeing more frequent and more extreme droughts due to climate change.

Aquatic and wetland ecosystems are very vulnerable to climate change. The metabolic rates of organisms and the overall productivity of ecosystems are directly regulated by temperature. Projected increases in temperature are expected to disrupt present patterns of plant and animal distribution in aquatic ecosystems. Changes in precipitation and runoff modify the amount and quality of habitat for aquatic organisms, and thus, they indirectly influence ecosystem productivity and diversity (Poff. *et al.,* 2002).

Figure 1: Forest Fire

Increases in water temperature will cause a shift in the thermal suitability of aquatic habitats for resident species. The success with which species can move across the landscape will depend on dispersal corridors, which vary regionally but are generally restricted by human activities. Fish in lowland streams and rivers that lack northward connections and species that require cool water (e.g., trout and salmon), are likely to be the most severely affected. Some species will expand their ranges in the United States. Seasonal shifts in stream runoff will have significant negative effects on many aquatic ecosystems. Streams, rivers, wetlands, and lakes in the western mountains and northern Plains are most likely to be affected because these systems are strongly influenced by spring snowmelt and warming will cause runoff to occur earlier in winter months. Increased water temperatures and seasonally reduced stream flows will alter many ecosystem processes with potential direct societal costs. For example, warmer waters, in combination with high nutrient runoff, are likely to increase the frequency and extent of nuisance algal blooms, thereby reducing water quality and posing potential health problems (Poff *et al.,* 2002).

- **Increased rainfall**

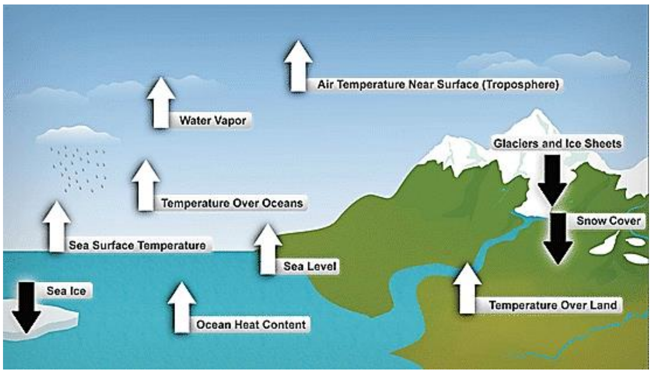
Warmer air holds more water, making heavier downpours more likely as temperatures have increased. This increased heavy rainfall can lead to increased flooding, damaging property, and threatening lives. In the UK, there is evidence that some specific weather events, such as the heavy rainfall in the winter of 2014/15, have been made more likely by climate change (Schaller *et al.,* 2016). Similar impacts are occurring elsewhere in the world. The record amount of rain that fell on Houston during Hurricane Harvey in 2017 helped make it the second most costly hurricane to hit the USA since 1900. Climate change has made a damaging downpour like this around three times more likely.

- **Changes in the availability of food and freshwater**

Changing weather patterns have affected crop yields – the number of crops like wheat and maize that can be produced from an area of land. In some areas of the world climate change has helped yields go up, but overall yields have not risen as fast as they would without the effects of climate change. The availability of freshwater for drinking and agriculture in some places has also been affected, particularly downstream from melting glaciers, in areas like the European Alps. Glaciers are an important source of drinking water for almost one-third of the global population.

- **Rising sea levels**

Higher air temperatures are causing the increased melting of huge ice sheets on land in Antarctica and Greenland, which run off into the oceans. The warming planet is also causing an expansion of seawater, increasing its volume - similar to how the liquid inside a thermometer expands when it is heated. Both of these factors are driving an increase in global sea levels. The global sea level has risen by around 20 cm since the start of the 20th century. This has made storm surges – the rise in sea level that occurs during intense storms – more likely to exceed existing sea defenses and cause flooding. As many densely-packed cities are in low-lying coastal regions around the world, this hazard can affect large numbers of people. This is particularly true in developing countries such as Bangladesh, but cities like Venice and Miami are also low-lying and will be affected too. In the UK, rising sea levels have contributed to recent decisions to abandon areas of coastline, such as the village of Fairbourne on the Welsh coast. Coastal wetlands are particularly vulnerable to sea-level rise associated with increasing global temperatures. Inundation of coastal wetlands by rising sea levels threatens wetland plants. For many of these systems to persist, a continued input of suspended sediment from inflowing streams and rivers is required to allow for soil accretion.



- **Loss of biodiversity and nature**

In the ocean, the increase in water temperature is putting pressure on ocean life. The Great Barrier Reef, where the coral population is in shallow water, has recently declined by up to 50% (Hughes *et al.*, 2017). The ocean heat that caused large damage to the Great Barrier Reef in 2016 would have been highly unlikely before the time of the industrial revolution around 200 years ago but is now likely to happen around 1 in every 3 years on average in today's climate (King *et al.*, 2017). Current ocean conditions haven't existed in at least the last 65 million years. There is also evidence of climate change affecting nature on land, with many species of plants and animals shifting to new areas due to warming.

- **Warm water habitats**

Warm water habitats occur in both urban and rural settings, and many have been greatly altered by channelization, damming, pollution, water withdrawals, and sedimentation. Warm water habitats support a variety of recreational activities, including valuable multispecies fisheries, and are also biologically diverse, containing numerous species of conservation concern.

- **Coral reefs**

Tropical intertidal and sub-tidal regions are dominated by ecosystems that are characterized by a framework of corals. They have undergone major changes, much of which have been associated with climate change. Despite the lack of external nutrients, these ecosystems form rich and complex food chains that support the large population of fish, birds, turtles, and marine mammals. Corals form the essential framework within which a multitude of other species makes their home. Fish that depend on corals for food, shelter, or settlement care may experience changes in the reef-building coral communities that are likely to have huge impacts on marine biodiversity. Corals form the essential framework within which a multitude of other species makes their home. Fish that depend on corals for food, shelter, or settlement cures may experience dramatic changes in abundance.

- **Seasonal patterns of precipitation**

Climate change can affect the intensity of the precipitation. Warmer oceans increase the amount of water that evaporates into the air. When more moisture-laden air moves over land it can produce intense precipitation. Inputs of dissolved chemical constituents into undisturbed aquatic ecosystems come from two sources, direct input of precipitation - runoff from the watershed and volume of the lake, the size of the watershed, and the type of soil. In aquatic ecosystems with a small lake area and volume and watershed area, the composition of its output will be controlled by direct input of precipitation. Undisturbed aquatic ecosystems in remote areas have been defined as having no local sources of anthropogenic inputs such as sewage or industrial wastes. Because they show a more pronounced dependent on precipitation as a source of nutrients. Due to magnitude of the magnitude of fossil fuel combustion and the long-range atmospheric transport of its volatile combustion products, the ionic composition of precipitation in remote areas is increasing.

What about the future impacts of climate change?

Much of the carbon dioxide we have already emitted will remain in the atmosphere for centuries – some even for thousands of years. As we continue to add to it, the concentration of carbon dioxide and other greenhouse gases will increase and the planet will become even hotter.
As the world warms, the impacts of climate change are becoming stronger and clearer: more frequent heatwaves, the declining availability of water in regions that are already dry today, and substantial risks to the diversity of animals and plants around the world today. The consequences of these impacts, and the possibility of higher migration of people around the world to escape them, have led to efforts to slow and eventually halt global warming by tackling its causes.

What is 'NET ZERO'?

The planet will only stop warming when we reach 'net-zero' carbon dioxide emissions. Achieving net-zero means reducing global greenhouse gas emissions to a much lower level than today – and balancing the remaining emissions by reabsorbing the same amount from the atmosphere. Greenhouse gases can be absorbed by growing trees and plants, as well as through technological processes that can remove carbon dioxide from the air, but have not yet been used at a large scale. Reducing global greenhouse gas emissions rapidly and emitting as little as possible on the way to net zero will also help minimize further changes in the climate.

What is climate assembly UK going to consider?

The scale of climate change risks has led to an international agreement to reduce global greenhouse gas emissions. This is called the Paris Agreement. It aims to keep global warming to beneath 2°C above temperatures before the industrial revolution, around 200 years ago – and to pursue efforts to keep it below 1.5°C. At the moment, every country in the world has signed the Paris Agreement. However, the United States, under the direction of President Donald Trump, has signaled that it intends to leave The Paris Agreement later this year. Several countries around the world – including the UK – have also signed up for a national goal of net-zero greenhouse gas emissions as part of our contribution to this global effort. In June 2019, the UK's Government and Parliament agreed on a law committing the UK to reach net-zero greenhouse gas emissions by 2050. The topic you are going to discuss at Climate Assembly UK is what the UK should do to achieve this goal, and how it should do it.

Suggestion:

Greta Thunberg is an extremely influential climate change activist who became famous in 2018 after protesting in front of the Swedish parliament. She decided to help and protect the planet. Likewise, we are not totally dependent on rules because we can't save the world by playing by the rules because the rules have to be changed. Everything needs to change and it has to start today. We are maintaining our planet's Oceans and fauna, funding the necessary research to advocate non-bias or politically motivated outcomes.

To make something better, to increase the value. What could be more valuable than our oceans? What we as people do to the oceans determines the future of all life as we know it. Seas make up more than 71% of the planet's surface. Advocacy and creating awareness are keys to conserving nature. By continued pressure on government bodies and corporations to the existing problems, real change can only be made.

The manner in which humans adapt to a changing climate will greatly influence the future status of inland freshwater and coastal wetland ecosystems. Minimizing the adverse impacts of human activities through policies that promote more science-based management of aquatic resources is the most successful path to continued health and sustainability of these ecosystems. Management priorities should include providing aquatic resources with adequate water quality and amounts at appropriate times, reducing nutrient loads, and limiting the spread of exotic species.

Conclusion:

The aquatic habitats including both freshwater and marine water habitats need to be preserved. The changes in climate like greenhouse – gas emissions and seasons impact the flora and fauna in many ways. So, to preserve a livable climate, greenhouse-gas emissions must be reduced by half by 2030 and to net zero by 2050. Bold, fast, and wide-ranging action needs to be taken by governments, foreign agencies, and businesses. Every one of us can help limit global warming and take care of our planet. By making choices that have less harmful effects on the environment, we can be part of the solution and influence change.

It is the responsibility of every person on this great planet to strive to improve this magnificent resource. We need a proper awareness program and training for future conservation. We strive to effect change by supporting like-minded organizations and groups. Making little changes in the way we live can go a long way to reducing energy use—and carbon emissions. Small acts when multiplied by millions of people, can transform the world

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FLORISTIC PATTERN OF COMMON SALINE PLANTS ON SEACOAST OF UMBERGAON REGION OF GUJARAT

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Introduction:

Seacoast plants grow above the high tide line, trapping and holding windborne sand to stabilize the formation of new dunes. They have evolved to withstand constant wind and salt spray. Many have moisture-retaining capabilities and grow along the beach and on the rocky headlands in exposed sunny situations. In a few areas littoral rainforest communities occur close to the sea on nutrient-enriched deep sands, often with a wind-sheared upper canopy. Removal of the seacoast's natural pioneer plants causes beach erosion. In urban areas scars are visible where the native vegetation has been smothered by weeds invading from coastal gardens where fertilizers are allowed to drain onto the beach.

This plants which grow in saline soils is so great that only specially adapted plants such as halophytes grow naturally upon them. Osmotic pressure, even as high as 150 atm., have been recorded in mangrove trees such as Avicennia. Sometimes in some of them (e.g. Cressa cretica) superfluous salts are excreted by guttation through special glands. Halophytic herbs grow chiefly during the rainy season owing to dilatation of the soil solution and also due to the movement of the salt down below the root zone.

A special halophytic vegetation represented by the well-known mangrove formations, some of them typically Indian are found on the Saline soils of the Sunderban area. All the regions are continually washed by tidal rivers and as a result of saline soil everywhere is sandy, loose and swampy. Such waterlogging by saline water, relatively high rainfall, high humidity, more or less equable temperature and complete absence of ground frost are some of the essential conditions necessary for the development of mangroves. Dense and frequently repeated cloudiness apparently is also an important climatic factor for the occurrence of mangroves in the tropics. During the recent years the mangrove forests have undergone considerable modifications in various regions due to biotic influences, i.e. manmaid activities.

Plant description

Caryophyllaceae

Polycarpaea Lam. (nom. cons.)

