ISBN: 978-93-88901-01-7

Limnology

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Bhumi Publishing
First Edition: 2020

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Bhumi Publishing

2020

First Edition: 2020

ISBN: 978-93-88901-01-7

Published by:

Bhumi Publishing,

Nigave Khalasa, Kolhapur 416207, Maharashtra, India

Website: www.bhumipublishing.com

E-mail: bhumipublishing@gmail.com

Book Available online at:

https://www.bhumipublishing.com/books/

PREFACE

*We are delighted to publish our book entitled "**Limnology".** 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.

- Editorial Team

Limnology

Content

ALGAL BLOOMS: CAUSES, EFFECTS AND CONTROL MEASURES

P. M. Kahate

WETLAND ECOSYSTEMS

Annapurneshwari H.

LIMNOLOGICAL STUDIES IN ULHAS RIVER IN AMBERNATH – BADLAPUR BELT

Jyothi V. Mallia

AN OBSERVATION OF WETLAND PLANTS AT NARMADA CATCHMENT AREA, KHANDWA DISTRICT, M.P., INDIA (PART I)

Shakun Mishra

A REVIEW ON ICHTHYOFAUNAL DIVERSITY OF RIVER GANGA, DAMODAR AND SUBARNAREKHA WITH CURRENT STATUS AND THREATS IN WEST BENGAL

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Introduction:

One major and most important ecosystem is aquatic ecosystem that covers around 75% of earth's surface. It plays vital role in metabolism of organism and physical, chemical and biological processes. The knowledge of functioning of different types of aquatic ecosystems is vital to manage effect of global change on aquatic ecosystem which will again help in aqua-culture. There are different types of aquatic ecosystems like freshwater, oceans and seas and brackish water ecosystems. So many varieties are found in freshwater ecosystem. These are rivers, streams, ponds, lakes, swamps etc. All these ecosystems harbour variety of flora, fauna and microorganisms by providing them food and shelter. Not only this, they are beneficial for human being. Humans are benefitted by fishing for food, fishing for recreation, ornamental fish production. These ecosystems are severely altered or destroyed today. This affects aquatic biodiversity very much. My concern is to know the current status of fish biodiversity of some freshwater rivers in our state.

Indian subcontinent harbours a rich variety of fish diversity. Total 3500 fishes have been recorded in the whole world. Among them, 2500 are from India (Mankodi, 1979). As a biodiversity hot spot, India contributes 60 to 70% biodiversity and 11.72% of total global fish biodiversity occupying third position (Kumar, 2012). Among 2500 fish species, 930 speciees are freshwater species (Mankodi, 1979),). Among 930 species, 667 species belonging to 12 orders, 35 families and 149 genera have been reported by Devi and Indra (2012) in annual report of ZSI. In West Bengal, total 267 freshwater species have been recorded. Among them, 186 species are primary freshwater species and 81 are secondary species, belonging to 12 orders, 40 families and 123 genera (Mogalekar et al, 2017). Among 12 orders, cypriniformes shows highest diversity having 117 species, 46 genera and 4 families. Among these four families, family cyprinidae is most diverse having 84 species, and 35 genera (Mogalekar et al, 2017). Among 267 species, 109

species are ornamental, 92 are food fishes, and 66 are either ornamental or food fishes. A total of 17.97% of fishes are under threats.

Results and Discussion:

Ganga River System:

Figure 1: Ganga river system

It is one of the largest river systems in the world. It is 12,500 km long and fifth largest in the world (Welcomme, 1985). It is sacred river and worshipped by Hindus. It originates from famous Gangotri glaciers of Himalayas and falls into Bay of Bengal. Near Rajmahal, Ganga enters into Bengal. It is reported that the Gangetic system alone accounts for 143 species of freshwater fish belonging to 11 orders, 32 families, 72 genera and contributing about 20% of total fish reported in India (Sarkar and Dubey, 2015). Among 143 species, 133 were native species of Ganga but 10 were exotic (Sarkar et al, 2012). Lakra et al (2010) reported that 29 freshwater fishes of Ganga have been listed as threatened species. Order Cypriniformes, Siluriformes, and Perciformes are the orders that show high species diversity (Sarkar et al, 2012). The family Cyprinidae, Bagridae, Channidae were most abundant (Sarkar et al, 2012) (Table 1). Gomti, Gharghara, Betwa, Ramganga, Ken etc are the major tributeries of river Ganga. All these tributeries also possess high percentage of threatened, migratory and commercially used species of fishes.

River Ganga is divided into three zones namely, upper zone (Uttarakhand with northern Himalayan region), middle zone (U. P. and Bihar) and the lower zone (Part of Bihar and West Bengal). Main threat to lower zone is sediment which is carried from upper and middle zone and

deposited in areas of lower zone. It blocks the fish spawning sites hampering fish breeding. For this siltation, wetlands of the lower zone of ganga basin are transformed into dry land which is available for agriculture. For this, catches of major carps, catfishes and hilsa have decreased and further species diversity has been decreased (Das, 2007; Payne et al, 2004).

Figure 2: Pollution of River Ganga

Again, in the middle zone, several industries have been established on the bank of river Ganga. The waste, disposed in the river, is carried to the lower zone creating severe Ganga pollution. This Ganga pollution is one of the causes of disappearance of aquatic biodiversity, mostly for threatened and migratory species. Recent studies have shown that some species from lower and middle zone migrate to the upper zone to avoid increasing temperature and pollution (Sarkar et al, 2012).

Damodar River system:

River Damodar originates in Palamau hills of Choota Nagpur plateau and flows through states of Jharkhand and West Bengal covering an area of 23370.98 sq. km. Earlier, it was known as ‘sorrow of Bengal’ for its devastating flood in West Bengal. Due to this river, vast areas of Bardhaman, Hooghly, Howrah and Medinipur became flooded. In this river, 46 species of fish had been identified. They belong to 7 orders, 18 families and 26 genera (Saha and Patra, 2013).

Figure 3: Damodar river system

It is one of the polluted rivers of India. Several industries and factories dump waste liquids in this river. This severely pollutes the river. This polluted water is carried through rests of the stream causing pollution.

River Subarnarekha:

Figure 4: Subarnarekha river system

Subarnarekha originates in Nagri village in southern Bihar and traverses through Jharkhand, West Bengal and Odisha. The tributeriees of Subarnarekha are Roro, Kanchi,

Kharkai, Karru, Gurma, Garra, Kodia, Dulunga etc. 66 species belonging to 8 orders and 23 families have been reported (Karmakar et al, 2008) in this river.

Table 1: Comparative study of Fish diversity of River Ganga, Damodar, and Subarnorekha in West Bengal

Name of fish (Scientific name)	**Common name**	**River Ganga**	**River Damodar**	**River Subarnarekha**
Labeo rohita	Rohu	✓	✓	✓
L. bata	Bata	✓		✓
L. calbasu	Calbose	✓	✓	✓
Catla catla	Catla	✓	✓	
Cirrhinus mrigala	Mrigel	✓	✓	✓
Channa striatus	Snakehead fish	✓	✓	
Channa punctatus	Spotted snakehead	✓	✓	
Clarius batracus	Walking catfish	✓	✓	
Heteropneustes fossilis	Stinging catfish	✓	✓	
Notopterus notopterus	Bronze featherback	✓	✓	✓
N. chitala	Chital	✓	✓	✓
Mystus vittatus	Dwarf catfish	✓		
M. cavasius	Gangetic mystus	✓	✓	
M. guilo	Long whiskers	✓		
Wallago attu	Barali	✓	✓	
Lates calcarifer	Bhetki	✓		
Tor tor	Tor barb or mahseer	✓		
Tor putitora	Putitor mahseer	✓		
Ompoh pabda	Pabda	✓		
O. bimaculatus	Butter catfish	✓		
Tenulosa ilisha	Ilish	✓		✓
Gadusia chapra	Indian river shad	✓	✓	
Eutropiichthyes vacha	Bacha	✓		
Liza persia	Goldspot mullet	✓		

Macrognathus pancalus	Barred spiny eel	✓	✓	
Pangasius pangasius	Shark catfish	✓	✓	
Rita rita	Bagrid catfish	✓	✓	
Scatophagus argus	Spotted scat	✓		✓
Polynemus paradiseus	Indian salmon	✓		✓
Mastocembelus armatus	Marbled spiny eel	✓		
Puntius sarana	Olive barb	✓		
Puntius sophore	Spotfin swamp barb	✓	✓	✓
Silonia silondia	Silond catfish	✓		
Xenontodon cancilla	Needlefish		✓	
Aplocheilus panchax	Blue panchax		✓	
Amblypharyngodon mola	Mola carpet		✓	
Danio devario	Bengal danio		✓	
D. rerio	Zebrafish		✓	
Puntius ticto	Twospot barb		✓	✓
P. phutunio	Phutuni barb		✓	
P. conchonius	Rosy barb		✓	
Salmostoma bacalia	Razorbelly minnow		✓	
Lepidocephalichthys guntea	Guntea loach		✓	
Chanda ranga	Indian glassy fish		✓	
Chanda nama	Elongate glassy perchlet		✓	
Channa marulias	Bullseye snakehead		✓	
C. gachua	Dwarf snakehead		✓	
Glossogobius guiris	Tank goby		✓	✓
Nandus nandus	Gangetic leaffish		✓	
Colisa fasciata	Rainbow gourami		✓	
Colisa lalia	Gourami		✓	
Mystus aor	Long whiskered catfish		✓	
M. seenghala	Seenghala/Giant river catfish		✓	
Macrognathus armatus	White spotted spiny eel		✓	
Macrognathus aculeatum	Spiny eel		✓	
Tetradon fluviatilis	Pufferfish		✓	

Tetradon cutcutia	Ocellated Pufferfish		✓	
Scoliodon laticaudus	Yellow dog shark			✓
Himantura bleekeri	Brow bellied ray			✓
H. imbricata	Scaly whipray			✓
Elops saurus	Ladyfish			✓
Pisodonophis boro	Rice paddy eel			✓
Escualosa thoracata	White sardine			✓
Anodontostoma chacunda	Chacunda gizzard shad			✓
Sardinella melanura	Blacktip sardinella			✓
Chirocentrus dorab	Dorab wolf-herring			✓
Raconda russeliana	Raconda herring			✓
Coilia dussumeiri	Goldspotted grenadier			✓
C. ramcarati	Ramcarat grenadier anchovy			✓
C. reynaldi	Amadi			✓
Setipinna taty	Scaly hairfin anchovy			✓
Stolephorus indicus	Indian anchovy			✓
S. commersonii	Commerson's anchovy			✓
Thryssa purava	Longjaw hryssa/Anchovy			✓
T. malabarica	Malabar anchovy			✓
Cirrhinus reba	Reba carp			✓
Chagunius chagunio	Chaguni			✓
Badis badis	Blue perch			✓
Kurtus indicus	Indian humphead			✓
Siganus javus	Streaked spinefoot			✓
Elutheronema tetradactylum	Forefinger threadfin			✓
Polydactylus indicus	Indian threadfin			✓
Pesudapocryptes lanceolatus	Pointed tail goby			✓
Stigmatogobius sadanundio	Knight goby			✓
Gobiopterus chuno	Glass goby			✓
Eleotris fusca	Dusky sleeper			✓
Butis butis	Duckbill sleeper			✓
Sillago sihama	Northern whiting			✓

Sillaginopsis panijus	Gangetic whiting			✓
Caranx carangus	Caranx			✓
Atropus atropus	Cleftbelly kingfish			✓
Alectis indicus	Indian threadfish			✓
Pampus argentius	Ponphret			✓
Terapon jarbua	Tiger Bass			✓
Upeneus sulphurous	Sulphur goatfish			✓

Source: Vass and Moza, 2011; Saha and Patra, 2013, Karmakar et al, 2008

Conclusion

The above studies depict that in Ganga 143 species of freshwater fish belonging to 11 orders, 32 families, 72 genera (Sarkar and Dubey, 2015) are available where as in Damodar, 46 species of fish belonging to 7 orders, 18 families and 26 genera (Saha and Patra, 2013) and in Subarnarekha, 66 species belonging to 8 orders and 23 families (Karmakar et al, 2008) have been identified. It is clear that fish species diversity is more in river Ganga than Damodar and Subarnarekha. Diversity in order level is also more in Ganga, then Subarnarekha and then Damodar.