Polycarpaea corymbosa (L.) Lam. Encyl. 2:129.1797; Edgew. & Hook f. in Hook f. Fl. Brit. India 1:245.1874; Cooke, Fl. Pres. Bombay 1:70.1958; Majmudar in Sharma *et al.* Fl. India 2:549.1993. *Achyranthus corymbosa* L. Sp. Pl. 205.1753.

Habit: Annual herb.

Leaves: Whorled, linear.

Flowers: Many, in terminal cymes, sepals lanceolate, acute.

Capsule: 3-valved.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS	■	■						■	■	■	■	■
FRS	■	■						■	■	■	■	■

Distribution: Common in Nargol, Maroli sea coast.

Herbarium No.: VHR 387

Fabacee (Papilionaceae)

Derris Lour. (nom. cons.)

Derris trifoliata Lour. Fl. Cochinch. 2:433.1790; Thoth. in Bull. Bot. Surv. India 3:181. (1961) 1962 & in Fasc. Fl. India 8:30. 1982; Sanj. Legumes of India 148. 1991. *Derris uliginosa* (Willd.) Bth. in Miq. Pl. Jungh. 1:252.1852; Baker in Hook. f. Fl. Brit. India 2:241. 1878; Cooke, Fl. Pers. Bombay 1:431. 1958.

Habit: Scandent shrub.

Leaves: Ovate-oblong, apex shortly acuminate, base rounded.

Flowers: Rosy pink, in axillary racemes.

Capsule: Pods oblong, reticulately veined.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS				■	■	■	■	■	■	■		
FRS				■	■	■	■	■	■	■		

Distribution: Along the sea coast; Umbergaon.

Herbarium No.: VHR 2120

Rhizophoraceae

Key to the Genera

1. Leaves mucronate …………………………………………..Rhizophora

1. Leaves not as above:

2. Bracteoles present ……………………………………… Ceriops

2. Bracteoles absent...……………………………………… Bruguiera

Bruguiera lam.

Bruguiera gymnorhiza (L.) Savigny in Lam. Encycl. 4:696. 1798; Henslow in Hook. f. Fl. Brit. India 2:437. 1878; Cooke, Fl. Pers. Bombay 1:504. 1958. *Rhizophora gymnorhiza* L. Sp. Pl. 443. 1753. (Sanvar)

Habit: Tree.

Leaves: Lathery, ovate, apex acute, base tapering.

Flowers: Drooping, calyx reddish, corolla brown, deeply bifid.

Capsule: Indehiscent, hypocotyls conical, smooth.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Rare, in tidal mangrove forest, Umbergaon.

Herbarium No.: VHR 1074

Ceriops arn.

Ceriops tagal (Perr.) C. B. Rob. in Philip. J. Sci. Bot. 3:306.1908; Ding Hou in Steenis, Fl. Males. 1,5:469, f.24. 1958. *Rhizophora tagal* Perr. in Mem. Soc. Linn. Paris 3:138. 1824. *Ceriops candolleana* Arn. in Ann. Nat. Hist. 1:364. 1838; Henslow in Hook. f. Fl. Brit. India 2:436. 1878; Cooke, Fl. Pers. Bombay 1:503. 1958.

Habit: Shrubs or small tree.

Leaves: Ovate-oblong, thick, yellowish green, base tapering.

Flowers: Petals with 3 hairs at tip.

Fruit: Indehiscent, pendulous, rough, hypocotyl ridged.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common along tidal swamps, Umbergaon.

Herbarium No.: VHR 1072

Rhizophora L.

Rhizophora mucronata Poir. in Lam. Encycl. 2:517. 1794; Henslow in Hook. f. Fl. Brit. India 2:435.1878; Cooke, Fl. Pers. Bombay 1:501. 1958. (KAROD)

Habit: Tree.

Leaves: Oblong-elliptic, base cuneate.

Flowers: Corolla white, shorter than calyx lobe.

Fruit: Indehiscent, ovoid-conical, pendulous, dark brown.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common along mangrove forest.

Herbarium No.: VHR 1372

Sonneratiaceae

Sonneratia L.f.

Sonneratia apetala Buch.-Ham. in Symes, Emb. Ava 3:313, t.25.1800; C.B.Cl. in Hook. f. Fl. Brit. India 2:579. 1879; Cooke, Fl. Pers. Bombay 1:547.1958.

Habit: Tree.

Leaves: Thick, apex obtuse, obscure.

Flowers: Calyx cup-shaped, stamens slightly exserted.

Fruit: Indehiscent, depressed-globose, tipped with style.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common in the tidal forests, Nargol.

Herbarium No.: VHR 20

Aizoaceae

Sesuvium Linn.

Sesuvium portulacastrum (L.) L. Syst. (ed. 10) 1058. 1759; FBI 2:659; C 1:589; S & J 24. *Portulaca portulacastrum* L. Sp. Pl. 446. 1753. Raghavan 39. FGS 1: 337. FMS 2: 87. 2001.

Habit: Perennial prostrate succulent herb.

Leaves: Opposite, fleshy, linear.

Flowers: Purple, axillary solitary.

Capsule: Oblonged, covered with persistent calyx.

Seeds: Black.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast; Nargol.

Herbarium No.: VHR 1391

Myrsinaceae

Aegiceras Gaertn.

Aegiceras corniculatum (L.) Blanco, Fl. Filip. 1:79.1837; Jafri and Guiser in Nasir & Ali, Fl. W. Pakisan 89:7, f. 2 C & D.1975. *Rhizophora corniculata* L. in Stickm. Herb. Amb. 13. 1754 & Amoen. Acad. 4:123.1762. *Aegiceras majus* Gaertn. Fruct 1:216, t.46.1788; C.B.Cl. in Hook. f. Fl. Brit. India 3:533.1882; Cooke, Fl. Pres. Bombay 2:147.1958.

Habit: Shrub or small tree.

Leaves: Obovate-oblong, shining above, base cuneate.

Flowers: White, fragrent, in terminal umbels.

Capsule: Reddish brown.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast; Umbergaon.

Herbarium No.: VHR 1205

Asclepiadaceae

Pergularia Linn.

Pergularia daemia (Forsk). Chiov. Res. Sci. Miss. Stefan Panoli Somali. Ital. 1:115 1916; WI 7:309. f. 137; Ch & O 140; S & J 32. Raghavan 51. *Asclepias daemia* Forsk. Fl. Aegypt.-Arab. 51.1775. *Daemia extensa* R. Br. in Mem. Wern. Soc. 1:50. 1809; FBI 4:20. FGS 1: 429. 1978; FMS 2 : 375. 2001. (*Chamar dudheli*)

Habit: A hispid twiner.

Leaves : Opposite, membranous, broadly ovate.

Flowers : Greenish yellow in corymbose cymes.

Follicles : Echinate, beaked, grayish.

Seeds: Ovate, hairy.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Umbergaon, on sea coast.

Herbarium No.: VHR 2521

Boraginaceae

Sericostoma Stocks ex Wight

Sericostoma pauciflorum Stocks ex Wight, Ic. t. 1377. 1848; C.B.Cl. in Hook. f. Fl. Brit. India 4:175.1883; Cooke, Fl. Pres. Bombay 2:288.1958; Kazmi in J. Arnold Arbor.51:181.1970. (KARVAS)

Habit: A perennial herb or undershrub.

Leaves : Linear-lanceolate, appressed hairy on both side.

Flowers : White, in terminal raceme, calyx enlarged in fruit.

Nutlets : Ovoid-oblong, tuberculate.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Occasional in coastal areas.

Herbarium No.: VHR 2631

Convolvulaceae

Key to the Genera.

1. Styles 2 …………………………………………………….…… Cressa.

1. Style 1 ………………………………………………………. Ipomoea

Cressa Linn.

Cressa cretica L. Sp. Pl. 223. 1753; FBI 4 : 225; C 2 : 296; WI 2 : 367; S & J 34; Austin, Revise Hendb. Fl. Ceyl. 1: 304. 1980. FGS 1: 463. 1978; FMS 2: 452. 2001. (KHARIYU)

Habit: A small much branched diffused grey herb.

Leaves: Ovate, silky hairy.

Flowers: White in axillary clusters.

Capsule: Ovoid, pointed.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common in saline soil and salt pans, Umbergaon.

Herbarium No.: VHR 413

Ipomoea Jacq.

Ipomoea pes-caprae (L.) R.Br. Hort. Sw. Lond. 35. 1818; WI 5 : 251; S & J 34. Raghavan 57. *Convolvulus pes-caprae* L. Sp. Pl. 159. 1753; *Ipomoea biloba* Forsk. Fl. Aegypt-Arab. 44. 1775; FBI 4 : 212; C 2 : 317. FGS 1 : 472. 1978; FMS 2 : 467. 2001. (*Dariya nivel*)

Habit: A perennial prostrate, twining herb.

Leaves: Orbicular, deeply two lobed, fleshy.

Flowers: Rose – purple, solitary or 2-3 axillary.

Capsule: Ovoid, apiculate, brown.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common along coastal sand places; Nargol.

Herbarium No.: VHR 1204

Pedaliaceae

Pedalium L.

Pedalium murex L. Syst. Nat. (ed. 10) 1123. 1759; FBI 4:386; C 2:412; Bruce in Fl. Trop. Africa 6:1953; WI 7:284; S & J 38; Abedin, Fl. W. Pak. Pedaliaceae 33:1. f. 1 F-H. 1973. Raghavan 64. FGS 1: 523. 1978; FMS 2: 586. 2001. (*Ubhu gokhru*)

Habit: An annual erect herb.

Leaves: Opposite, ovate or elliptic-oblong.

Flowers: Yellow, axillary solitary.

Drupes: Pyramidal-ovoid, spiny.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: On sea coast, common.

Herbarium No.: VHR 2528

Acanthaceae

Acanthus L.

Acanthus ilicifolius L.Sp. Pl. 639. 1753; C.B.Cl. in Hook. f. Fl.Brit. India 4:481.1884; Cooke, Fl. Pres. Bombay 2:427. 1958; Sant. in Univ. Bombay Bot. Mem.2:16.1952.

Habit: Subshrub, armed.

Leaves: Pinnatifid, coriaceous, apex acuminate, lobes zigzag.

Flowers: Bluish-purple, sessile, in opposite pairs.

Capsules: Oblong, obtuse, apiculate, brown, smooth, shining.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the coast in tidal swamps, Nargol.

Herbarium No.: VHR 1571

Avicenniaceae

Avicennia L.

Key to the Species

1. Stem blackish; inflorescence spicate; capsules ellipsoid ……..
……….. A. alba

1. Stem greyish; inflorescence umbellate; capsules ovoid:

2. Trees 10-20 m tall; capsules beaked……….A. officinalis

2. Shrubs or small trees; capsules apiculate…… A. marina

Avicennia alba Bl.Bijdr. 821.1826; Cooke, Fl. Pres. Bombay 2:517. 1958; Banerjee *et al.* Mangroves in India Id. Man. 33,f.35.1989. *A. officinalis* L. var. alba (Bl.) C.B.Cl. in Hook.f.Fl. Brit. India 4:604.1885(TIVAR)

Habit: Trees, bark lenticelled.

Leaves: Lanceolate, silvery papilose below, acute at apex.

Flowers: Yellow, fragrent.

Capsules: Ellipsoid, shortly beaked at apex.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Frequent along river banks near coastal areas; Waroli.

Herbarium No.: VHR 1231

Avicennia marina (Forssk.) Vierh. var. acutissima Stapf & Mold. in Phytologia 1:411.1940 & 7:225. 1960; Banerjee *et al.* Mangroves in India Id. Man. 39. 1989. (Tivar)

Habit: Shrubs.

Leaves: Elliptic, sharply acuminate at apex, cuneate at base.

Flowers: Yellow.

Capsules: Ovoid.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along elevated tidal flats, Umbergaon.

Herbarium No.: VHR 51

Avicennia officinalis L. Sp. Pl. 110. 1753; C.B.Cl. in Hook. f. Fl. Brit. India 4:604. 1885; Cooke Fl. Pres. Bombay 2:516.1958. *A. tomentosa* Jacq. Enum. Pl. Carib. 25. 1760. (TIVAR)

Habit: Trees.

Leaves: Broadly ovate-elliptic or oblong, glabrous above, tomentose beneath, base tapering.

Flowers: Yellow, sessile in axillary cymes, calyx ciliate on margins.

Capsules: Ovoid, compressed, beaked.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Infrequent along coastal swamps, Nargol.

Herbarium No.: VHR 764

Chenopodiaceae

Key to the Genera.