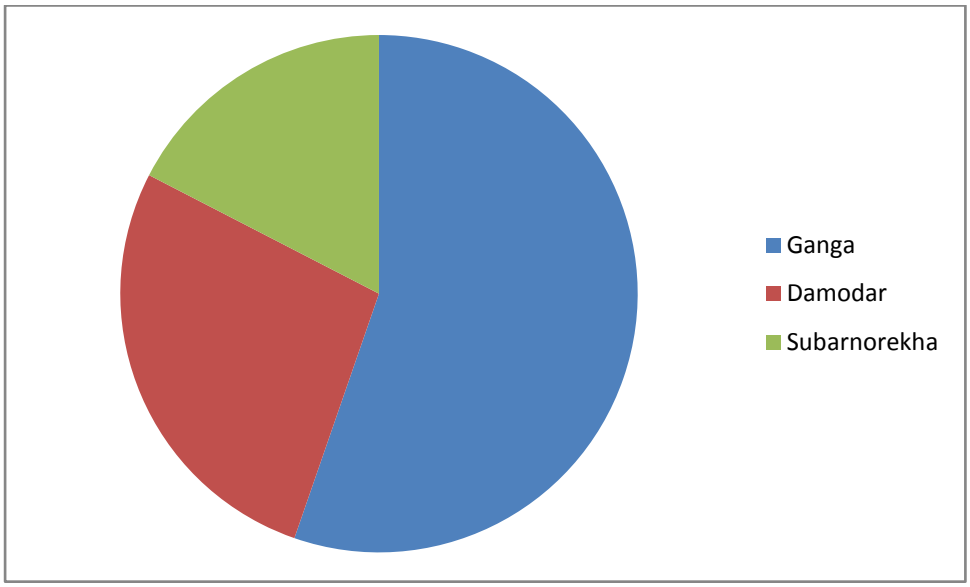

Figure 5: Fish diversity in River Ganga, Damodar and Subarnarekha

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PHYSICOCHEMICAL ANALYSIS OF GROUNDWATER AROUND AMBARNATH INDUSTRIAL AREA, MAHARASHTRA, INDIA

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Abstract:

Ground water quality around Ambarnath industrial zone was studied for a period of six months during June 2014 to January 2015. Groundwater samples were collected from 6 sampling sites during study period and analyzed for different physicochemical parameters like Temperature, pH, Conductivity, Alkalinity, Total hardness and Chloride. Obtained results were compared with WHO and BIS standard. An attempt has been made to find out the groundwater quality around industrial zone. Bhimnagar area open well and Kansai Gaon open well shows higher conductivity value compared to other water samples. During study period it was observed that open wells were more affected by pollution compared to hand pumps and bore well.

Keyword: Physicochemical, bore well, water quality, Industrial zone.

Introduction:

The availability of water on the earth's surface is in abundance, still it is a scarce resource due to its unequal distribution and its major portion occupied by saline water and with this at many locations it is difficult to obtain desired quantity of water with its suitable purity. With increasing population pressure on available water sources also increases. Available surface water resources are not sufficient to fulfill the increasing demand of man; therefore rely on groundwater sources increases in different parts of the world.

Different manmade activities cause serious groundwater quality contamination. Pollution from effluent discharge by industrial areas, sewage infiltration, leakages, disposal of wastes, mining activity and sometime excess of nutrients from agriculture also leads to groundwater

pollution. Once the groundwater get contaminated it is very difficult to restore it to the original water quality of the aquifer, therefore it is better to protect it first, rather than depending on new technology to clean the contaminated source (Sharma,2014).

Water quality depends on the natural physical and chemical status of the water as well as any alterations that may have occurred as a consequence of human activities. Anthropogenic activities cause serious groundwater contamination; therefore it is important to analyze the ground water as well as water quality in different parts of the India, before using it for any purpose. Water is such a medium which has unique properties of dissolving number of chemicals in it, therefore it is used as a solvent in number of industries and further it get contaminated easily as it is used as a medium of dilution.

Ambarnath town is fast growing area from Thane district of Maharashtra. Urbanization and industrialization day by day increases in this area, which leads to development of residential area around industrial area with this slum area also increases around industrial zone, in such slum areas lack of sanitation facilities, poor drainage system, inadequate waste management facilities were observed. The industrial effluents and sewage water from surrounding area may cause the contamination of underground water resources. People are using groundwater for different purposes; hence it is important to assess the groundwater quality of such area, therefore an attempt has been made to find out the groundwater quality around Ambarnath industrial zone.

Materials and Methods:

Ambarnath Chikloli-Morivali industrial zone is present in main Ambarnath town. It is important industrial zone in Thane district, surrounded by residential and slum area since few years. 6 groundwater samples, within 2-3 km. vicinity around industrial zone were selected, and water samples were collected from selected sites during June 2014 to January 2015. Following sites were selected for study purpose.

Table 1: Sampling Sites

Sampling Site	Station No.
Kansai Gaon (Ganesh chauk)Open Well	S-1
Kansai Hand Pump	S-2
Bhimnagar Area Open Well	S-3
Vadavli area Bore Well	S-4
Bhendipada area Bore Well	S-5
Samarth Service Centre Bore Well	S-6

Samples were collected in 2 litre capacity of clean polythene bottles. The bottles were rinsed with the groundwater to be taken for analysis. Tightly sealed after collection and labeled in the field area. Collected samples were analyzed for Temperature, pH, Conductivity, Alkalinity, Total hardness, and Chloride parameter during study period.

The temperatures, pH of the water samples were determined on the spot using a thermometer and portable pH meter respectively. Conductivity measured by conductivity meter, Total Alkalinity was determined by visual titration method using methyl orange and phenolphthalein as indicator. Total hardness was measured by EDTA titrimetric method using EBT indicator. Chloride contents by argentometric method using potassium chromate as an indicator. (APHA, Trivedi and Goel) The quality of groundwater has been assessed by comparing each parameter with the standard desirable limits prescribed by BIS and WHO.

Results and Discussion:

After analysis obtained results are shown in table 2 and 3 and further it was compared with the BIS and WHO standards from table 4.

Table 2: Mean value of parameter for Monsoon Season (June 2014 to September 2014)

Station No.	Temp.	pH	Cond.	Alkalinity	Total Hardness	Chloride
S-1	23.9	7.25	560	204.5	203.5	118.93
S-2	24.3	7.76	399	157	153	118.57
S-3	23.95	7.45	776.3	161.5	159	126.03
S-4	24.18	7.19	528.5	165.5	224	118.22
S-5	23.98	7.12	354.8	159	154	109.34
S-6	24.05	7.2	248	177.5	193	105.79

Temperature:

Temperature ranges from 23.9 ^{0}C to 24.18^{0}C. in monsoon season and 22.7 ^{0}C to 23.7^{0}C in winter season. During winter season temperature value decreases naturally compared to monsoon season.

pH:

In monsoon season pH was observed from 7.12 to 7.76 and during winter season it was found between 7.16 to 7.54. At station no. S 2 highest pH was observed during monsoon season

and at station no. S2 highest pH was observed during winter season. All the samples were found within the desirable limit given by BIS and WHO. pH of water is influenced by geology of catchments area and buffering capacity of water (Shyamala *et.al.*,2008).

Table 3: mean value of parameter for winter Season (October 2014 to January 2015)

Station No.	Temp.	pH	Cond.	Alkalinity	Total Hardness	Chloride
S-1	23.3	7.24	564.7	208.67	217.34	109.82
S-2	23.4	7.54	394	164.67	160.7	110.76
S-3	23.2	7.32	786.4	167.34	165.4	112.18
S-4	23.2	7.24	542	165.34	238.7	106.98
S-5	22.7	7.16	352	164	160.7	100.35
S-6	23.07	7.17	268	174.67	203.4	98.93

Table 4: Drinking water standards

Sr. No.	**Parameters**	**BIS (IS 10500-91)**		**WHO**
		Desirable Limit	**Max. permissible Limits in the absence of alternate source**	
1	P^H	6.5 - 8.5	No relaxation	6.5 – 8.5
2	Conductivity	-	300	-
3	Total hardness as CaCO3(mg/l)	200	600	500
4	Alkalinity (mg/l)	200	600	200
5	Chloride as Cl(mg/l)	250	1000	250

Conductance:

During monsoon season conductance was ranged from 248 to 776.3 µS/cm, and during winter season it was ranged from 268 to 786.4 µS/cm. Highest conductance was observed at station no. S3 during both seasons. Except station no.S6, all samples were found above the BIS permissible limit.

The major reason for difference in Electrical Conductivity is anthropogenic activities prevailing in this region, and lithological composition of the area. It was observed that Electrical

Conductivity values increases in some samples with the increasing amount of Sulphate, Chloride, Bicarbonate and Hardness as $CaCO_3$ (Ramesh *et.al.*,2012).

Total Alkalinity:

In monsoon season alkalinity observed from 157 to 204.5 mg/l and it was found within 164 to 208.67 mg/l during winter season. Slight increase in alkalinity was observed during winter season. Highest Alkalinity was observed at station no.S1 for both seasons. All the samples were found within the permissible limit given by BIS and WHO for Total Alkalinity. Alkalinity in water is a sign of natural salts present in water. Minerals which dissolve in water from soil, cause alkalinity. Water Alkalinity and Hardness are functions of the geology of the area and the percolation of rain and surface water along with the dissolved carbon dioxide of the atmosphere. Rain water is naturally acidic, which tends to dissolve some minerals more easily (Arabi *et.al.*,2011).

Total Hardness:

Total hardness ranges from 153 to 224 mg/l during monsoon season and it was ranged from 160.7 to 238.7 mg/l during winter season. At station no.S4, highest hardness value observed for both the seasons. For total hardness all the samples were found within the permissible limit given by BIS and WHO.

The Hardness of water varies from place to place and it reflects the nature of the geological properties of the area, with which water have been in contact. Total Hardness includes both temporary and permanent hardness caused by the Calcium and Magnesium, on the basis of which water is categorized as soft or hard and very hard (Sengupta, 2013; Ramya *et.al.,* 2015).

Chloride:

Chloride in study area ranges from 105.79 to 126.03 during monsoon season and it was ranges from 98.93 to 112.18 during winter season. At station no.S3, highest chloride was observed for both the seasons. All the samples were found within the desirable limit given by BIS and WHO for chloride during study period. Chloride is primarily obtained from the dissolution of salts of hydrochloric acid as table salt (NaCl), $NaCO_2$ and gets added through industrial waste, sewage, sea water etc. Surface water bodies often have less concentration of chlorides as compare to ground water. High chloride concentration damage metallic pipes as well as cause harm to growing plants. According to WHO, standard concentration of Chloride should not be exceed 250 mg/l (Mohsin *et.al.,* 2013).

Conclusion:

All ground water samples collected around Industrial zone were found within the permissible limit given by BIS and WHO for different parameter, except the conductivity parameter. In case of S3 and S1 sample i.e. Bhimnagar area open well and Kansai Gaon open well shows highest conductance during both season, indicates presence of dissolved material in it, which may be due to pollution around open well and seepage of waste water around the well side. It was observed that open well shows higher values of different parameter compared to bore well and hand pump area. Thus water from open wells is not suitable for different purposes.

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COMPREHENSIVE STUDY ON PEARL FARMING AND ECONOMIC VIABILITY

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Historical Perspective:

A new discovery of pearls in 2004 at Blombos caves in South Africa concluded that they are of 75000 years ago. It is evidenced that 41 marine snails, *Nassarius kraussianus* are tantamounted uniformly. Likewise Pearls are well known for their beauty and shining. Pearl oyster shells having iridescent nacreous layers are used in jewelries and also for ornamental purpose, though their usage have long history, the ancient findings marqueteries of pearl oysters nacreous layers were used in almost 4500 BC and they were evidenced in the wrecks of Mesopotamia. The sculptures which were disclosed in the diggings done in Nineveh and Nimrud of Babylonian era revealed that pearls are used in ornamental items.

In 'Veda' it is mentioned that Lord Krishna presented a pearl which he discovered from the in-depth area of the sea to his daughter Pandaia in her marriage, By this act, every bride in India follows to wear pearls in their chains at the time of their marriage.

The usages of pearls by the ancestors are mentioned in the Bible, the holy book of Christians. In the Old testament, the Proverbs of Solomon (8:11) specifies that

Wisdom is more precious than coral or Pearls

And it is not even equaled by rubies.

The Koran, the holy book of Muslims discussed that the paradise trees bearing bear fruits are formed of emeralds and pearls, which were used to felicitate those followers who get into the paradise.

Pearl culture comprises of five steps in which first one includes selection of pearl oyster, implanting of nucleus, nourishing, reaping and treatment or handling of pearls respectively. As pearl culture and its production is an intricate and prolonged procedure and also having lengthy

cycle of culturing process, it is somewhat perilous in the economic corner as like as fish and fish products playing role in the economy of India and entire world (Bhaskar and Govindppa, 1986a; Bhaskar, 1994; Pradeepkiran Jangampalli Adi and Bhaskar, 2016). Rapid urbanization pressurized the pearl farming techniques to yield more production and gradually developing its industrial sector similar to that of prawn and aquaculture industry (Bhaskar and Govindappa, 1986a; Sailaja *et al.*, 2009).

Among the nine gems only the pearl is cultured by humankind. Pearls are mentioned in many legends and there is myth about its lovable charming. In the past decades before the initiation of pearl culture and producing pearls artificially, the natural pearls are collected from the red sea, from the Mannar of Gulf and Bay of Bengal (Zhu *et al.*, 2019). At that time the pearl trading added economy overwhelmingly. But in the 19th century culture pearls occupied the major part in world trade market (Carter, 2005).

Pearl farming was first started by the Chinese Song Dynasty existed between 960-1279AD and later it was continued by Ming Dynasty through growing blister pearls in the interior faces of the shell in fresh water pearl oysters. Round shaped pearls were developed in Japan through Mise-Nishikawa method. And this production was made commercial by Kokichi Mikimoto (1859-1954) and hence called 'Father of modern pearl production', (Zhu *et al.*, 2019). It opened the door to enhance the industrial production (Southgate, 2007). As the technology used in Japan from several years' time scale, this made the Japan to evolve as a leading country in pearl production at the current period. Australia and Indonesia are the major producers of sea pearls from the pearl oysters of silver or gold lip type, *Pinctada maxima*. These are the large sized cultural pearls (Southgate *et al.*, 2008a).

Biomineralisation-Pearl Formation:

Pearls are formed due to the capacity of molluscans shell layers activity against the damage to the tissue of the mantle. It seems same as the process of shell formation in order to protect the inner body parts. It is an extraordinary procedure called '**Biomineralisation**'. Hence the mantle layer of the pearl producing molluscans having a specialized cells in the epithelium which are secreting the biomolecules like carbohydrates, acid proteins, mucopolysaccharides, sulphated acid and granules of calcium. These secretions form as layers around the injured tissue to form a pearl. Hence pearl formation is treated as a part of healing of the injured part of the body. It is a natural process.

An artificial production of pearls through the surgical process of implanting a part of mantle or nucleus having a shell of a donar pearl oyster into another pearl forming through a process called seeding or grafting (Taylor and Strack, 2008).

Cultural Stages in Pearl Oyster Farming:

Different cultural methods are involved in pearl oyster farming. Typically in pearl farming, '**spat**' is collected by using varied spat collectors and culture them to an optimum size for grafting i.e., insertion of nucleus. Generally at present culturing methods rely on culture of hatchery larvae for conditions like brood stocking, spawning, fertilization and incubation of egg. Of these culturing of larvae is the crucial phase which influences by the water quality, exchange, culling of larvae, their stocking and nutrition for its growth, as like as several environmental problems creating problems for the growth and development of fish in aquaculture practices especially in acidic and alkaline media (Krishna Murthy *et al.,* 1981; Sobharani *et al.,* 1983; Bhaskar and Govindappa, 1985c; Bhaskar and Govindappa, 1986b).

Structures Involved in Pearl Culture:

Structures involved in pearl culture farms are useful in collecting the materials needed by culture by hanging them. They are:

1. Surface rafts and long lines
2. Subsurface long lines
3. Benthic racks
4. Trestles and
5. Fence line

In addition to the above the following conditions also have to favor the pearl culture. They are:

1. Light
2. Turbidity
3. Optimum temperature
4. Salinity
5. Dissolved oxygen

(Nagappan Nayar and Mahadevan, 1987; Gervis and Sims, 1992; Southgate, 2008a).

The lines or structures which are 'on growing structures' are hung in single or one by one in upward position. The lines or rafts are also using with various containers. The selection of the above lines depends on various factors like:

1. Speed of water current
2. Cost of operation
3. Exposure to Wind and waves
4. Variations of tides

Larvae settles on different substrates can be collected and left for about half a year and then moved to juvenile on growing systems. As the larvae grown into pearl oysters, it is vital to protect them from fouler, sponges, polychaets and borers. Hence regular cleaning is mandatory. Culling is done with the aid of knife or meat cleaver, if the infection is not too serious (Gervis, and Sims, 1992).

Figure 1: Pearl oyster farming (Source: www.ThePearlSource.com)

Pearl Oyster Farming:

Stages of Larvae:

After spawning and fertilization, the zygote undergoes cleavage to form blastula and further it transforms into gastrula, which in turn into Trochophore larva, Veliger larva, Umbo stage, Eye spot stage, Pediveliger stage, Plantigrade stage, Spat respectively.

Pearl Oyster stock can be collected from Natural beds through skin diving, scuba diving and dredging. Spat can be collected from rafts of subsurface through caddar sprige, hyzex film,

polyethylene sheets, nylon ropes, and old fish nets and the same way through split bamboo from under water shelves.

Brood stock can be collected through induced spawning, larval spawning, spat setting and nursery rearing. They were further carried out to hatcheries and were grown on rafts. Rafts, Loglines, under water Platforms are used for growing spat and they are cultured on Pearl string and Oyster Baskets. Spat of oysters are grown on the above and regular activity of cleaning of shells and baskets are carried out and the treatment of borers/ fouler can be done to protect against predators and routine maintenance is carried out. These are used for surgery to incorporate nucleus like material and were cultured by implementing proper measures of post-operative culture.

Pearl Oysters used for surgery are selected on the basis of their size or weight, health, good condition, and proper nucleus size are selected and their number to insert into pearl Oyster also taken into account.

The process of surgery is carried out by preparing a graft tissue implantation or nucleus implantation in single or multiple according to the need. The period of recuperation should maintain and further postoperative measures can be taken.

Steps involved in Pearl Harvesting:

- Bleaching of Oysters
- Collection of Pearls
    1. Reuse of Oysters (optimal)
    2. By products - Shells, Seed pearls and meat
- Sorting/grading of pearls

Edible oysters are insensitive than pearl oysters when exposed to air. Generally spat/larvae mortality shall occur even under optimal conditions also (Nagappan Nayar and Mahadevan,1987; Alagarswami,1987).

Environmental circumstances prevailing at that time influences the size and days to grow in the larval stages. Developments in hatchery culture are very beneficial and pave the way for further progress of pearl culture rather than depending on the collection from natural resources.

In Japan cedar twigs or branches are used in bunches to collect spat by dipping them beside the surface of water in a season of highly spawning. Collapsible rafts and on-bottom culture rafts are used in India along with ordinary box cages and plastic baskets with

multitudinous pores. Finally oyster culture was done through frame nets and become available for induction to form pearls (Alagarswami *et al.*, 1987).

Pearl Formation Technology:

Generally the natural pearls are produced within the mantle or in the soft tissue or between the inner part of the shell and mantle. They can be generating by chance in their life cycle rarely in varied shapes and sizes and hence they occur in nature rarely.