1. Stems leafy not jointed…….……………………………Suaeda.

1. Stems jointed………………………….……………Arthrocnemum.

Arthrocnemum Willd.

Arthrocnemum indicum (Willd.) Moq. Chenop. Enum. 113. FBI 5 : 12. C 2 : 589. FGS 1 : 598. 1978; FMS 2 : 794. 2001. (Machhar ni bhaji)

Habit: Perennial prostrate herb.

Leaves: Fleshy, thick.

Flowers: Small, pink, anthers oblong-ovoid.

Fruits: Ovoid, compressed.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common along sea coast, Umbergaon.

Herbarium No.: VHR 1250

Suaeda Forssk. ex Scop (nom. cons.)

Key to the Species.

1. Erect; flowers 1-3 nate; bracteoles with entire or slightly toothed margins……………………………………………fruticosa.

1. Diffuse; flowers many in dense clusters; bracteoles with pectinate margins……………..…………………………nudiflora.

Suaeda fructicosa (L.) Forsk. Fl. Aegpt-Arab. 70. 1775; FBI 5:13; C 2:590; l.e. Gujarat, Baroda, Bhavnagar, S & J 43. *Salsola fruticosa* L. Sp. Pl. ed. 2. 324; 1762. Gr. 170. Salsola land, Edgew. In HK. Journ. Bot. 2:230:1840. FGS 1 : 600. 1978; FMS 2 : 796. 2001. (Khari Luni Ni BhajI)

Habit: Erect or diffuse perennial herb; branches glaucous green. Leaves: Sessile, fleshy, subterete.

Flowers: Minute, deep green in axillary globose clusters.

Utricles: Ovoid, smooth.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast on mud flats, common.

Herbarium No.: VHR 380

Suaeda nudiflora (Willd.) Moq. in Ann. Sci. Nat. 23:316. 1831; FBI 5:14; C 2:591; S & J 43. *Salsola nudiflora* Willd. Sp. Pl. 1:1313. 1797. Gr. 170. FGS 1: 600. 1978; FMS 2: 797. 2001. (Moras)

Habit: A perennial much branched woody shrub. Stem yellowish. Leaves: Fleshy, glaucous green.

Flowers: Green in axillary dense clusters.

Utricle: Ovoid.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast on mud flats, common.

Herbarium No.: VHR 763

Euphorbiaceae

Excoecaria L.

Excoecaria agallocha L. Sp.Pl. ed. 2, 1451. 1762; Hook. f. Fl. Brit. India 5:472. 1888; Cooke, Fl. Pres. Bombay 3:122. 1958; Airy Shaw in Kew Bull. 26:168.1972.

Habit: Shrubs with milky latex.

Leaves: Alternate, ovate-elliptic, coriaceous, apex acuminate.

Flowers: Greenish yellow, male flowers in axillary spike.

Capsules: Deeply lobed, smooth.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast on mud flats, common.

Herbarium No.: VHR 1249

Poaceae (Gramineae)

Key to the Genera

1. Herbs or shrubs, not woody without culm-sheaths; leaves with paralled veins, not articulate on sheaths:

2. Grasses unawned ……..…………………………. Aleuropus.

2. Grasses awned ………………………………………Perotis.

1. Spikelets 2-flowered, falling entire at maturity, usually with the upper floret hermaphrodite and the lower male or barren and if the latter, of ten reduced to the lemma or rarely the lemma entirely absent, all alike or more often differing in size, shape and structure frequently compressed:

2. Grasses unawned ………..…………………………. Setaria.

2. Joints not toothed at apex……………………Cymbopogon.

Aeluropus Trin.

Aeluropus lagopoides (L.) Trin. ex Thw. Enum. Pl. Zeyl. 374. 1864; Bor, Grass. Ind.380. 1960. *Dactylis lagopoides* L. mant. 33. 1767. *Aeluropus villosus* Trin. ex C.A. Mey. Verz. Pfl. Cauc. 18. 1831; Hook. f. Fl. Brit. India 7:334.1896; Cooke, Fl. Pers. Bombay 3:567.1958. A. repens (Desf.) Parl. Fl. Ital. 1:462.1848; Blatt. & McC. Bombay Grass. 277. 1935.

Habit: Perennial herb.

Leaves: Narrowly lanceolate, acuminate, flat.

Spikelets : Elliptic-oblong in globose panicles.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast; Umbergaon.

Herbarium No.: VHR 1836

Cymbopogon Spr.

Cymbopogon jwarancusa (Jones) Schult. Mant. 2:458.1824; Blatter & McC 102; Bor 128; Patel 91:313. *Andropogon jwarancusa* Jones in As. Res. 4:109. 1795; C 3:495. *Andropogon jwarancusa* Jones subsp. jwarancusa ; FBI 7:203.

Habit: Perennial herb.

Leaves: Flat, narrowly linear.

Spikelets : 3-4 pairs, pedicelled spikelet equal to or rather larger than sessile one.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast; Umbergaon.

Herbarium No.: VHR 2231

Perotis Ait.

Perotis indica (L.) O Ktze. Rev. Gen. Pl. 3:787. 1891; Blatter & McCann 220.t.147; Bor 611.t.72; Patel 91:337. *Anthroxanthum indicum* L. Sp. Pl. 28. 1753. *Perotis latifolia* Ait. Hort. Kew. 1:85. 1789; FBI 7:98; C 3:538. FGS 2: 856. 1978; FMS 3: 568. 2001.

Habit: A slender leafy annual herb, branching from base.

Leaves: Ovate-lanceolate, margins spinulous.

Spikelets: Pedicillate, 1-flowered, in terminal racemes.

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	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Common along sea coast, Nargol.

Herbarium No.: VHR 112

Setaria P. Beauv (nom. cons.)

Setaria pumila (Poir.) R. & S.; *Setaria pallide-fusca* (Schum.) Stapf & Hubb. in Kew Bull. 1930; 259. 1930; Bor 363; Patel 91:327; S & J 57. *Panicum pallide-fuscum* Schum. Beskr. Guin. Pl. 58. 1827. FGS 2: 864. 1978; FMS 3: 595. 2001.

Habit: An annual tufted herb.

Leaves: Linear.

Spikelets: Ellipsoid in spikes.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
FLS												
FRS												

Distribution: Along the sea coast; Umbergaon.

Herbarium No.: VHR 1840

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TOTAL LIPID CONTENT IN INTENSTINE OF FINGERLINGS OF FRESHWATER FISH *LABEO ROHITA* FED ON FORMULATED FEED

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Abstract:

Aquaculture is the fastest growing food production sector in the world. For the expansion of aquaculture to need nutritious and low-cost fish feed because feed contributes significantly to the cost and efficiency of fish production. The quality of flesh of fish is evaluated with the biochemical composition of fish. For this in the present experiment, Nighty days experiment was conducted in glass aquaria to study lipid content in intestine of fingerlings of freshwater fish *Labeo rohita* fed on 100%,75%,50% and 25% non-conventional source of protein in formulation of fish feed i.e. .Blood of bovine animals obtained from slaughter house waste and conventional feed .i.e. .Groundnut oil cake. The fishes were fed at the rate of 2% of the body weight every day. After specific time intervals the fishes were weighed and sacrificed for intestine tissue. The tissue were quickly excised and cleaned off extraneous material, weight and used for estimation of total lipid by Floch's method. Results revealed that the total lipid was highest at 75% formulated feed followed by 25%, 50% and 100% formulated feed.

Keywords: Non-conventional resource, Formulated Feed, *Labeo Rohita*, Total lipid.

Introduction:

Fisheries have always played a very significant role in many countries and communities (Sakthivel *et al.*, 2017). Fish require a high quality and nutritionally balanced diet for adequate growth within the shortest time. Therefore, local production of fish feed using locally available ingredients at low cost is crucial to the development and sustainability of aquaculture. Affordable quality feed will make fish farming attractive to private investors and boost fish production. In the fish feed formulation protein in the feedstuffs helps to formulate proper and growth effective fish diet (Maina *et al.,* 2002). The identification and utilization of non-conventional and lesser utilized plant protein sources to replace fishmeal either partially or totally in practical diets of fish has been an area of research in aquaculture nutrition (Siddhuraju and Becker, 2003). However the increasing cost of quality fish feed required for aqua feed, due to decline in stocks of fish form capture fishery and competition for feed in animal husbandry, therefore need of search alternative sources of animal protein for fish feed. Hence in the present study, non-conventional animal protein source as blood of bovine animal is used in feed formulation as primary ingredient along with other ingredient.

Fishes and their biochemical parameters can be considered as bio-indicators or bio-monitors of aquatic system for assessing the quality of water and also the survival and growth rates of fishes grown such environment.

Biochemical composition is of great help in evaluating not only fish nutritive value but also helps in quality assessment and optimum utilization of these natural recourses (Rodriguez-Gonzalez *et al.,* 2006; Dong-Kyu Kim *et al.*, 2012). In fish, the lipids and their constituent Fatty Acids (FA) along with their metabolic derivatives, such as the eicosanoids, play significant roles in various functions of the organism, including growth, health and reproduction (Sargent *et al.,* 2002). Dietary lipids provide energy and Essential Fatty Acids (EFA) to the fish and they also assist the absorption of fat-soluble vitamins (NRC, 1993). Lipids play important physiological roles in providing energy, essential fatty acids and fat soluble nutrients for normal growth and development of fish and human being. Hence in the present study aimed to determine effect of different combinations of formulated feed (100%, 75%, 50% and 25%) and conventional feed on activity total lipid alteration in gill and muscle of freshwater fish *Labeo rohita* which gives the understanding of utilization of nutrients in feed by fish.

Material and Method:

Formulation of feed

In the present study, for formulation of fish feed, the non-conventional animal protein source such as blood of bovine animal (80gm) was taken along with ingredients like milk powder (60 gm), corn flour (20 gm) and eggs (70 gm) were added and mixed well. Agar powder (4 gm) was added as binding agent and turmeric (0.5gm) and garlic (1 gm) were added as antibiotics. Then the mixture was boiled and cooled at room temperature. After cooling cod liver oil (3.5 ml) was added. The vitamin mixture of vitamin B complex (1gm) and vitamin E (1ml) were added in the mixture. This mixture was kept under refrigeration for 12 hrs. After 12 hrs it was squeezed over polythene sheet and then dried at room temperature for 24 hrs. The dried nodules were crushed into small pellets. The nodules were sun dried to avoid fungal infection. Finally it was weighted and stored in the bottle. Following the above procedure all the feeds were formulated in the percentage composition of 25% (blood 25%+groundnut oil cake 75%), 50% (blood 50%+ groundnut oil cake 50%),75% (blood 75% + groundnut oil cake 25%),100%

formulated (100% blood) and 100% conventional (100% groundnut oil cake) (Bhilave *et al.*, 2010).

Experimental protocol

The fingerlings of freshwater fish *Labeo rohita* measuring about 4 to 5 cm in length were obtained from the Fish Seed Rearing Centre, Rankala, Dist. Kolhapur, unit of Department of Fisheries, Government of Maharashtra. After obtaining them, they were brought to the laboratory and acclimatized in rectangular glass aquaria of 36x12"with 60 liters capacity containing aerated water for seven days. During acclimatization adequate aeration was maintained and temperature was maintained from 280C to 300C. The fishes which survived during acclimatization were distributed randomly into five aquaria (10 in each) and labeled as per the feed combination. They were fed at the rate of 2% of total body weight. The feeding was done once in a day. The body weights and lengths were recorded at each time interval i.e.30, 45, 60, 75 and 90 days throughout the experimental period respectively.

Estimation total lipid by Barnes and Black Stock (1973)

The method is based on the ability of unsaturated lipid metabolism to produce by reaction with vanillin reagent. A colour compound whose intensity of coloration is proportion at for the total lipid concentration in the sample and it is measured at 540 nm.

Protocol

For lipid estimation homogenates of selected tissue (Intestine, gill and muscle) were prepared in Folch's mixture with mortal and pistal (Folch's *et al* 1957). The Folch's mixture was prepared by taking chloroform and methanol in 2:1 ratio. For standard graph known concentration of cholesterol were used for calculation. The blank and unknown tubes contained 1 ml of distilled water and homogenate from respective organ of fish fed on formulated feed. The homogenate as evaporated at 40^{o}C in water bath and then added 1ml of concentrated sulphuric acid. The tubes heated in boiling water bath for 10 minutes. After cooling 2 ml of vanillin reagent were added in each tube. The pink colour developed was measured at 540 nm on spectrophotometer. The standard graph was plotted against unknown sample and calculates the actual amount of lipid in all tissues.