Pearl Producing Through Culture Manner:

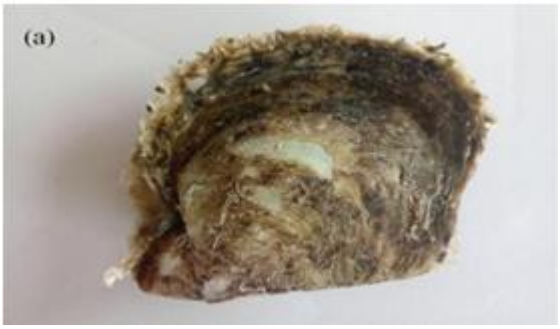
In this process pearls are intentionally produced through pearl farming. The key core in this process is that the mantle is having pearl secretion cells and hence used as graft tissue and prepared, treated shell beads which are termed as nucleus would be recognized as foreign material by the pearl oyster. After grafting or embedding the grafting tissue and nucleus into the oyster's gonads through the proper surgery. When back to the sea grafted tissue epithelium covers the nucleus building a pearl sac. The grafted mantle epithelial tissue gets accustomed to the tissue around to it by discharging regular requirements of exudation of nacreous layer or mother of pearl which gets concentric micro layers finally producing a pearl. This pearl is known as cultured pearl. Cultured pearls differ from natural pearls only in the matter of nucleus present inside the pearl.

Artificial pearls are not the cultured pearls but they are cheap imitations made of shiny other materials consisting of glass, plastic and so on (Alagarswami,1987).

Pearls Generating Molluscans:

Pearls are nothing but the shiny nacreous layer deposits as concentric layers, where as it is coated or formed on the shells inner surface. The quality of pearl is decided by its nacreous layer quality. Though the pearl is made up of prismatic layer which is made up of crystals of calcite generated in the clam '*Donax faba'* has no importance as gem. The giant clam *Tridacna* also produces large pearl like structure, but it is not considered as a gem. Mussels like *Mytilus and Perna* develops pearls which are small in size and are of low grade. Further they cause irritation also while eating. *Pinna, Pteria of penguin, Strombus* and *Haliotis discus* produces moderate quality pearls. Quality pearls are produced from fresh water mussels like *Pleurobema, Hyriopsis, Parreysia, Tritogenia, Cristaria, Quadrula, Amblema, Megalopods* and *Unio*. Marine

pearl oysters like *Pinctada maxima, P. fucata and P. margaritifera* produces high quality pearls (Alagarswami, 1987).



Specimen of *Pinctada martensii*

Akoya pearls produced by *P. martensii*

(Photo courtesy: Dahui Yu, South China Sea Fisheries Research Institute)

Economic Viability:

They are used to provide embellishment to the ornaments due to their unique shiny appearance. Pearls are used in medicine as their extracts have antioxidant and anti-inflammatory properties. Pearl formation through biomineralisation process of Pearl oysters can be utilized for preparing artificial human bone preparation. Pearls powder is used in cosmetic industrial creams for the purpose of skin brightening. Pearl Oysters shells are collected and stored for the aesthetic perspect. As the pearls are rich source of calcium, its powder is used as calcium tablets.

Pearl oysters can eliminate phosphorous and nitrogen from water as they need these elements. Hence they are useful in the process called bioremediation beneficial in enhancing the quality of water. For example: Akoya Pearl Oysters (Gifford *et al.,* 2005; Southgate *et al.,* 2008b; Duncan and Ghys, 2019).

Conclusion:

The historical and conceptual perspectives of pearl oyster are discussed, so as to attain attention for a sustainable future regarding blue economic growth towards pearl culture. So that it can also offer income through export (Gervis and Sims, 1992). Pearl culture not only improves diverse economical approach but also it can empower individuals mainly women and families. It does not require high technology to tackle and also a great capital resource. Apart from other benefits, pearl oysters can also utilize for shell and meat.

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SHORT NOTES ON TYPES OF BENTHIC INVERTEBRATES

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Abstract:

Benthos is also known as benthic invertebrates and it is most important integral part of aquatic ecosystems. It occupies all the stratum of sediment, serves to maintain the ecosystem proper. It comprises of both flora and fauna which are interrelated in relation to their food web. There is diversity in types of benthic invertebrates found in both freshwater and saline too. The present chapter deals with the types of benthic invertebrates, based on the habit and habitat (distribution, size and feeding habits) of the organism in aquatic ecosystem.

Keywords: Benthos, Benthic Invertebrates, benthic zone, sediment, types of Benthos

Introduction:

Benthos is the bottom layer organisms occupied in all types of ecosystems, both in saline as well as in freshwater. The term 'benthos' is used as an expressive term for the entire bottom community and the 'benthic boundary layer' relate to the immediate physical environment of the benthos (McCave, 1976). Benthos word is coined by a German zoologist Ernst Hackel in1891. In Greek, the meaning of benthos is 'Depth of the Sea'; the organisms live in a benthic region concerning the sediment. On the basis of types of organism they are classified into Zoo-benthos and Phyto-benthos e.g. all the benthic animals are known as zoo-benthos while benthic plants known as phyto-benthos such as microalgae etc. In all the benthos community or even closely related species may receive their food resources differently (Covich *et al.*, 1999). There are numerous food web relationships in which one species interrelates positively or negatively with others or in which the addition or defeat of only species alter food web dynamic. Benthos converts 'organic detritus', from 'sedimentary storage' into 'dissolved nutrients' that can be

mixed into overlying waters, which is used by rooted plants, macro-phytes and algae, phyto-plankton to improve primary productivity. Some benthos is 'omnivores' and feed on macro-phytes, algae, and zooplankton. Many benthoses are consumed by fishes. Through their mixing of sediments and consumption of diverse resources, benthos can, directly and indirectly, influence microbial production and release of greenhouse gases, toxic gases, and nitrogen (Covich *et al.,* 1999).

Types of Benthos:

On the basis of distribution of these organisms in water are classified into three types, Endo-benthos, Epi-benthos (Pearson and Rosenberg, 1978) and Hyper-benthos (Mees and Jones, 1997).

Endo-benthos:

These organisms are living inside the sediment, they ingest sediment's fine particulate matter e.g. Oligochaetes. Endo-benthic organisms are sedentary. They consist of diverse species that show different tolerances to pressure. They are representative of different zoological groups including annelids, bivalves, and crustaceans that contribute greatly to aquatic ecosystems. Among annelids, oligochaetes are mainly presented in freshwater, whereas polychaetes are mainly marine organisms. Among Insects Chironomus larvae used in eco-toxicological freshwater studies. (Amiard-Triquet and Berthet, 2015).

Epi-benthos:

These organisms are lying over the surface of sediment, e.g. Hydroids, mollusks, sponges, crustaceans etc. According to Rees, (2007), epi-benthos that comprises the flora and fauna inhabit the seabed surface like seaweeds, sponges, colonial hydroids, crabs, shrimps, and fish etc. the size of epi-benthos is considerably greater than their endo-//benthic organisms.

Hyper-benthos:

These organisms are living above the sediment floor, they have capability to swim near the bottom instead of attached to substratum, e.g. Rock cods. Many larval and early post-larval fish and crustaceans have a hyper-benthic life style (Mees and Jones, 1997). Mysids, a major component of the hyper-benthos, are used increasingly in aquaculture, and in eco-toxicology and pollution studies (Laughlin and Linden, 1983; Brandt *et al.,* 1993). There are two arguments in favor of using the term hyper-benthos in preference to the commonly used term supra-benthos (Mees and Jones, 1997). The similar assemblage of organisms is referred to as demersal

zooplankton in the tropics, and as hyper-benthos or supra-benthos at higher latitudes, deep-sea workers prefer the term bentho-pelagic plankton and refer to the zone as the benthic boundary layer.

On the basis of size of organisms they are classified into Macro-benthos, Meio-benthos and Micro-benthos.

Macro-benthos:

These organisms are living at the bottom of water column and they are easily seen with the naked eyes e.g. it is mostly Polycheates, Chironomids, Bivalves, Echinoderms, etc. generally their dynamics are elevated in low productive ponds. They are larger than 1 mm. Macro-benthic organisms are extremely responsive to ecological discomfort; they are greatly influenced by various factors in water. The density of macro-benthic invertebrates are controlled by a variety of ecological factors such as habitat characteristics (Hynes, 1970; Peeters and Gardeniers, 1998), sediment feature (Chapman and Lewis, 1976), size of sediment grain (Tolkamp, 1980), and by biological factors such as competition and predation (Kohler, 1992; MacKay, 1992; Macneil *et al.,* 1999). Stream flow, nature of substratum and organic pollution, generally regulates the species composition (Negi and Singh, 1990). According to Koperski (2011) many of factors which potentially controls the biodiversity of macro-benthos, however, clear-cut examples of strong influence on biodiversity of the total macro-benthos are rare and the diversity of macro-benthos dwelling in fresh waters is determined by geographic, climatic, and historical factors. The macro-benthos is acting as important tools of bio-monitoring due their long life cycle, limited mobility and differential sensitivity to different kind of pollution. Diversity of the total macro-benthos appears to be related only to composite environmental factors, viz. productivity or habitat heterogeneity (Voelzl and McArthur, 2000), while different groups of benthic invertebrates may be strongly affected by simple, abiotic environmental factors (Koperski, 2011).

Meio-benthos:

These organisms are smaller than 1 mm but larger than 0.1 mm e.g. Foraminifera, Ciliophora, Amphipod, Cladocera, Crustacean, Ostracoda etc. They are roughly defined as metazoans that can pass through a 500-μm sieve, but are retained on a 40-μm sieve (Higgins and Thiel, 1988). Nematodes, rotifers, and harpacticoid copepods often dominate permanent meio-faunal (or meio-benthos) communities, although curious animals such as tardigrades (water

bears), ostracods, cladocerans, gastrotrichs and micro-turbellarians can be found in some habitats. Temporary meio-fauna are typically dominated by the youngest instars of aquatic insects (chironomids), but also comprise oligochaetes and water mites (Traunspurger and Majdi, 2017). Meiofauna can be found worldwide, from glacier fed rivers to thermal springs, from oligotrophic to eutrophicated waters and they massively inhabit groundwater biotopes (Ward and Palmer, 1994; Rundle *et al.,* 2000; Traunspurger, 2000). Meio-fauna are diverse, numerically dominant, and act as trophic intermediaries between micro- and macroscopic organisms in stream ecosystems (Schmid *et al.,* 2000; Schmid-Araya *et al.,* 2002a). Some meio-fauna (especially oligochaetes, bdelloid rotifers, and some nematodes) are quite healthy and can thrive in organically polluted environments. (Traunspurger and Majdi, 2017).

Micro-benthos:

These organisms are very small in size, less than 0.1mm e.g. diatom, amoeba, bacteria etc. The micro-benthos includes various groups commonly presented in interstitial environments, with a noticeable abundance and diversity. These groups are important for coastal ecosystem functioning, participating both as producers and consumers (Dietrich and Arndt, 2000; Patterson *et al.,* 1989). In shallow water, the bottom substratum is soft; some important bio-chemical processes occurs in the sediment, where dense micro-benthic communities drive central ecosystem functions like primary production, decomposition and nutrient cycling (Larson and Sundback, 2008). The microbial organisms are eukaryotic e.g. diatoms, dinoflagellates, phytoflagellates, etc., but also some prokaryotic photosynthetic organisms i.e. cyanobacteria, contribute to the benthic community (MacIntyre *et al.,* 1996). Micro-benthos especially in shallow waters is often enriched by planktonic species. Micro-phyto-benthos comprise only autochthonous source of primary production on sediment in the absence of macroscopic vegetation (Larson and Sundback, 2008). Benthic micro-algae regulate sediment-water nutrients fluxes, might reduce the population of nitrifying bacteria capable of having an active metabolism (Risgaard-Petersen, 2003).