Result and Discussion:

Islam and Tanaka (2004) reported that, protein is one of the most important dietary nutrients in feed and which considerably affecting by growth, survival and yield or production of fish. They are providing essential and non-essential amino acids to synthesize body protein and energy for maintenance. According Robinson and Lii (1998) and Mohanta (2013), the feed stuffs of animal origin are considered the better alternative protein sources of the fish meal in formulating fish feed because of their higher protein content and superior indispensable amino acids than that of plant origin. Thus, in the present investigation, the non conventional animal protein source such as blood of bovine animal is used in feed formulation as primary ingredient along with other ingredients which was observed enhance the growth and disease resistance in fishes.

Table 1: Total lipid content from intestine of freshwater fish *Labeo rohita* fed on conventional and formulated feed

Sr. No	Days	Conventional feed	Formulated feed			
			100%	75%	50%	25%
1	30 days	2.88±0.080	3.46±0.31 ns	3.96±0.17**	3.35±0.38 ns	3.78±0.25*
2	45 days	4.40±0.39	4.24±0.35 ns	6.15 ± 0.43**	3.78±0.30 ns	4.29±0.69 ns
3	60 days	5±0.05	6.16±0.43 ns	6.35±0.43 ns	4.66±0.25 ns	4.22±0.35 *
4	75 days	6.34±0.075	7.46±0.20 ns	6.59±0.92 ns	7.5±0.095 ns	5.11 ±0.58 ns
5	90 days	5.71 ±1.32	6.92 ±0.60 ns	7.51±0.095 ns	7.50±0.095 ns	7.49± 0.096*

Value expressed is mean of n (n=5) ± SD, * P< 0.05, **P<0.01, ***P<0.001, NS = Non significant

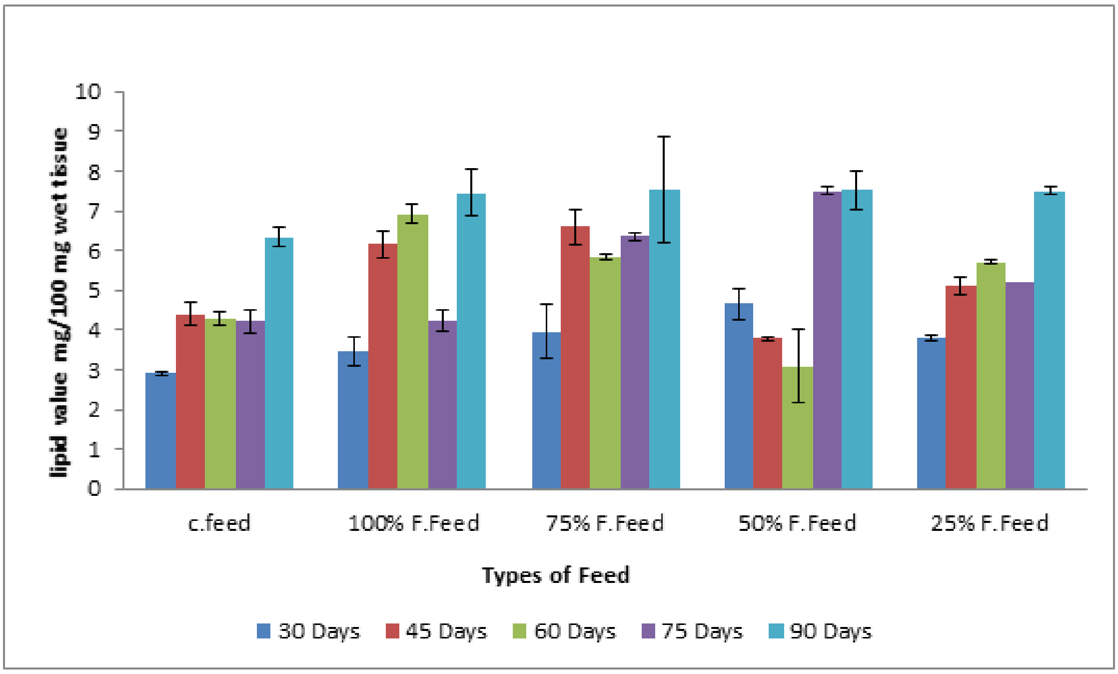

Figure 1: Total lipid content from intenstine of *Labeo rohita* fed on conventional and formulated feed

According Bhilave *et al.* (2011) to least cost formulation to include non-conventional animal protein source such as blood of bovine animal of with different percentage with groundnut oil cake (100%, 25%, 50%, and 75%) and this formulated feed was well accepted and utilized by fingerlings of *Labeo rohita.* Kaushik and Oilva –Teles (1985) and Medal *et al.* (1991) reported that the total lipid contents of fish are with gradual increase in the weight and length of the fish and also due to seasonal changes as well as the availability of nutrient in varied habitats.

In the present research work, the lipid content in intestine was oscillated from specific time interval such as 30,45,60,75 and 90 days. The highest lipid content was found at 75% formulated feed 7.51±0.095 mg/100mg wet tissue followed by 50% formulated feed was 7.50±0.095 mg/100mg wet tissue, at 25% formulated feed 7.49± 0.096 mg/100mg wet tissue and 100% formulated feed was 6.92 ±0.60 mg/100mg wet tissue as compared to conventional feed 5.71 ±1.32 mg/100mg wet tissue. Comparatively, the formulated feeds was observed non-significantly ($P>0.005$) lipid content compared with conventional feed. The lipid content at 75% formulated feed was significantly ($P<0.01$) varied between 30 and 45 days with conventional feed. At 25 % formulated feed fed groups was found less significant ($P<0.01$) difference in lipid content at 30, 60 and 90 days. Hence, above result stated that, the highest lipid content in intestine tissue of fingerlings of *L. rohita* was observed at 75% formulated feed followed by 50% formulated feed, 25 % formulated feed and 100% formulated feed when compared to conventional feed of 90 day experiment.

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SPOILAGE IN FISH AND SHELLFISH PRODUCTS

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Introduction:

Food preservation is required to extend its shelf life and preserve its nutritional value, texture, and flavour due to the ever-increasing global population and the necessity to store and move food from one location to another where it is needed. Consequently, effective food preservation methods must stop microbial decomposition of food without compromising its nutritional value and quality. Food products can become spoiled due to chemical, enzymatic or microbiological activities. Through microbial activity alone, one-fourth of the world's food supply and 30% of fish caught are lost. The quality of fish and fish products can be improved and their shelf life can be extended, by using the right handling, pretreatment, and preservation techniques. Fish was traditionally preserved via salting, drying, smoking, fermenting, and canning to keep it fresh longer. New techniques, such as cooling, freezing, and chemical preservation, were developed in response to consumer demands for texture, look, and flavour. A thorough analysis of the literature on fish rotting and contemporary preservation methods was conducted. Since the fish and its products is a high nutrient rich food, the spoilage accelerated rapidly due to this high nutritional content. The spoilage occurs due to the activity of enzymes, atmospheric oxidation and the action of microorganisms. There are different mechanisms through which the spoilage progress as discussed below:

(i) Spoilage due to Enzymatic Action

The autolytic enzymes present in the fish are the main cause of the enzymatic spoilage. The autolytic fish enzymes cause the fish spoilage rapidly. The high temperature accelerates the activity of these enzymes. Hence to prevent the spoilage the temperature must be lowered in the proximity of the fish.

(ii) Spoilage due to Oxidation

This spoilage occurs due to the oxidation of the fish fat. Due to the oxidation of various unsaturated fish oils, the degradation and hence the spoilage of fish occurs. Therefore, the fish spoilage is proportional to the fat present in it. A fatty fish degrades more rapidly than a lean fish.

(iii) Spoilage due to Bacterial Action

The microorganisms present in the fish are responsible for its bacterial spoilage. The spoilage commences after the stage of rigor mortis completes. It release of products of protein denaturation owing to a drop in pH that are usable by bacteria. Hence delaying the rigor mortis help in delaying the spoilage and hence keeps the fish fresh.

The factors that enhance the rigor mortis are mainly the shortage of oxygen, high temperature environment. In order to delay the rigor mortis, the enzyme activities need to be reduces and it can be done by lowering the pH and providing adequate cooling to the fish. The pH of the fish is also one of the key factors which determine the time and extent to which the bacteria may develop in the fish. Hence lower the pH of the fish implies slower bacterial decomposition of fish. When the muscle glycogen gets converted to lactic acid, the pH gets lowered.

Fish from both freshwater and saltwater, spoil in the same way. Fish are low in carbohydrates, high in protein and non-protein nitrogenous components (16–20%), and the fat content varies depending upon the species. Free amino acids, creatine, betaines, uric acid, taurine, anserine, carnosine, and histamine volatile nitrogen bases including ammonia and trimethyl amine (TMA) are among the non-protein nitrogenous substances found in fish. Due to a high bacterial load, fish spoilage starts at the surface, in the gills and in the intestine. As the spoilage progress, microorganisms from the intestine and the surface gradually migrate from the gills to the neighbouring tissue and cause rotting. The stomatitis organism first uses simpler substances, and subsequently fish protein releases a variety of ill-odorous substances.

Factors affecting spoilage of fish

The two characteristics that need to be defined explicitly are spoilage and freshness. A "fresh product" is the one whose original characteristics are unaltered. Whereas, spoilage reflects the changes occurring post-harvest. These changes can be categorized from absolute fresh to the acceptable limit or beyond it as unacceptable. Typically, physical traits alter as the spoilage progresses. Some characteristics of spoiled fish include a change in colour, ill-odour, a change in texture, eyes that have changed colour, gills that have changed colour, and mushy muscles. The bacteria, enzymes and the chemicals in the fish are the prime driving agents for the spoilage in fish.

1. **Kind of fish**

The spoilage of the fish varies widely. Some flat fish undergo the rigor mortis early than the round fishes, hence they spoil fast and more rapidly.The oxidation of unsaturated fats/oils causes certain fatty fish, such as oil sardines, to degrade quickly. Fishes those are rich in Trimethyl amine oxide (TMAO) spoil rapidly and emit a stale fishy odour by producing TMA.

2. **State of fish when captured**

Fish that have been overworked during capture (such as with gill netting or lengthy lining), or oxygen-deprived, and have been handled excessively deteriorate rapidly. This is mainly because the glycogen gets exhausted while the fish struggles and ultimately cause smaller drop in pH. Fish with a full stomach are more perishable than fish with empty intestines.

3. **The kind and degree of fish contamination**

Increased bacterial load occurs when fish are contaminated with bacteria from a variety of sources (dirt, water, handlers, contact surfaces, slime, etc.). Bacteria in slime, gill, and gut bacteria infiltrate the flesh and spoil it. In general, the greater the bacterial load, more and faster is the spoilage. Breakdown of food in the intestines of ungutted fish (whole fish) may generate odorous chemicals that allow decomposition products to diffuse into the flesh. Fish gutting on a boat exposes surface and intestinal slime germs to the flesh. However, thorough cleaning will get rid of the majority of bacteria, and appropriate cooling will stop them from growing. Damage to the fish skin or mucous membrane injury will hamper the keeping quality of the fish product.

4. **Temperature**

As the temperature rises, bacterial activity will be fast and food will spoil more quickly. By freezing the fish, its temperature is lowered and decreases the bacterial development that leads to deterioration. Cooling down to the temperature of about 0 degrees will help to delay the spoilage.

5. **Using preservatives**

Utilizing preservatives, such as antibiotics, will stop bacterial growth and increase the Shelf life of fish. However, some of the antibiotics are banned which must be avoid for fish preservation.

Features of spoiled fish

The progression of fish rotting can be detected by changes in exterior characteristics. As the rotting progresses, the following transformations occur in order:

- Fish lose their vivid colour and become discoloured as time goes on (appear dirty yellow or brown).
- An increase in skin slime, particularly on the gills.
- The cornea becomes opaque, the pupil becomes clouded, and the eyes gradually droop and shrink
- The colour of the gills changes from bright pink to pale yellow.
- Squeezing the flesh causes it to soften and release juice; pushing the flesh with fingers causes it to easily indent
- The flesh may be easily torn away from the backbone or vertebral column.

Release of odorous compounds:

TMA and other noxious substances will cause the natural, fresh sea weedy smell to shift to a painfully sweet, stale fishy smell. Additionally, fatty fish emit a rotten odour.