Feeding habits of the benthos retrieve the existence of diversity of life at the bottom of water bodies. The feeding habits can be classified on the basis of capturing as well as ingestion of the food particle five types of feeding habits are recognized as Suspension feeders, Deposit feeders, Herbivores, Carnivores and Scavengers.

Suspension feeders:

These are the immobile organisms and remain attached to the substratum, generally hard substratum and construct a tube or hard case into which they retreat when they sense danger. These organisms have appendages covered by mucus to which suspended particles from the water column becomes attached. They are then carried by means of the cilia and antennae to the mouth (Lavaleye *et al.*, 2007). These organisms may capture and ingest the particulate food particles present in the suspended in water. This comprises of mainly bacteria, detritus, phytoplankton and zooplankton. The size, shapes, chemical composition and concentration of suspended particle also influences rates and efficiencies of particle capture, the activities of diverse suspension feeding organisms influence a wide range of ecological processes (Hentschel and Shineta, 2008) e.g. sponges, polycheates, snail, clams, oysters, lancelets etc. many active suspension feeders are known as filter feeders (Hentschel and Shimeta, 2019; Cumming and Graf, 2010).

Deposit feeders:

The organisms which ingest particulate and deposited food, ingestion of sediment (microorganisms, decomposing organic matter) the animals which feed on surface layer of sediment is known as tentaculate surface deposit feeders (use tentacle to feed on surface) e.g. polycheates, sea cucumber etc. the organism which create sediment cone e.g. lugworm, Arenicola marina, it creates U shaped burrows, funneling sediment into mouth.

Herbivores:

The organism which feed on algae or algal cells in detritus is known as Herbivore benthos. They are generally found in shallow region, these organisms have unique mouth parts known as radule, which helps to cut and chew herbs matter (Lavaleye *et al.*, 2007) they are also know as shredders and grazers. Kajak and Warda, (1968) postulate that chironomus species has selective feeding habit and prefer algae; he also stated that the chironomus larvae could live purely on bacteria ingested with the detritus. Diatoms are the most important group of chironomid diet (Johanson and Beaver, 1983). Cocconeis diatom are more frequently as an important component in the diet of Hydropsyche occidentalis (caddis fly), while the filamentous green algae, Cladopora glomerata consumed in large amount by Sigara (corixidae) (Koslucher and Minshell, 1973).

Carnivores and Predators:

These are the organisms which feed on other live organisms of varying in size; they acquire a modified sensory organ which helps to find out the prey. They are very fluent to acquire their food prey as food. They have well modified mouth parts, teeth, jaws and extendible pharynx to capture and consume their prey. Some of the benthos is referred to as a scavenger which is subcategory of carnivores. The body of scavengers is same as that of carnivore but they feed on dead bodies or remnants of either benthic or pelagic organism (Lavaleye *et al.*, 2007). Carnivores consume additional animals which consist of asteroid starfish, may crabs, many fish, and anemones. Scavengers nourish on carcasses as well as residue of other animals and plants. Many deposit feeders also scavenge. Good examples of such species are the fiddler crabs, which are normally deposit feeders but can also scratch apart departed fish. According to Cummins (1975), the benthic macro-invertebrates may be divide into the functional trophic groups i.e. Scappers, shredders, collectors, and predators. The scappers or grazers are mainly herbivores feeding on attached algae. The shredder feed on coarse particulate organic matter and egests it in a fine particulate matter from which is in turn filtered and accumulated by the collectors and lastly the predators which are carnivorous and feed on small macro-invertebrates.

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PROPERTIES OF WATER WITH UNCOMMON ACCENTUATION IN LIMNOLOGY

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Abstract:

In brief, limnology is the consider of all sea-going frameworks counting lakes, wetlands, swamps, lowlands, lakes, reservoirs, streams, rivers etc. with respect to their physical chemical and natural characteristics. The natural limnologist is mainly frightened with the intuitive between sea-going living beings and their physical and chemical situations. This book chapter is outlined for those who wish a collection of set up framework in a shape helpful for utilize in either the research facility or field.

Introduction:

The branch of limnology which negotiates with the estimation of significant morphological highlights of any bowl and its included water mass is known as morphometry. Certain crucial conditions of generation emerge specifically out of measure and shape interrelations. In this manner it gets to be fundamental for the limnologist to form different estimations of shore line, region, profundity, slant, volume, and other morphological highlights and to set up from them certain proportions which serve as lists of lake differences. Details of these procedures belong more properly to field and laboratory work (see Welch, 1948) and will not be treated here. The enormous range of all aspects of groundwater chemistry subject to those foci is beyond the scope of this chapter. Instead, the emphasis herein will be on the various processes controlling groundwater chemical characteristics.

Life Supporting Properties of Water:

Pressure:

Water is a heavy substance. Pure water weighs 62.4 lb. per cu. ft. at 4^{o}C. This is a direct result of its density. Since density changes with differences in temperature, compression, substances in solution, and substances in suspension, the weight of a cubic foot of natural water is not always the same. It is roughly about 0.2 lb. per cu. ft. lighter at 27°C than at 4°C., and it has been estimated that substances in solution and suspension in inland waters usually do not add more than about 0.1 lb. per cu. ft. to the weight. However, for ordinary purposes, calculations of pressure on the basis of 62.4 lb. per cu. ft. are customary. In calculating pressures in the sea, a value of 64 lb. per cu. ft. is commonly used. The pressure at any subsurface position is the weight of the superimposed column of water plus the atmospheric pressure at the surface. Pressures in water, as depth increases, rapidly become great, so that ultimately a crushing effect is imposed upon objects submerged to considerable depths. This collapse under pressure is called *implosion.* Apparatus which includes inner spaces to which water has no access must be protected against the crushing effects of pressure in deep water.

Density:

Some of the most remarkable phenomena in limnology are dependent upon density relations in water. For example in concern to lake water, as the surface water is being cooled the lake will become stratified. That is, the density will increase with depth to 1000 kg m−3, and the deep water will have a temperature of 3.98 °C. Imagine the convection continuing until all the water has reached 3.98 °C.

Variations Due to Pressure:

Water at the surface, subject to a pressure of only 1 atmosphere, is considered as having a density of unity (1.0); at a pressure of 10 atmospheres, the density is about 1.0005; at 20 atmospheres, the density is about 1.001; and at 30 atmospheres, it is about 1.0015.

Variations due to Temperature:

Pure water forms ice at 0^{0}C., and steam at 100^{0}C., but the main interest here is in the changes of density of the liquid due to temperature. Water possesses that unique quality of having its maximum density (Fig.1) not just before it forms ice but at 4^{o}C (39.2^{o}F). Strangely

enough, it actually becomes progressively less dense (lighter) as it cools from 4°C, to the freezing point.

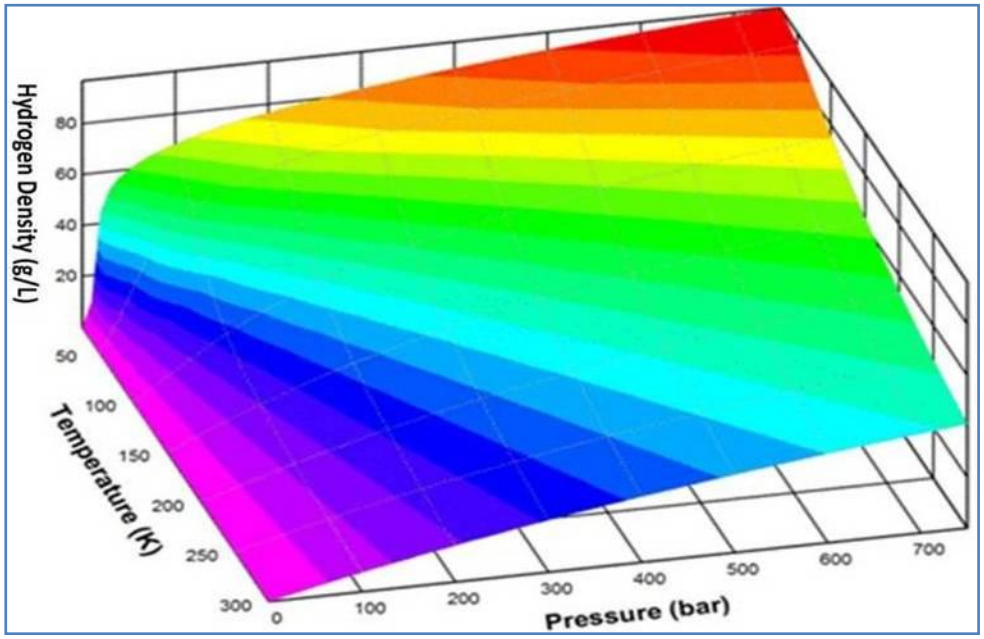

Figure 1: Graph showing relation between density and temperature in pure water Curve discontinued at 20^0C

The performance of many, possibly most, inland waters parallels closely that of pure water, as shown in Fig.1. However, one departure should be mentioned, viz., it is a well-established fact that with increasing hydrostatic pressure the temperature of maximum density in pure water becomes lower than 4°C although the change is of small magnitude. It seems likely that this fact explains the occurrence of temperatures slightly lower than 4°C. at the bottom of very deep inland lakes in summer (Wright, 1931; Eddy, 1943).

In natural environments, water is ordinarily least dense (lightest) at the maximum summer temperature. As it cools down during autumn and early winter, it gradually increases in density until 4°C. is reached. Further cooling decreases density until the 0°C. is reached. According to Coker (1938), sea water becomes heavier as it cools until the freezing point is reached, i.e., the temperature of maximum density is at 0°C, Instead of 4°Cas in pure water.

Changes due to Dissolved Substances:

All natural waters contain substances in solution. The concentrations of these substances vary widely, although, as a rule, the total amount in fresh water is less than that in sea water. Such substances usually increase the density of water, the amount of increase depending upon

the concentration of dissolved materials and upon their specific gravity. A marked influence of this sort occurs in salt lakes in which the density may exceed that of the oceans. Evaporation increases density by concentrating the dissolved materials; dilution reduces the density.

Changes Due to Substances in Suspension:

All waters, as they occur in nature, contain some suspended particulate matter. The quality and quantity of these substances vary greatly in different waters and at different times. Silt and certain other materials are heavier than water and thus increase its weight; others may have a specific gravity similar to that of water and cause no significant change in its weight. *Density currents* and related phenomena may be caused by substances in suspension.

Mobility (Viscosity):

Water is an exceedingly mobile liquid. Nevertheless, it has internal friction (viscosity). This viscosity varies with the temperature. Water is distinctly more mobile at ordinary summer temperatures than it is just before it freezes (Fig. 2). For the present purposes, the values given in Table 1 indicate the essential features of this variation with temperature.