Spoilage of crustaceans (Shrimps, Crabs and Lobsters)

Crustacean spoilage is pretty similar to that of fishes. Depending on the handling and chemical makeup, spoilage varies. Crustaceans differ from fish in that they contain a little amount of carbohydrates (approximately 0.5%), more free amino acids than fish, and enzymes that quickly break down the proteins. The bacterial flora of crustaceans includes pollutants picked up during catching, handling, transportation, processing, etc. as well as bacteria from the water from which they were gathered.

Usually, spotting starts at the skin's surface. They are more prone to bacterial spoiling assault due to the larger concentration of free amino acids and nitrogenous extractives present. Production of huge levels of volatile base nitrogen (VBN) causes the initial spoilage. The lowering of TMA also results in the production of some VBN. As a result of further spoiling, foul-smelling substances are produced, and it becomes unfit for consumption.

Spoilage in Molluscs

The spoilage of molluscs differs from that of fish and shrimp due to differences in their chemical composition. When compared to fish and shrimp, these have high carbohydrate content and low total nitrogen level. Clams and oysters both include carbohydrates, primarily in the form of glycogen (3.40% and 5.60%) respectively. Due to the presence of glycogen, fermentation-related microbial deterioration is apparent. These also have higher concentrations

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of nitrogen bases than fish (free arginine, aspartic acid, and glutamic acid). Different spoilage patterns in molluscs compared to other seafood are caused by their higher carbohydrate content. The molluscs that feed on filters have a high bacterial load and contribute to spoilage.

As the fermentative type of spoilage continues, the pH decreases. This pH drop is used as a spoilage extent indicator. So, the best objective criterion for evaluating the microbiological quality of oysters is pH. As microbial quality parameters, pH, organoleptic quality, and microbial load are some of the microbial quality indicators. Oysters can be classified as good (pH 6.5- 5.9), off (pH 5.8), musty (pH 5.7-5.5), and sour/putrid using the pH scale as a microbiological quality indicator (pH 5.2 or below).

Semi-processed and processed fisheries product spoilage

Fresh as well as processed fish and fishery products can get spoiled due to the native microbial flora and microorganisms that infiltrate the food throughout various handling and processing phases. Even though it is sometimes anticipated that handling and treating fish after harvest will limit microbial growth, yet some process-tolerant and surviving bacteria persist and develop, resulting in product deterioration.

Microbiology and spoilage fresh fish

The microflora of the immediate environment from which fish is harvested directly correlates with the microbial load and types of microorganisms associated with the recently obtained fish. Additionally, number of microorganisms from fishing equipment such as nets, boat decks, fish contact surfaces, fish holds, and fishermen are added to the fish.When a fish dies, the microorganisms on its body surface, gills, and intestine begin to multiply and grow in quantity, which causes deterioration offish. As more time passes, the fish quickly becomes spoiled and unfit for consumption. The sunken eyes, loss of vibrant body pigment, fading of gill colour and the production of off-odor metabolites of spoilage bacteria are the main characteristics of the rotting fish.The Gram negative bacteria typically predominate in the rotting flora of fresh fish.

Reducing the activity of spoilage microorganisms, which can be accomplished by lowering the temperature of retaining the harvested fish, is the most efficient technique to prevent or delay deterioration of fresh fish.

Microbiology and spoilage chilled fish

Fish microflora is impacted when held at low temperatures close to the freezing point of water. The low temperature prolongs the shelf life of fish by reducing microbial and enzymatic activity. The quality of chilled fish is influenced by a number of variables, including the type of fish used, duration for which it is chilled, and how effectively it is stored. Many fish-associated bacteria can withstand low temperatures, and psychrotrophs are mostly responsible for spoiling. Gram negative bacteria predominate over gram positive bacteria in the bacterial flora. Microflora composition changes as a result of chill storage and mesophiles gradually give way to psychrophiles as the dominant species. However, the low temperature only helps keep fish in good condition for a short period of time. Continued storage under the cold environment leads to the growth of psychrophilic microorganismswhich cause spoilage of the fish.

Microbiology and spoilage of frozen fish

The bacterial load of the raw material, contamination during handling and processing, and the degree of removal of these contaminants during processing all affect the bacteriological quality of frozen goods. The storage under the frozen conditions has a significant impact on existing microorganisms and the reduction in count is variable.

Prevention and reduction of spoilage

Fish deterioration is brought on by bacterial, enzymatic, and chemical action. The right handling and quick lowering of the temperature can control, reduce, or even delay the activity of the organism. The amount of spoiling can be decreased by freezing the fish as soon as it is caught and keeping it at 0 degree Celsius with the right icing. When it comes to shrimp, removing the head as soon as it's caught will lower the rate of rotting. Beheading and eviscerating large fish will lessen the enzymatic reactions that lead to deterioration.

There are several methods for reducing or preventing spoiling, including drying, salting, chilling, canning and freezing. By lowering the temperature while utilizing ice, seafood can be chilled for short-term preservation. The best option for long-term seafood preservation currently available is freezing. Since fish maintains nearly the same natural conditions even after freezing, it is actually by far the best method for protecting fish from spoiling. It works well at keeping seafood's flavour, colour and nutritional value. The water in the fish muscle crystallizes into ice during the freezing process. At -40^{o}C, the crystallization will be completed.

The fish must be kept frozen and kept at a consistent temperature of -18 degree Celsius or lower. Variations in this temperature will result in product deterioration. If the temperature varies significantly, recrystallization occurs. Dehydration is another significant physical reaction brought on by the melting of ice and resulting in variations in the air in the storage area and over the product surface. The product surface dries out as a result of moisture loss from ice evaporation, giving it a dull appearance and, in some circumstances, even discoloration. The moisture from the product will continue to transfer as the evaporating water finally condenses and freezes on the storeroom's cooling surfaces.This evaporation can be prevented by proper glazing and packaging.

Conclusion:

Fish spoiling is caused by three main processes: microbial growth, oxidation, and enzymatic autolysis. The most widely used methods on the market today for controlling water activity, enzymatic, oxidative, and microbiological spoilage are chemical methods and low temperature storage. In conclusion, preventing fish from spoilage may reduces the wastage and increase the quality of finfish and shellfish, which may helps to reduces the human hunger.

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ALGAE AS A SOURCE OF FOOD IN FRESH WATER ECOSYSTEM

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Introduction:

Water is the life of every living organism. It is transparent, tasteless, odourless, colourless chemical substance, which is main constituent on earth's stream, lake, ocean and living organism. Fishing, agriculture, food processing, chemical industry, power plants, etc., are totally dependent on water; hence plays an important role in world economy. From biological point of view water has many distinct properties which are very important for all metabolic activities and proliferation of life. Algae are simple, aquatic, plant-like organisms that do not have true roots, stems and leaves. Algae have chlorophyll and can make their own food through the process of photosynthesis. Algae can range from unicellular to multicellular organisms. Many studies have shown that algae lack the specialized tissues that are found in land plants. The absence of these cells could be an adaptive mechanism to the environment in which the plants will live. More than half of the world's oxygen is produced by microscopic algae. Algae are classified into three groups namely Red algae, Green algae, and Brown algae. There are over 30,000 species of algae. Yet, we only learn of them when they become a nuisance and impact water quality, recreation, aesthetics, or when they cause unpleasant taste and smells. The most common species encountered in lakes and ponds are filamentous, planktonic, and macrophytic algae.

Plants and phytoplankton use these three ingredients (Carbon dioxide, water and sunlinght) to produce glucose (sugar) and oxygen. This sugar is used in the metabolic processes of the organism, and the oxygen, produced as a by-product, is essential to nearly all other life, underwater and on land. Freshwater algae are found growing underwater on rocks and mud in streams and rivers. They are usually more abundant in slower streams than in fast flowing rivers. There are thousands of species of planktonic algae, or microalgae, floating in water all over the world. Green algae, diatoms and dinoflagellates are the most well-known, though other microalgae species include coccolithophores, cryptomonads, golden algae, yellow-green algae and euglenoids.

An aquatic ecosystem is an ecosystem formed by surrounding a body of water, in contrast to land-based terrestrial ecosystems. Aquatic ecosystems organisms that is dependent on each other and on their environment. Aquatic ecosystems include oceans, lakes, rivers, streams, estuaries, and wetlands. Within these aquatic ecosystems are living things that depend on the water for survival, such as fish, plants, and microorganisms. Plant life that grows in and around a pond ranges from single celled algae, called phytoplankton, to large woody trees.

Fresh water ecosystem are made up of water on land consist of low salt level. It is of two types, first is Lentic or still water ecosystem which includes all ecosystems with static or still water. The examples of lentic ecosystem include lakes and ponds. The inhabitants are algae, crabs, shrimp and amphibians like frogs and salamanders. Second is lotic or riverine ecosystems relate to fast-moving water bodies that run in one direction, such as rivers and streams. Furthermore, these settings support a diverse range of organisms, including beetles, mayflies, stoneflies and a variety of fishes including trout, eel and minnow.

Algae use as food material for aquatic life

Algae play a vital role in all aquatic ecosystems. Most float freely and are therefore unable to maintain large populations in fast-flowing water. They build up large numbers in slow-moving rivers or backwaters. Algae form the food and energy base for all organisms living in lakes, ponds, and streams. Algae also form the base of water food chains; all aquatic organisms depend either directly or indirectly on algae as a food source. They are food for many small aquatic invertebrates, and in turn, these small creatures are food for larger animals such as fish. Algae also provide important habitats for invertebrates and fish. Without organisms that can capture energy from the sun by photosynthesis, none of the higher organisms would exist. There were several freshwater algae are found like *Anabaena*, *Aphanizomenon*, *Chara*, *Cladophora*, *Euglena*, *Hydrodictyon*, *Lyngbya*, *Microcystis*, *Mougeotia*, *Oedogonium*, *Pithophora*, *Rhizoclonium*, and *Spirogyra* naturally eated by fishes.

Algae also form a component of periphyton, which not only provides natural food for fish and other aquatic animals but is actively promoted by fishers and aquaculturists as a means of increasing productivity. Protein content differs widely across groups of algae. The filamentous cyanobacterium *Arthrospira platensis* (spirulina) and various commercial species of the unicellular green alga *Chlorella* contain up to 70 % dry wt protein. Fishmeal is so widely used in feeds largely thanks to its substantial content of high-quality proteins, containing all the essential amino acids. Algae are also high in Vitamin A, K, Selenium and Magnesium and are one of the best natural sources of iodine. Algae generally contained more metallic ions and less carbon, nitrogen, and phosphorous. There was a marked mean accumulation of one or more elements above the usual levels by several genera as follows: nitrogen, cyanophycean genera and *Euglena*;

phosphorus, cyanophycean genera; sulfur, Aphanizomenon, *Hydrodictyon*, and *Pithophora*; potassium, *Hydrodictyon* and *Nitella*; calcium, *Chara* and *Pithophora*; magnesium, *Chara*; sodium, Spirogyra; boron, *Pithophora* and *Lyngbya*.

Many Aquatic consumers such as tadpoles, small fish, crustaceans and water dwelling insects eat algae as their primary source of energy. As a fact, algae are the basis of different energy production for plants and animals. Let's look at what eat algae, 1. In freshwater, some fish species like plecostomus, kuhli loach, otocinclus, bristlenose pleco, siamese algae eater, Chinese algae eater, flying fox, and hillstream loach eat algae. 2. Shrimps also an excellent algae eaters in freshwater – these sea creatures are opportunistic omnivores that eat anything from algae to plankton, Some popular shrimp species include ghost shrimp, cherry shrimp, Amano shrimp, bamboo shrimp, etc. 3. Many species of snails in freshwater including nerite snail, apple snail, ramshorn snail, rabbit snail, pond snail eat algae. 4. Crabs are omnivores, and intriguingly, they enjoy a meal of protein and algae, examples are the sally lightfoot crab and the common mithrax crab.

Freshwater tanks and jheels scattered all over the India, particularly in the South, pisciculture has already set up a tradition among the local fishermen. In these areas, either in nature or in culture, larger fishes are often found swallowing masses of free floating blue-green and green algae. Of these algae *Microcystis aeruginosa*, *Oscillatoria* sp., *Phormidium* sp., *Arthrospira* sp., *Enteromorphoa intestinalis* and *E. prolifera*, *Spirogyra* sp. and species of Diatoms —*Synedra affinis*, and *S. ulnct*. *Enteromorphoa compressa*, *E. prolifera*, *E. intestinalis* , *Cladophora glomerata* , *C. crispate* and *Polysiphonia* sp. are the common edible algae of various kinds of delicious fishes which are of considerable market value.