Table 1: Changes in the viscosity of pure water due to temperature

Temperature (^{o}C)	Percentage of Viscosity
0	100.0
5	84.9
10	73.0
15	63.7
20	56.1
25	49.8
30	44.6

The mixing and stirring of water in nature are largely due to wind action. It is evident from the table given above that the response of water to a wind of fixed velocity would differ with different temperatures of the water. Much more work is required of the wind to produce a certain result when the water is near freezing than when it is near summer temperatures. Pressure does not cause any significant change in viscosity.

Buoyancy:

Buoyancy is a direct outcome of density and varies with the same factors. The law of Archimedes is as follows: A body in water is buoyed up by a force equal to the weight of the water displaced. (The greater the density the greater the buoyant force; the denser the water the higher will a floating object ride in the water. Ships passing from fresh water into sea water rise a little higher and the same ships with the same loads would ride somewhat higher in winter than in summer. Submerged bodies of all sorts are, of course, under the same influences and subject to the same changes of buoyant force.

Surface Film:

When water is exposed to air, it acts as if it were encased within an extremely thin, elastic, surface membrane. This boundary is commonly known as the *surface film* and is interpreted as a manifestation of unbalanced molecular action. In the interior of the water, the molecules do not exhibit any such phenomena, since in that position they are attracted to each other in all directions, neutralize the attraction of one another, and are thus balanced. However, at the surface film, a phenomenon called *surface tension* occurs, due to unbalanced attractions between molecules at the surface, since the surface molecules are attracted on one side only, and upward attraction is lacking because there are no water molecules above them. It happens, therefore, that a surface tension is produced which acts inwardly, and the molecules act as if they formed a tightly stretched, elastic membrane over the water. This surface tension diminishes with rise of temperature, and it is also lowered by organic substances in solution, although most salts increase it. In pure water, it is said to be greater than in any other liquid except mercury. Objects which do not wet may be supported on top of this film, even though their specific gravity is several times greater than that of the underlying water. A time-honored demonstration is the supporting of a dry, steel needle on the surface film. The limnologist is accustomed to seeing, at times along sandy lake shores, patches of sand floating on the surface film. The under surface of the surface film also serves as a mechanical support for certain objects in nature. Light rays, impinging from above, penetrate it if the angle of incidence is not too great, but beyond a certain angle the surface film reflects light. Viewed from below, especially at an angle, it appears as an exceedingly smooth, somewhat silvery, opaque film. This film is now known to have many limnological relations, the more important ones of which will be discussed later.

Table 2: Range of surface-tension depressions in various situations

Situation	Surface-tension Depression, Dynes per cm.
Oligotrophic lakes	0-2
Eutrophic lakes	0-20
Bog lakes	0-20
Lakes with foam	2-9
Near Lemma and lilies	5-20
During plankton bloom	0-20

Masses of foam, sometimes of considerable size, appear occasionally along the shore in inland lakes. Hardman observed reduced surface tension in regions of foam formation and suggested that the piling up of an organic film by a steady, strong, onshore wind operating for several hours might cause such an emulsion.

Temperature:

Temperature is one of the most important factors in an aquatic environment. In fact, it is possible that no other single factor has so many profound influences and so many direct and indirect effects. It, therefore, becomes necessary to give a rather detailed discussion here. Certain inherent thermal properties of water will be treated first.

Specific Heat:

Water has the greatest *specific heat* of all substances, except liquid hydrogen and lithium at high temperatures. Since this heat capacity is so great, it is used as the standard in expressing specific heats of other substances. The heat capacity of water is given the value of 1 (i.e., specific heat of water is 1), and. the specific heats of other substances are recorded as the ratios of their thermal capacities to that of water. More specifically, the numerical value of the specific heat of any substance is the number of calories of heat necessary to raise the temperature of 1 g. of the substance to the extent of 1^{o}C. Since the specific heat of water is so great, a lake must absorb vast quantities of heat in order to increase its temperature by 1^{o}C and this explains the slow rate of warming up of lake water in spring; likewise, its slow cooling in autumn is due to the large amounts of heat which must be given off. Thus, it is seen that the response to the major changes in air temperatures is a very deliberate one. Water temperatures always lag far behind the larger changes of air temperatures.

Latent Heat of Fusion:

Another peculiarity is that before water at 0°C. can become ice, it must give off a large amount of heat, and, conversely, when ice has just been formed at the freezing point, it must absorb a large amount of heat before it can transform into the fluid state. Actually, it requires about 80 units of heat to change 1 g. of ice to the liquid state when both are at 0°C. The heat thus involved is called *latent heat of fusion.* From the statement just made, it follows that the amount of heat required merely to convert ice into water with no change of temperature would, after the conversion has occurred, raise the temperature of the same amount of water about 80^{o}C. Latent heat of fusion is thus eighty times greater than the specific heat, although the specific heat of water is greater than that of all other substances save two.

Combined Effect of Specific Heat and Latent Heat of Fusion:

In lakes and other natural waters, the cooling of water in autumn with subsequent ice formation in winter and the disappearance of ice followed by warming up of the water in spring involve interchanges with the air of vast quantities of heat. As a consequence, the changes of water temperature are slow. In northern Michigan, for example, where the winter comes early, the larger inland lakes may not freeze over until December or early January; while in spring, the ice may not disappear completely until April.

Evaporation:

Water, including ice and snow, evaporates at all environmental temperatures. In evaporation heat is consumed. That quantity of heat necessary to convert 1 g. of water at 100°C. into steam without altering the temperature of the latter is known as *latent heat of evaporation,* sometimes called *heat of vaporization.* Water has the remarkable peculiarity of requiring 536 heat units for this conversion, a quantity of heat much greater than that of many other liquids. When evaporation occurs, the necessary heat required to make the change from water to steam must come from somewhere. It may come from some source of high temperature, such as the sun; it may be withdrawn from the water itself from bodies in or around it, thus lowering their temperature. Rate of evaporation is determined by several factors usually acting simultaneously, viz., temperature, relative amount of free surface of the water, vapor pressure, barometric pressure, and amount of wind action. The manner in which these factors operate is too well known to require description here. Still another factor, viz., quality of the water, sometimes affects evaporation in a significant way. According to Harding (1942), the rate of evaporation of

water decreases about 1 per cent for each 1 per cent increase in salt content until such content reaches about 30 per cent. Sea water "would be expected to have a rate of evaporation about 2 to 3 per cent less than that of similarly exposed fresh water." It would thus seem that in various inland saline waters evaporation is significantly slower than in comparable fresh waters, There appears to be little information available as to the extent to which rate of evaporation is affected by substances in solution in the so-called fresh waters; possibly, for limnological purposes, the effect is commonly negligible. The removal of heat by vaporization of water in nature goes on more or less continuously and plays an important part in the heat cycle of water and the superimposed air.

Thermal Conductivity:

The thermal conductivity of water is very low. If the water of a lake were heated only by conduction from the surface, the whole thermal complex would be radically different. Heating of water artificially by conduction alone would alter man's whole economic scheme. The influence of conduction in the transmission and distribution of heat, compared with certain other factors, is distinctly minor. Heat coming to a lake from the sun is partly absorbed and to some extent conducted, but the really effective heat distribution is due to wind action in agitating the water and, to a much more limited extent, to convection currents.

Convection:

When water in a beaker is heated by a flame placed below it, those portions of water first heated expand and rise while the upper, colder, denser (and therefore heavier) portions sink. If the heat supply continues for some time, there are thus set up ascending and descending currents, by means of which heat is carried all through the total water mass. This form of heat distribution is known as convection. Most forms of artificial heating of water are of this type. It should be noted, however, that the relation of the sun to a lake surface is just the, reverse of that of a beaker and flame, since the source of heat is above instead of below; and it might appear at first thought that no convection currents would result, since the water being heated is already at the surface. However, convection does occur under the following conditions: (1) cooling and sinking of surface water, as when the sun sets and, under conditions of falling air temperature; (2) entry of colder water from a surface tributary; (3) cooling of surface water with the passing of autumn into winter; (4) alternations of cloudy and clear skies; (5) alternations of winds and calm; (6) entry of cooler subterranean water at a high level in the basin; (7) advent of a cold rain; and (8)

cooling of the surface water by evaporation. These and other possible conditions produce a situation in which convection currents are in action most of the time in surface waters at least during the open season.

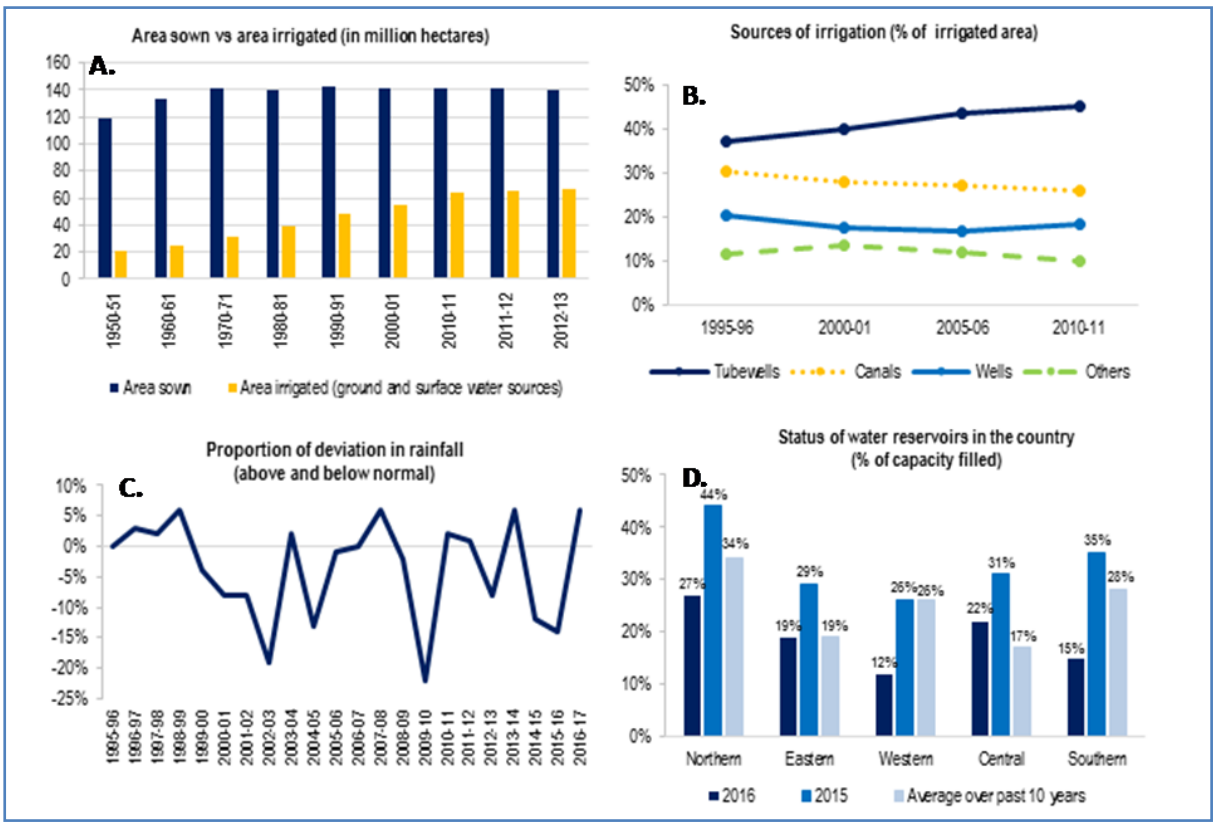

Figure 2: A. Area sown vs area irrigated B. Sources of irrigation C. Proportion of deviation in rain fall D. Status of water reservoirs in the country

Thermal Relations of Ice:

When water has reached a temperature of 0°C and has given up the large amount of latent heat of fusion, it changes its physical state and becomes ice. In so doing, certain other significant thermal changes suddenly come into existence. The ice expands (coefficient of expansion = 1.125), and its density becomes less (0.917), thereby becoming lighter than the underlying water, and hence it floats. The specific heat is only about one-half that of the water from which it was formed (0.505 at temperature 0 to -21°C.), but the thermal conductivity becomes twice as great (0.005). Transmission of sun's heat to the water through the ice in winter, but it should be pointed out here that while it might appear that because of its reduced specific heat and its increased conductivity the ice would facilitate passage of heat from the water to the colder air in winter, only a relatively small amount of heat is actually lost in this way. The thermal

conductivity of ice, even though twice that of water, is nevertheless relatively ineffective, and the ice cover seriously interferes with the passage of heat from water to the air.

Status of water accessibility for farming in India:

As of July 7, 2016, precipitation within the nation within the 2016 storm season is assessed to be 1% above normal precipitation. In any case, due to lacking precipitation within the nation resulting in dry spell conditions over the past two a long time, the water capacity within the nation is at lower levels than normal. In this setting, we show a few patterns with respect to the accessibility of water for agriculture within the nation (Fig.2. PRS India, 2020).

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WATER POCKETS ON THE EARTH

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Abstract:

Aquatic ecosystem is composed of both biotic and abiotic factors of environment. The natural cycle of environment is regulated and maintained by these vital factors. There are different water bodies on the earth surface providing food and shelter to organisms. The lake ecosystem is an important ecosystem which is made due to glaciers, volcanoes, rivers, meteor attack and movement of earth crust. The lakes are categorized as oligotrophic, mesotrophic, hyper-eutropic and Dystrophic on the basis of concentration of nitrogen and phosphorus in water. It shows stratification especially in summer season. The stratification is divided into epilimnion, hypolimnion and metalimnion on the basis of penentration of light to a depth. The physical chemical and biological parameters of the water bodies are studied from time to time by many limnologist. The phytoplanktons are microscopic plants; they are indicators of fresh water ecosystem and are the primary producers and food of zooplanktons. The abundance of plants indicates productivity. The flora and fauna of the ecosystem varies depending upon the light and nutrient factors of the environment. The concentration of pollutants affects on the population of water dwelling organisms. There are many anthropological activities responsible for deterioration and destruction of the water bodies. The eutrophication of lakes is due to excessive addition of nitrogen and phosphorus which depletes the amount of oxygen in water bodies. Wetlands are the aquatic water bodies that harbour many different types of plants, animals and microorganisms. Wetland loss has been both qualitative and quantitative due to anthropogenic and natural reasons. The pollution, climate change and encroachment are the major causes of wetland degradation. Different measures for conservation of water bodies are taken from time to time for sustainable development of aquatic ecosystems.

Keywords: wetland, Abiotic factors, Biotic factors, Eutrophication, Pollution, Conservation.

Introduction:

Water is one of the most important natural abiotic resources. It occupies most of the land area of earth. Aquatic ecosystems perform many important environmental functions of recycling nutrients, purifying water, recharging ground water and provide habitats for wildlife. It is also used for human recreation and is very important to living world. Inland water may be salty and brackish. The water bodies which are slow moving are called as Lentic type and the other faster moving are called as Lotic type. Wetlands are treated as water bodies where the soil is saturated or inundated for at least part of the time. The water bodies are an ecological systems interacting with their drainage basins and the atmosphere (Forel, 1901). The study of water bodies is called as Limnology (Greek word, *limne* = Lake or Pond or Marsh and *logos* = knowledge or to discourse or to study). Limnology is the discipline in which study of inland aquatic ecosystems or water bodies such as Lakes, water reservoirs, ponds, rivers, springs, streams, wetlands and ground water etc. takes place (Wetzel, 1983). The term limnology was coined at first by François-Alphonse Forel (1841–1912) and he is regarded as the father of limnology in 19^{th} centuary. The Limnology includes study of physics, chemistry, biology and geological approaches. The study of water bodies is conducted at all levels of organization from individuals, populations and communities to complex ecosystems of the earth including biogeochemical processes and interactions of abiotic factors with biotic factors working in aquatic ecosystems.

Components of aquatic ecosystem:

1. Abiotic:

Abiotic components of the environment are vital for functioning of any ecosystem. The components are air, light, temperature, topography, altitude, slope, steef, humidity, mineral nutrients, oxygen, carbon dioxide etc.

2. Biotic:

The biotic components are living components of the ecosystem. They are the producers, consumers and decomposers.

Producers:

The plants are the producers of an ecosystem, They are autotrophic in nature and synthesizes their own food material in presence of certain abiotic factors (e. g. water, light, CO_2 etc.) of environment by the process of photosynthesis and provide energy to the consumers.

Consumers:

The consumers are the heterotrophic organisms they feed on plant organic material. The consumer may be primary consumers that feed on plant material and secondary consumers they feed on primary consumers.

Decomposers:

These are the organisms present in the soil. They breakdown dead organic material of plants and animals and releases mineral elements and compounds in the soil, which in turn are obtained and utilized by the producers.

Lake Ecosystem:

Lake is a general term used for any standing water generally large enough in area and depth irrespective of its hydrology, ecology and other characteristics. These water bodies are used primarily for drinking water supplies, irrigation or recreation. It store and clean the water that is crucial for people and wildlife. The lake ecosystem constitutes the physical, chemical and biological properties. It may have fresh or saline water and may be shallow or deep, permanent or temporary. On the basis of its formation they are categorised into aeolian lakes, solution lakes, landslide lakes, fluvial lakes, Tectonic lakes, Glacial lakes, volcanic lakes and organic lakes. The lakes are classified on the basis of their formation and according to depth of water. River and streams are driven by underlying geology of the area as well as the general velocity of the water. The wetlands vary in size, shape and pattern. The most common types of wetland are marshes, bogs and swamps. They often fluctuate between shallow freshwater and being dry as per the season falling. The amount of sunlight penetration into water influences the structure of water body. The depth of water column where sunlight is able to penetrate and where most plant life is able to grow is the photic or euphotic zone of aquatic water bodies. If water column is deeper and does not receive sufficient amount of sunlight for plant growth is known as the aphotic zone. The photic and aphotic zones of the lake ecosystem show different levels of productivity.

Wetlands:

Wetlands are the most threatened ecosystems in the world. It support large amount of flora and fauna. At present wetland loss has been both qualitative and quantitative due to anthropogenic and natural reasons. The wetlands are threatened due to siltation, indiscriminate and unscientific construction of roads in the surrounding areas, construction of embankment etc. Threat is also due to infestation by exotic plant species, catching of young fishes, artificial

fisheries constructed for commercial growth of fishes, Lack of awareness of local people on the ecological part, pollution, climate change, encroachment are the major causes of wetland degradation. We have to protect and preserve our fragile wetland ecosystems. The joint venture helps to protect and restore wetlands. The illegal activities should be avoided. The litter should be picked up and disposed in appropriate trash container; these control measures should be followed.

Significance of lake:

The lakes are of great importance as they are useful by many ways such as they provide healthy and freshwater environment, supply of water for drinking, growing crops, manufacturing, energy and transport. They help to prevent erosion, dispose of waste and provide natural protection from flooding. Proper lake function can ease the impact of floods and droughts by storing large amounts of water and releasing it during shortage. They work to replenish groundwater, positively influence water quality of downstream water courses and preserve the biodiversity and habitat of the area. Lakes are essential elements of the landscape for several reasons. They provide important ecosystem services; they act as natural regulator of river flow, trapping sediments and nutrients from rivers and streams that flow into them. During the rainy season they prevent flooding while during the dry season help to maintain the flow of water. They moderate the climate of the surrounding areas, maintain an aquatic ecosystem and help in developing tourism. The pollination and water purification to support ecosystems and recreational opportunities gives aesthetic benefits. Healthy lakes and their shores not only provide us with a number of environmental benefits but influence our quality of life and strengthen our economy. In a healthy lake nutrients nourish and promote growth of aquatic organisms such as phytoplanktons, zooplanktons, algae, bacteria and other aquatic plants. It forms the base of the food chain and food web supporting the entire aquatic ecosystem.

Genesis of Lakes:

The lakes are formed as a result of different natural and artificial processes. They are constantly changing and follow the natural stages of transition and death. Starting from the deep they fill in due to natural causes. They become shallower until the wetland turns into a bog and finally ceases to exist. The overall quality and quantity of the water is dependent on the physical dimensions of the lake and its architecture of basin. The lakes may be formed by any of the following ways.

1. Glaciers:

The scraping actions of glaciers led to the formation of lakes. Glaciers followed existing valleys deepening and widening them. When the mass of ice is melted it blocks valleys damming, streams and rivers.

2. Ice-scour lakes:

The ice sheets move over relatively flat surfaces of hard jointed or fractured rock. Hollow basins are formed and subsequently filled with water.

3. Movement of the earth's crust:

If a portion of the earth's surface subsides in relation to its surroundings or conversely the sides are uplifted, a lake basin may be formed. The area and depth of water will depend on the drainage from the surrounding land which depends on the amount of rainfall and the size of the area from where water drains into the lake.

4. Volcanoes:

Many lakes are formed due to volcanic eruptions called crater lakes. These lakes are fed only by rainfall and run-off. They are found where a series of minor eruptions have taken place fairly close to each other rather than one massive eruption. In some cases, where the volcano was big and erupted long ago, the floor of the enormous crater is relatively flat and water accumulates in the lowest places. It is formed when the ash or lava from an eruption blocks natural drainage.

5. Rivers:

When the flow of water is suddenly slowed by a decrease in gradient, it takes a longer route and flows at a slow rate. The sediments are eroded from the outside and deposited on the inside so that the channel becomes more twisted. Sometimes the river breaks through a narrow isthmus between two succeeding curves. This may leave a loop of the river to one-side of the new watercourse. The isolated portion may retain enough water to form a lake.