Conclusion:

There are many different types of aquatic habitats around the world, each of which is home to some incredible animals. Knowing the importance of water for sustenance of life, the need for conservation of water bodies especially the fresh water bodies is being realized everywhere in the world. The river water is main source for drinking and agriculture field. As water is one of the most important components of the ecosystem, due to increased human population, industrialization, use of fertilizers in the agriculture and man-made activity, the natural aquatic resources are subjected to heavy and varied pollution leading depletion of aquatic biota.

Elevated algal and aquatic plant growth can clog water intake pipes and filters as well as interfere with recreational uses such as fishing, swimming, and boating. Excessive algal growth (blooms) coupled with the prevalence of nuisance species indicate excessive nutrients. It is important to note that while algae tend to be the most notable problem or issue in an aquatic ecosystem, other planktonic biota or organisms, including zooplankton and macroorganisms (both plants and animals), can also affect the physical, chemical and biotic properties of a water body. The natural food provides the constituents of a complete and balanced diet. Natural feeds have high protein and fat content, which promote the growth of fish. Hence, it is necessary to increase the live food in the aquatic ecosystem to improve the growth of aquatic animals.

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ROLE OF PHYSICAL METHODS FOR CONTROLLING WATER POLLUTION

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Introduction:

Water affects almost every aspect of our lives and causes a tremendous interest in its properties. For thousands of years people used to drink only natural water. In 1853 first standards for drinking water were established. By that time the pollution of surface water sources was not so dramatic, therefore, the quality of drinking water was determined only by 9 components. Over past decades chemical composition of water has changed. A vast amount of anthropogenic components have been released into the environment; these substances were made artificially by people and never existed in nature. Projections of global water needs are worrisome enough when the water demands arising from future population and economic growth are compared with current estimates of developed and developable supplies.

Water pollution can be defined as the contamination of water bodies. Water pollution is caused when water bodies such as rivers, lakes, oceans, groundwater and aquifers get contaminated with industrial and agricultural effluents. When water gets polluted, it adversely affects all life forms that directly or indirectly depend on this source. The effects of water contamination can be felt for years to come.

The key causatives of water pollution in India are:

- Urbanization.
- Deforestation.
- Industrial effluents.
- Social and Religious Practices.
- Use of Detergents and Fertilizers.
- Agricultural run-offs- Use of insecticides and pesticides.

Effects of water pollution

The effect of water pollution depends upon the type of pollutants and their concentration. Also, the location of water bodies is an important factor to determine the levels of pollution.

- Water bodies in the vicinity of urban areas are extremely polluted. This is the result of dumping garbage and toxic chemicals by industrial and commercial establishments.

- Water pollution drastically affects aquatic life. It affects their metabolism, and behavior, and causes illness and eventual death. Dioxin is a chemical that causes a lot of problems from reproduction to uncontrolled cell growth or cancer. This chemical is bioaccumulated in fish, chicken and meat. Chemicals such as this travel up the food chain before entering the human body.
- The effect of water pollution can have a huge impact on the food chain. It disrupts the food chain. Cadmium and lead are some toxic substances, these pollutants upon entering the food chain through animals (fish when consumed by animals, humans) can continue to disrupt at higher levels.
- Humans are affected by pollution and can contract diseases such as hepatitis through faecal matter in water sources. Poor drinking water treatment and unfit water can always cause an outbreak of infectious diseases such as cholera, etc.
- The ecosystem can be critically affected, modified and destructured because of water pollution.

Control measures of water pollution

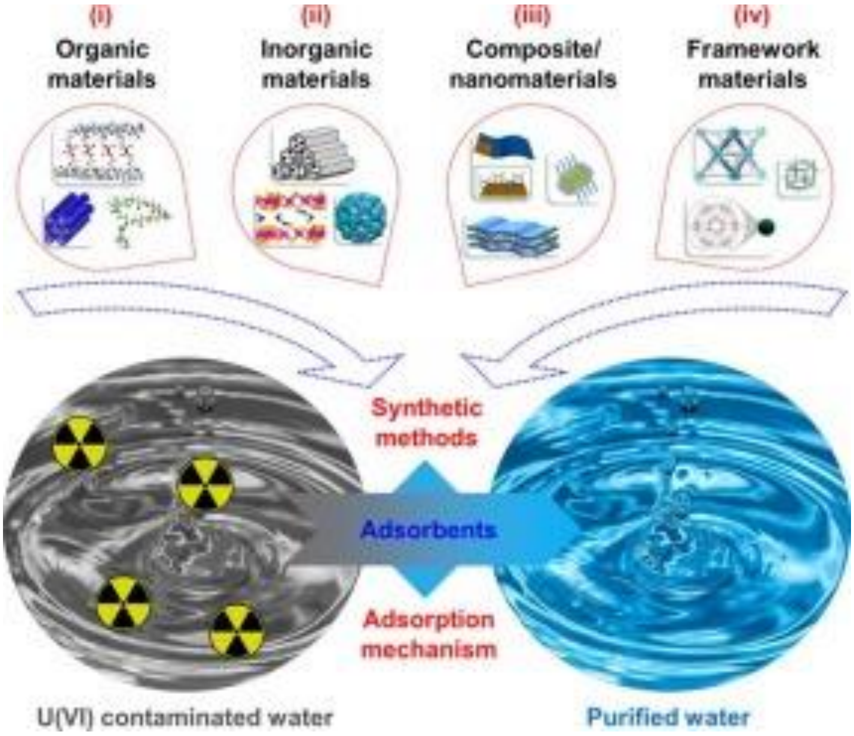
Water pollution, to a larger extent, can be controlled by a variety of methods. Rather than releasing sewage waste into water bodies, it is better to treat them before discharge. Practising this can reduce the initial toxicity and the remaining substances can be degraded and rendered harmless by the water body itself. If the secondary treatment of water has been carried out, then this can be reused in sanitary systems and agricultural fields.

A very special plant, the Water Hyacinth can absorb dissolved toxic chemicals such as cadmium and other such elements. Establishing these in regions prone to such kinds of pollutants will reduce the adverse effects to a large extent. Some chemical methods that help in the control of water pollution are precipitation, the ion exchange process, reverse osmosis and coagulation. As an individual, reusing, reducing, and recycling wherever possible will advance a long way in overcoming the effects of water pollution.

(1)The objective of radioactive waste management is to prevent human exposure to radioactive materials and therefore to minimize the possibility that radioactive materials will enter drinking water or the food chain or be inhaled. To date, isolation of the waste has been the only possible option for achieving this objective.

(2) One of the commonly used methods of water purification for radioactive water is the adsorption process because of its strong points such as fast kinetics, high selectivity, and ease of

operation. The adsorption process is widely used for treatment of industrial wastewater from organic and inorganic pollutants and meets the great attention from the researchers. In recent years, the search for low-cost adsorbents that have pollutant-biding capacities has intensified. Materials locally available such as natural materials, agriculture wastes and industrial wastes can be used as low cost adsorbents. Activated carbon produced from these materials can be used as adsorbent for water and wastewater treatment.



Methods of water purifications (Jun *et al.*, 2021)

(3) One of the main techniques of physical wastewater treatment includes sedimentation, which is a process of suspending the insoluble/heavy particles from the wastewater. Once the insoluble material settles down at the bottom, pure water can be separated.

Conclusions

Water is a key resource for our quality of life. It also provides natural habitats and eco-systems for plant and animal species. Access to clean water for drinking and sanitary purposes is a precondition for human health and well-being. Clean unpolluted water is essential for our ecosystems. Plants and animals in lakes, rivers and seas react to changes in their environment caused by changes in chemical water quality and physical disturbance of their habitat. Hence these methods are very much useful for the treatment of waste water.

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MACROINVERTEBRATE POPULATIONS IN FISH PONDS MANURED WITH RAW AND PROCESSED ORGANIC MANURES

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Abstract:

The present research involves the study on the composition and diversity of macrobenthic populations along with physico-chemical variations in fish ponds manured with raw cow manure and processed organic manure biogas slurry. During the fifteen months study period the counts of the benthic populations in the two treatments were a) raw cow manure at 10t/ha/yr, Urea at 100 kg N/ha/yr and Single super phosphate at 50 kg/ha/yr and b) biogas slurry at 30t/ha/yr with supplementary feed at 1% of fish biomass were assessed for a period of fifteen months in the ranges of 13-150 and 10-248/m^2 with mean counts of 69 and 99/m^2 with higher counts recorded in treatment with biogas slurry. The study revealed the occurrence of fourteen macrobenthic species including 6 from insecta, 7 from mollusca along with minor prawns and weed fishes. The present findings gives an idea of the habitat structure and clearly indicate that organic manuring with processed biogas slurry had a discernible influence on the benthic populations as compared to raw cow manure and the counts were higher in both the treatments during summer months.

Keywords: organic manured ponds, macro benthic diversity, physicochemical profile

Introduction:

Macro invertebrate populations include benthic organisms which are associated in activities of the bottom sediments of aqua systems. These are stable aquatic benthic forms that indicate the past and present environmental conditions of a habitat. Community structure and species composition of benthic invertebrates has frequently been used in environmental monitoring and assessment of aquatic systems (Subba Rao, 1989; Riise and Roos, 1997; Kownacki, 2006, Bovill *et al*., 2013; Chakrabarty, 2017). They are efficient modifiers of sediment properties due to their ability to move through a relatively large volume of sediment and their feeding and respiratory habits. Costa-Pierce and Pullin (1989) and Chakrabarty and Das

(2006) suggested that clayed sediment bottom supports high density of benthic forms. Devine and Vanni (2002) studied seasonal variation in nutrient excretion by benthic invertebrates in a eutrophic reservoir. Sharma and Rawat (2009) opined that monitoring of aquatic macroinvertebrates are indicators for determining the healthiness of wetlands in India. The effects of a thermal discharge on the macroinvertebrate community of a huge British river were deliberated by Worthington *et al*. (2015). Hamerlík *et al*. (2012) studied diversity pattern of benthic macroinvertebrates in high elevated water bodies. Overwintering of freshwater benthic macroinvertebrates was studied by Oswood *et al*. (1991). Bioturbation of bottom sediments at the sediment–water interface is currently gaining more attention in studies dealing with the functioning of aquatic ecosystems. Such bioturbation can be caused by a variety of benthic macroinvertebrates or benthivorous fish that forage and burrow various bottom tubes, holes and pits. Thus, the processes involved may either be a result of direct interception by benthic animals, e.g., through bioresuspension of particles or through food ingestion and biodeposition or of other indirect effects, e.g., changes the physical properties of sediments or through the constructions mentioned above, along with corresponding changes in pond ecosystem functioning (Kajak and Dusoge, 1968; Stief and de Beer, 2002; Lagauzere *et al*., 2009). Thus the bioturbating organisms' tubificid worms recycle organic matter resulting in its mineralization and their 'engineering' has a dramatic effect on the substratum.

They consume sediment at depth and deposit undigested material at the sediment–water interface (Fukahara and Sakamoto, 1987; Jiang *et al*., 2010; Dafoe *et al*., 2011; Zdeněk and Blahoslav, 2013). Kearns *et al.* (1996) studied particle transport by benthic invertebrates. The importance of benthic macroinvertebrates in bioturbation processes is also indicated by an increase in the numbers of resting cyanobacterial colonies recruited due to bioturbation of bottom sediments. The effects of tubificid worms on processes of nitrification and denitrification in aqua sediments were analyzed by Krantzberg (1985) and Henry and Santos (2008). Molluscs are extremely important benthic communities of many ecological systems. The molluscs mainly comprising the gastropods constitute the community of grazers and shredders. Molluscan dominance in the bottom biota has been recorded by several workers (Radheyshyam and Nayak, 1990; Saha *et al*., 2016).

Organic enrichment through manuring in fish culture ponds influences the populations of the benthic communities in aquatic systems and its study gives an idea on the operation and habitat structure of an aquatic ecosystem. Preserving the biotic diversity for future sustainability is an important limnological concern (Arthington *et al*., 2010). The variations in benthic populations have been related with physico-chemical parameters (Voshell Jr. *et al*., 1984; Worrall *et al*., 2014). Soil organic carbon content was observed to influence the density of benthic invertebrates (Hansen *et al*., 1998). Higher populations during the summer season may be attributed to higher organic contents in both the water and sediment media (Bunn and Arthington, 2002; Strayer, 2006). Matisoff *et al*. (1985) studied effects of macroinvertebrates on switch over of solutes between sediments and freshwater. Research findings on communities of macrobenthic organisms in organic manured ponds are limited.

Materials and Methods:

Present study was conducted in carp polyculture ponds at the fish farm of Central Institute of Freshwater Aquaculture, Kausalyaganga, Odisha (Lat.$20^0$11'06"-$20^0$11'45" N; Long. $85^0$50'52"-$85^0$51'35"E). fish culture ponds (0.04ha) with manurial treatments of raw cow manure and processed biogas slurry at 10 t/ha/yr, urea at 100 kg N/ha/yr and single super phosphate at 50 kg P/ha/yr (i), and biogas slurry at 30 t/ha/yr with supplementary feed (rice bran-groundnut oil cake in equal proportions at 1% of fish biomass) (ii) (Fig.1). The fish ponds were stocked with fingerlings of three Indian major carps and exotic carps at a density of 5000/ha.

The benthic fauna of the ponds were analyzed at monthly intervals during the experimental period of fifteen months. The samples were collected using an Ekman's grab (15 cm x 15 cm) with the sediments sieved through a standard sieve (BSS No.40; pore size 0.425mm) with washings of water. The samples were preserved in 10% formaldehyde solution and the forms identified upto generic level (Odum, 1971; Tonapi, 1980). The counts of the forms were expressed as no. /m^2, with percentage compositions of the different groups. (APHA, AWWA, WPCF; 2012).

Results and Discussion:

The benthic components comprising molluscs, insects and other groups were in ranges of 13-150 and 10-248/m^2 with mean counts of 69 and 99/m^2 with higher counts recorded in treatment with biogas slurry (Fig.2). The study revealed the occurrence of fourteen macrobenthic species including 6 from insecta, 7 from mollusca along with minor prawns and weed fishes. The overall macro invertebrate density was due to molluscan dominance of *Melania, Pila, Viviparus, Katalysia, Gyraulus, Lamellidens, Lymnaea* and from Insecta were *Chaoborus*, Chironomous larvae, Tardigrades, *Corixa*, *Pleacopteraus* and dragon fly nymph (Hyman, 1967; Gallepp, 1979; Gosselin and Hare, 2003; De Haas *et al*., 2005; Gupta and Narzary, 2013; Laurince *et al*., 2015). The present findings clearly indicate that organic manuring with processed biogas slurry had a discernible influence on the benthic populations as compared to raw cow manure and the counts were higher in both the treatments during summer months (Biswas *et al*., 2009).

The variations in the percentage compositions of benthic components comprising molluscs, insects and other groups are presented in Fig. (3 & 4).The ranges of percentage compositions of molluscs in the two treatments were 44.44 – 100 and 0 -100% with respective means of 80.37 and 90.12%. Treatment 2 showed higher molluscan representation of the total biomass followed by insects (9.31%) and others (0.57%). The ranges of percentage compositions of insect populations in both the treatments were 0-55.56 and 0-35% with mean of 17.6% and 9.3%. The mean representations of others (minor prawns, weed fish etc.) were 2.03 and 0.57%.

Molluscan dominance in the benthic fauna has been recorded by several workers (Usseglio Polatera *et al*., 2000; Tripathy and Mukhopadhayay, 2015; Saha *et al*., 2016). In the present study also the molluscan dominance went up to 90.12% of the benthos in Treatment 2. Higher levels of alkalinity and specific conductivity of the water medium in ponds under these treatments was influenced by the application of the processed organic matter might be influencing this association (Latha and Thang, 2010; Doley and Kalita *et al*., 2014; Worrall *et al*., 2014). The molluscs mainly comprising the gastropods constitute the community of grazers and shredders. The insect populations were dominated by the dipteran larvae (Subramanian and Sivaramakrishnan, 2007; Lewandowski *et al.*, 2007; Kumar and Khan, 2013). Prawn juveniles were also encountered in the collections could be categorized as the littoral fauna with a migratory behavior between the littoral and benthic zones of the ponds (Croel and Kneitel, 2011).

Organic enrichment through manuring under the two different treatments had a perceptible influence on the populations of the benthic communities, as evident from the increasing population counts through the study period. Higher populations in the ponds during the summer season may be attributed to higher organic contents in both water and sediment media (Kalyoncu and Zeybek, 2011). The sustenance of benthic populations by higher organic contents as in the present study has also been recorded by Tulonen (2004), Chellapandian and Ramachandra (2010) and Zdeněk and Blahoslav (2013) in freshwater systems. Organic enrichment in fish pond ecosystems with both raw and processed manure increases the abundance and change the species composition of the communities. Culture of benthivorous fish *Cyprinus carpio* in fish ponds enhances the release of nutrients from sediments and culture of some benthivorous exotic breams in organic manured ponds might be an added ecological intervension in freshwater ecosystems. For proper ecosystem functioning bioturbation activities by benthivorous fishes and macroinvertebrates at the sediment-water interface is of great concern (Ritvo *et al.*, 2004; Miller and Crowl, 2006: Matsuzaki *et al.*, 2007; Anschutz *et al.*, 2013). Bioturbation activities affect water quality and are also help in increase of cyanobacterial colonies which results in increasing production and improving sediment characterstics (Phan-Van *et al.*, 2008; Joyni, *et al.*, 2011). In carp polyculture experiments with organic manuring the fish *Cyprinus carpio* could be stocked up to 5% and up to 10% in perennial ponds. Thus biotic resource studies in fish pond culture have great opportunity and it is possible to increase fish production by enriching the trophic pathways through various environmental management practices.

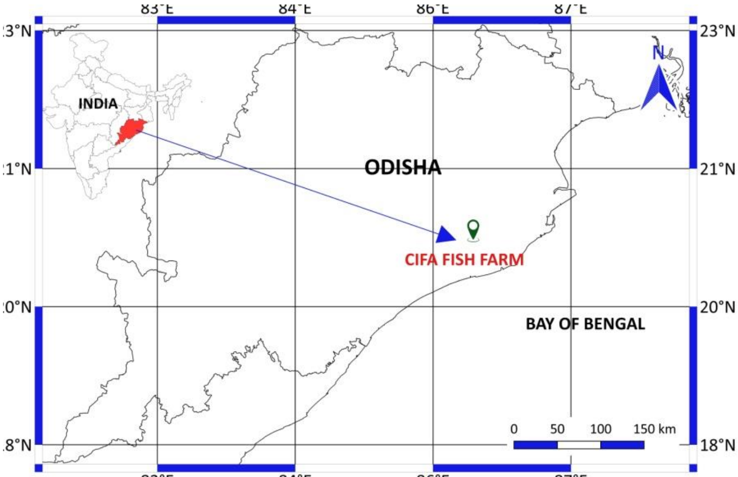

Figure 1: Site of the investigated ponds

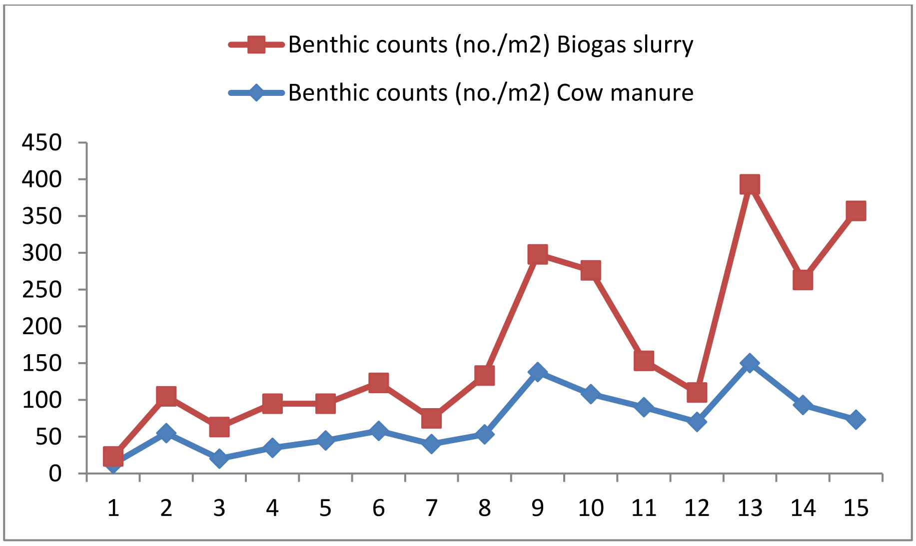

Figure 2: Seasonal variations in benthic populations (no./m^2) in sediment media under two different treatments

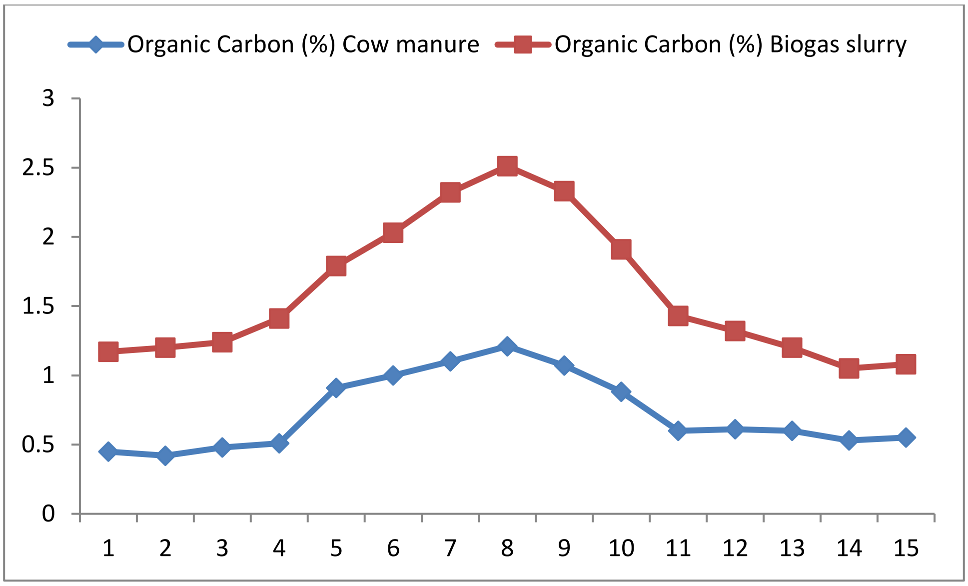

Figure 3: Seasonal variations in organic carbon contents (%) in sediment media under two different treatments

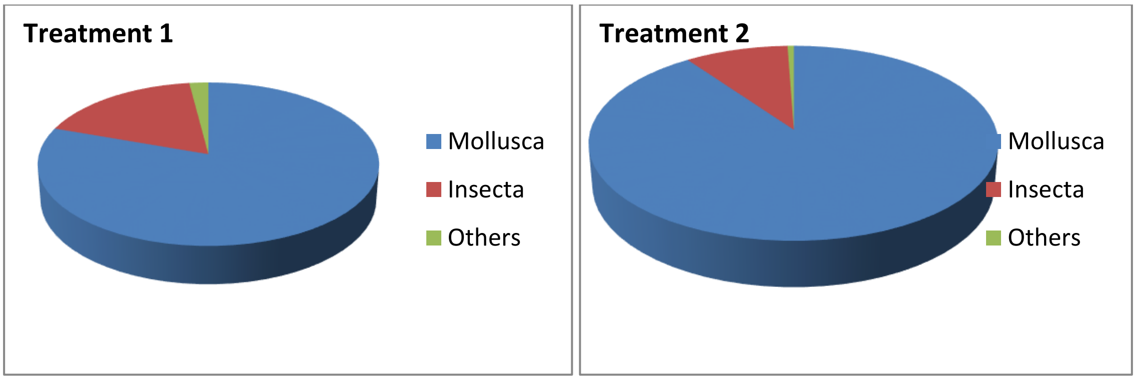

Figure 4: Mean percentage compositions of different groups of benthos in ponds under two different treatments

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ASSESSMENT OF PHYSICO-CHEMICAL CHARACTERISTICS AND MICROBIAL CONTAMINATION OF GROUND WATER SAMPLES OF SELECTED HAMLETS OF KINATHUKKADAVU, COIMBATORE, TAMILNADU, INDIA

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Abstract:

The research study was carried out to determine the quality of water in four blocks (samples from ground water) at Kinathukkadavu, Coimbatore. In these water samples the Physico- chemical parameters, heavy metal and microbial contamination were determined. In Physico-chemical analysis, parameters such as pH, turbidity, total dissolved solids (TDS), etc., and was compared with FSSAI and WHO standards of water quality. The pH of all water samples found almost neutral and all other parameters were found to be within the permissible limits. The results were indicated and discussed.

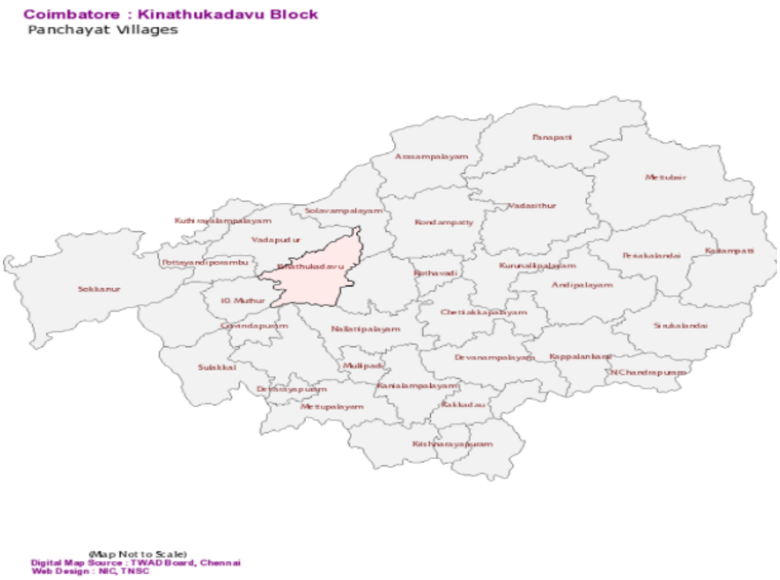
Keywords: Physico-chemical analysis, FSSAI, pH, turbidity and neutral.

Introduction:

The most important resource which forms an integral part of every human life and health is the water. It is a very vital component because the entire life on the earth sustains and flourishes only because of it. Most of the diseases in human are treated with the aid of water. But in recent years, water is being polluted mainly due to the human activities by way of antropogenic contaminants. Hence most of the water has become useless and people suffer a lot for drinking water since there is no rain. One of the most key reasons for water pollution is the discharge of heavy metals and chemicals into the ground and water reservoirs by the industries. Hence the present work is designed to analyze the depth of ground water pollution in the selected hamlets of Kinathukadavu, Coimbatore, Tamilnadu, India by physico-chemical characteristics and microbial contamination.

Study area:

Kinathukkadavu is a Suburb of Coimbatore district in the Indian state of Tamil nadu. It is along the National Highway 209 and is 23 kilometres (14mi) from Gandhipuram heart of Coimbatore city and 20.5 kilometres (13mi) from Pollachi town.



Materials and Methods:

Ground water samples from different hamlets of Kinathukkadavu were collected with necessary precautions in polyethylene bottles of two litre capacity (Brown *et al.*, 1974). FSSAI and WHO Standard procedures were followed to avoid unpredictable changes in their characteristics. All the samples were determined for the following Physico-chemical parameters such as Temperature, pH, Electrical conductivity (EC), Total dissolved solids (TDS), etc., Temperature:The temperature of the water was determined using theMercury Thermometer. Odour (Qualitative Human Receptor):Organic and inorganic chemicals originating from domestic wastes and by decomposition of vegetables matter contributes taste and odour to the water.Determinationof pH of the sample using the potentiometric procedure were done.Total alkalinity (Indicator method): To the sample few drops of methyl orange indicator and sulphuric acid were added and titrated so that colour changed from yellow to orange.Free carbon dioxide was estimated using sodium hydroxide titrate and phenolphthalein indicator. Turbidity can also be termed as the measure of a liquid’s relative clarity. Conductivity is also referred to as specific conductance. TDS and TSS were also checked.Turbidity method was adopted to determine the totalcontent of the sulphate and chloride in the sample.The following heavy metals have been detectedCadmium (Cd) -1000ppm, Chromium (Cr)-1000ppm, Lead (Pb) -1000ppm using Atomic Absorption Spectrometry. Biometric observation from list of plants grown using the water samples collected from different hamlets were done and Microbial contamination was also detected.

Results and Discussion:

Ground water samples from different hamlets of Kinathukkadavu were collected in polyethylene bottles of two litre capacity with necessary precautions (Brown *et al.,* 1974). Standard procedures of WHO were followed to avoid unpredictable changes in their characteristics (Sudhakar 2013; WHO, 1998). The collected samples were preserved in an icebox to avoid retarding biological action, deterioration, hydrolysis of chemical compounds and complexes, volatility of constituents and then taken to the laboratory for the determination of both physico-chemical parameters. All the samples will be analyzed for the following Physico chemical parameters. The analysis of water samples were carried out in accordance to standard analytical methods (WHO, 2005). All the chemicals used are AR grade and double distilled water for preparation of solutions. The nutrient values of the plants grown were also analysed.

The results of variations in physico-chemical parameters of water, biometric observation, biochemical characterization of plant samples were grouped and presented in the tables.

Table 1: Physico-chemical parameters of water

Sr. No.	**Parameter In units**	**Unit**	**S 1**	**S 2**	**S 3**	**S 4**
1	Temperature	^{o}C	28	27	27.5	28
2	Odour	-	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
3	Colour	-	Clear	Clear	Clear	Clear
4	Ph	-	7.1	6.7	7.6	7.3
5	Conductivity	µs	0.30	0.30	0.28	0.13
6	Turbidity	FAU	15	26	19	12
7	TA	mg/l	2.7	4	4.1	2.5
8	Free CO2	mg/l	3.8	4.3	4.2	5.2
9	TDS	g/l	7	9	6	8
10	TSS	g/l	2	3	2	4
11	Sulphate	mg/l	2.57	34.7	8.24	2.83
12	Chloride	mg/l	92.4	162.6	142.46	97.5

Physico-chemical Parameters

Temperature: Water temperature has direct and indirect effects on almost all facets. The amount of oxygen that can be dissolved in water is fairly managed by temperature.Temperature of the sampling station ranged from 27^0C to 28^0C. The maximum temperature was recorded in sample 1 and 4 and minimum temperature was recorded in 2 and 3. If water temperature raised beyond their normal range, the plants and animals in water ways can become hassled and expire. Similar results have been reported by Ameeth Basha *et al*. (2016).

Odour: The odour of the groundwater samples are unobjectionable which is found to be in accordance with the results observed by Kistan *et al*. (2015).

Colour: The colour of the groundwater samples are clear. The same clearance of water have been observed by Semila Pushpam *et al*. (2015).

pH: The balance between the concentration of hydrogen ion and hydroxyl ion in the water is termed as pH. The limit of pH value for drinking water is specified as 6.5 to 8.5 (WHO 2011, ISI 1983). The pH value of most of the groundwater samples in the study area varies from 7.1 to 7.6, which clearly shows that the groundwater is slightly basic in nature. The result of present study is found to be in accordance with the result absorbed by Pulugandi (2014).

Turbidity: In the present study the minimum value of 2.6 NTU in sample 4 and maximum value of 6 NTU turbidity in sample 1 was recorded which is found to be in contradictory with result observed by Sasikala *et al*. (2015).

Alkalinity: The typical enviable limit of alkalinity in drinking water is 600mg/l and the desirable limit is 200mg/l. In the present study the average values of alkalinity were within the pleasing limit in all the water samples. The same result has been observed by Velusamy, *et al*., (2015).

Free carbon dioxide: The values of free carbon dioxide are found to be in the range between 3.8 to 5.5mg/l in the water samples. This result is found to be in contradictory with the result observed by Mohamed Sihabudeen *et al*., (2015).

Electrical conductivity: The electrical conductivity is the measure of a materials ability to conduct an electric current so that the higher EC indicates the enrichment of salts in the water samples. The most desirable limit of EC is prescribed as 1500µs/cm (WHO, 2011). The EC of the water sample in the study area ranges from 0.134 to 0.308. The value may be an approximate index of the total content of dissolved substance in water.

TDS (Total Dissolved Solids): It is the concentration of all dissolved minerals in water which indicates the general nature of salinity of water. The TDS in the study area ranges from 6g/l to 9g/l. Similar result has been observed by Srinivas *et al*. (2017).

TSS (Total Suspended Solids): TSS consists of consists of huge variety of materials for example, decaying plant, silt, etc. TSS is more useful as it gives an actual weight of the undissolved material in the samples provided. The TSS of the water sample ranges between 2g/l to 4g/l. Similar result has been observed by Srinivas *et al*. (2017).

Sulphate content: It is one of the major anion occurring in natural water. The concentration of the sulphate varied from 2.57mg/l to 34.75mg/l. The desirable range of the sulphate is 400mg/l (WHO, 2011).

Chloride content: The chloride level in the water samples is found between the ranges of 97.47mg/l to 162mg/l, where 250mg/l is the maximum permissible limit given by WHO.

HEAVY METAL ANALYSIS:

Table 2: Heavy metal analysis

Sr. No.	Cadmium mg/l	Lead mg/l	Chromium mg/l
1	0.019	2.800	0.835
2	0.018	0.408	0.575
3	0.028	0.555	0.690
4	0.046	0.229	0.388

Cadmium (Cd): Cadmium have been detected using the standards 1, 2, 5ppm and results have been observed between the range of 3.2 to 7.9 RSD%.

Chromium (Cr): Chromium have been detected using the standards 1, 2, 5ppm and results have been observed between the range of 4.6 to 8.3 RSD%.

Lead (Pb): Lead have been detected using the standards 1, 2, 5ppm and results have been observed between the range of 1.4 to 4.2 RSD%.

Biometric observation:

It means, the analysis of physical parameters of the plant that can be measured. The examples of commonly analysed biometric observations are germination % of the plants grown, fresh and dry weight of the plants, shoot and root length of the plants, etc. Highest germination % has been observed in *Cicer arietinum L.* whereas fresh and dry weight has been found to be high in *Vigna unguiculate L.* and *Trigonellafoenum-graecum L.* and the shoot and root length is found to be high in *Cicer arietinum L.* and *Trigonellafoenum-graecum L.*, which are reported.

Carbohydrate: The plant *Coriandrum sativum L.* grown using the sample 3 found to have highest carbohydrate concentration of about 0.430mg/ml.

Protein: The*Trigonellafoenum-graecum L.* grown using the sample 3 found to have highest carbohydrate concentration of about 0.564 mg/ml.

Chlorophyll: The *Trigonellafoenum-graecum L.* grown using the sample 1 found to have highest carbohydrate concentration of about 0.915mg/g.

Table 3: Germination percentage of the seeds (%)

Sr. No.	P1	P2	P3	P4	P5
1	10.3	4.6	8.6	6.3	9.3
2	5.6	7.3	7.6	4.7	7.6
3	7.0	5.3	3.3	5.3	9.8
4	6.3	5.0	9.4	7.7	8.2

Table 4: Shoot length and root length (cm)

Sr. No.	P1	P2	P3	P4	P5
1	3.4	6.5	5.6	4.9	4.2
2	4.8	4.3	5.2	2.6	5.0
3	5.6	5.4	6.7	6.8	5.1
4	7.7	6.2	6.3	6.6	6.7

Table 5: Fresh weight and Dry weight

Sr. No.	P1	P2	P3	P4	P5
1	0.16	0.11	0.09	0.12	0.7
2	0.12	0.14	0.19	0.8	0.16
3	0.07	0.06	0.7	0.15	0.19
4	0.11	0.13	0.16	0.18	0.9

Table 6: The amount of carbohydrate (mg/ml) present in the plants

Sr. No.	P1	P2	P3	P4	P5
1	0.352	0.244	0.084	0.299	0.277
2	0.223	0.251	0.288	0.134	0.342
3	0.341	0.333	0.321	0.261	0.430
4	0.317	0.135	0.420	0.311	0.356

Table 7: The amount of protein (mg/ml) present in the plants

Sr. No.	P1	P2	P3	P4	P5
1	0.140	0.311	0.532	0.258	0.332
2	0.076	0.142	0.210	0.332	0.116
3	0.132	0.320	0.564	0.432	0.413
4	0.075	0.126	0.221	0.246	0.321

Table 8: The amount of chlorophyll (mg/g) present in the plants

Sr. No.	P1	P2	P3	P4	P5
1	1.595	0.751	1.308	0.837	0.915
2	0.799	0.642	0.902	0.865	0.799
3	0.907	0.651	2.15	0.651	0.877
4	0.725	2.687	0.881	0.732	0.786

Microbial contamination:

Table 9: Microbial contamination found in the water

Bacteria	*Escherichia coli*	*Streptomyces sps*
Fungi	*Aspergillus niger*	-

From the water samples analysed in the present study it has been observed the presence of microorganism and the name of the microbes are mentioned.

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