Classification of Lakes:

Lakes are classified in different types on the basis of their Primary productivity, they are divided into five types as follows

1. Oligotrophic lakes:

This type of lakes shows low rate of primary productivity and biomass due to low concentration of nitrogen and phosphorus. Due to low nutrient concentration the population of aquatic algae, phytoplankton gets decreased. Decay of the relatively small amount

of organic matter in oligotrophic lakes does not completely deplete the hypolimnetic supply of dissolved oxygen.

2. Mesotrophic lakes:

These are the lakes in transition state between oligotrophic to eutrophic conditions. The amount of oxygen may get depleted in hypolimnion during summer season and shows stratification.

3. Eutrophic lakes:

These types of lakes are having high concentration of phosphorus and nitrogenous nutrient contents. The rate of biomass production is very high. It shows low transparency. The oxygen concentrations may becomes very low as low as 1 mg/L) in the hypolimnion during summer season. In this type wide seasonal changes are seen in their biological and chemical conditions. Due to large amount of organic matter produced in these lakes, the decay rate is high inthe hypolimnion causing depletion of oxygen, complete loss of dissolved oxygen below the thermocline during summer season is observed, and Most of the fishes and other animals cannot live. Algae or macrophytes grow thickly as the light penetrates a short distance and nutrients below that depth are not assimilated.

4. Hyper – eutrophic lakes:

These are the lakes at the extreme end of eutrophication, possess very high concentration of nutrients and biomass production is seen. During summer season complete loss of oxygen takes place in the hypolimnion zone.

5. Dystrophic lakes:

These are the lakes which possess organic matter with humic acid and fulvic acids. Phosphorus is typically the limiting nutrient in freshwater lakes. The plants deplete all available phosphorus before depleting the other mineral nutrients. The rate of photosynthesis is limited by light rather than by nutrients. When a great abundance of phosphorus is available in a lake, nitrogen may become limiting. In such lakes certain species of blue-green algae that can fix atmospheric nitrogen becomes dominant. The blue green algae dominate the other algae until another nutrient or usually light become a limiting factor.

Stratification of Lake:

On the basis of temperature gradient in aquatic habitat the water bodies can be categorised into different stratas or layers as follows.

1. Epilimnion:

It is the upper layer or stratum having highest dissolved oxygen concentration and temperature gradient is less that 1^0C / m of depth. It contains more or less uniformly warm, circulating and fairly turbulent water. When the nutrients are in ample supply then algal growth is accelerated and blooms mats are formed . This zone is well oxygenated with sufficiently high temperature to promote algal productivity and hence it supports zooplanktons and fishes. Under extreme conditions the epilimnetic material provides an energy source for benthic invertebrates.

2. Metalimnion:

It is the middle zone marked with thermal change between the epilimnion and hypolimnion. It is characterised by a temperature gradient of more than 1^0C / m of depth. It refers to the plane or surface of maximum rate of decrease of temperature in the metalimnion (Wetzel, 1983).

3. Hypolimnion:

It is the lowermost zone of water characterised by a temperature gradient of less than 1^0C/ m of depth. It contains denser, cooler and relatively quiet water. It is cold, dark and becomes progressively deoxygenated because the decaying remains of organisms sink down. The condition of hypolimnion may become so extreme that biological productivity becomes less. The sinking of dead algae and zooplanktons contributes to the potential deoxygenation of the hypolimnion and prevents immediate recycling of nutrients. The nutrient depletion in this zone may become high so that algal growth becomes limited.

Phytoplanktons:

Phytoplanktons are primary producers of aquatic ecosystem. The population of primary production in aquatic water bodies is dependent upon the quality of water. Some of the ecological studies related to phytoplanktons were made by Singh (1990) who correlated physico-chemical parameters with primary production of plankton. Gurudev *et al.,* (1983) reported the Desmid flora of fresh waters of Savandurga. Hosmani (2010) studied seasonal changes in phytoplankton community in fresh waters and found that blooms of *Franceiaovalis, Euglena elastica, Euglena gracilis* had a significant effect in reducing the number of species in ponds. Depending on the species, algae divide to form new individuals two to ten times per month. In general there is a tendency for diatoms to dominate in spring followed by green algae. The seasonal periodicity of phytoplanktonic biomass is reasonably constant from year to year if the freshwater ecosystem is not disturbed by outside influences, such as human modifications of the

watershed, nutrient loading etc. The extent of change in phytoplanktonic numbers and biomass through the seasons is usually very high. The seasonal variations in tropical waters are much lower. Maximum and Minimum numbers and biomass of phytoplankton often are related with rates of primary production. Primary productivity usually follows closely the annual cycle of incident solar radiation in temperate lakes.

Productivity:

Productivity can be defined as the rate of production of a group of organisms that representing the net growth rate. Lakes may become unproductive due to lack of sufficient nutrients required for growth and reproduction of plants. The plants are basic food material for the whole aquatic ecosystems. The abundance of plants indicates productivity. Productivity is measured as the new carbon collected from the air and fixed as organic compounds by photosynthesis so that it can be added to the total food supply in the lake. Productivity is expressed as grams of carbon fixed per cubic metre (gC/m^3) per unit of time. The amount of small floating plants or phytoplankton indicates productivity measured as the total amount of chlorophyll present. The amount of chlorophyll -as per cubic metre is an index of phytoplankton abundance and potential productivity. The efficiency of carbon transfer within lake ecosystems is dependent on the two factors 1) Quantity of biomass created at primary producer level 2) Composition of species which determines efficiency of grazing quality and quantity of fish. After death organisms at primary, secondary and tertiary levels decay and recycle mineral nutrients in the soil

Flora of lake:

The fresh water generally contains different types of plants. The diatoms and blue-green algae are common phytoplanktons that attract and hold other organisms. The lake contains lower and higher plants like *Navicula, Chlorella, Volvox, Zygnema, Scenedesmus, Oscillatora, Anabaena, Phragmites, Nymphaea, Potamogeton, Myriophyllum, Ceratophyllum, Lemna, Eichhornia, Salvinia etc.*

Fauna of lake:

The fresh water body generally contains the animals such as Trout, Salmon, frogs, toads, Salamanders, Otters, Beavers, Ducks, Gooses, Swans, Turtles, ticks, leeches, Snails, worms, marsh birds, mollusks, Alligators, snakes, diving bell spider etc. There found

cryptomonad, microflagellates, ciliates, fishes, shrimps, crabs etc. The insects like *Odonata, Ephemeroptera*, *Plecoptera, Trichoptera, Diptera, Scaphaloberis, mucronata* etc.

Eutrophication and consequences:

Eutrophication is the increase in supply of nutrients in any water bodies. It may takes place due to disposal of sewage, industrial effluents, and fertiliser run-off from agricultural fields. The eutrophication becomes continuous due to addition of decayed organic matter of plants and animals. The inflow of nutrients and consequent algal growth deteriorates the water quality. Phosphorous inputs in lakes results in frequent blooms of blue green algae that liberates toxins (Bratli, 1994, Pandey *et al.,* 1998). The importance of phosphorous in eutrophication of fresh waters and production of abundant autotrophs mainly cyanophyceae was reported by Correl (1998). Eutrophication becomes highly detrimental to the quality of water and may limit its use. The detrimental effects may result from inefficient use of phytoplankton biomass that in turn is derived from high nutrient availability. This is mainly due to changes in dominance of algal species that are not consumed by zooplanktons. Eutrophication usually affects physical and chemical environment and can lead to significant changes in community structure. The eutrophication results in zooplankton community dominated by rotifers and small bodied Cladocerous (Flores and Barone, 1994; Uku and Mavuli, 1994). Eutrophication can have serious effects like algal blooms that block light from getting into the water and harm the plants and animals that need it. If there is enough overgrowth of algae, it can prevent oxygen from getting into the water, creating a dead zone where no organisms can survive.

Control of lake pollution:

The lakes are polluted by natural and anthropological activities taking place from time to time. The pollution affects badly on the aquatic biota. The lake pollution can be avoided by adopting some steps such as:

1. Not to use disposable water bottles
2. Avoid washing of vehicles
3. Do not dispose chemicals
4. Do not spill the oil
5. Reduce, Reuse and Recycle of plastic
6. Avoid gaseous emission
7. Use conservation practices on agricultural lands

8. Plantation of the native trees along shorelines and river banks to help to hold soil particles together in place and reduce soil erosion.

Management of water bodies:

The water bodies are important to us for the survival of living organisms on the earth planet. Their protection is necessary and it is responsibility of the human beings as many anthropological activities are responsible for the deterioration and destruction of living creatures in it. To avoid the loss of water bodies proper and careful management practices are essential. The following measures can be taken to manage water bodies properly:

1. Survey of endangered water bodies
2. Educate and encourage peoples
3. Collaborative research among scientists, water resource managers in govt. and non – govt. Organizations
4. Execution of projects in relation to aquatic ecosystems
5. Acquaint peoples with providing scientific information on local water quality issues through social media
6. Meetings of different organizations ranging from environmental and sporting groups like scouts, Lions clubs, Rotary clubs etc.
8. Data collection and Interpretation to understand the status of water body.
9. Planning of public outreach programs
10. The university, institutes, colleges and school students training through graduate programs and conduct research to increase society's knowledge
11. Exposure to students in practical problems in water resource management
12. Reduction of energy consumption
13. Avoid use of plastic and plastic products.

Conclusion:

The aquatic ecosystems are significant to us by various ways. Lake Ecosystem is interesting and unique on the earth as it harbors different types of microorganisms, plants and animals. Today lakes and wetlands are threatened due to anthropological activities and disturbed ecological balance. Urbanization is taking place very fast; cities are growing larger in places where freshwater is not readily available. The decreasing lake levels due to water withdrawals are increasing day by day. Almost every year there is threats of invasive species introduced into

the lakes and displace natural aquatic plants. The discharge of pollutants into the lakes due to industrialization is the biggest barriers to the improvement of water quality. The human settlements, negligence of the concerned authority and public effluent sources are the chief factors for the degradation of lake.

The humans has resulted in degradation of the catchment area due to destruction of vegetation, extensive agricultural use and consequent erosion and increased silt flows mared the quality of water stored in this natural reservoirs. The high level of dependency on wetlands and its poor quality calls for immediate restoration of degraded lakes and appropriate measures for conservation and management in order to maintain ecological balance of nature.

It is the need of the hour to formulate viable plans, policies and management strategies. The conservation strategy should have an extensive basis of participatory process and better monitoring mechanism to increase the knowledge of the physical, chemical and biological characteristics of aquatic resources, their values and better understanding of its dynamics. Conservation of natural resources through sustainable ecosystem management and planned development is the key to our secured future.

Acknowledgement:

Author is thankful to the limnologist who shared their valuable information through means of research articles, reference books and information made available on the websites.

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AQUATIC LIFE AND PESTICIDE RESIDUES: WITH SPECIAL EMPHASIS ON FATE AND BEHAVIOUR OF AQUATIC ORGANISMS

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Introduction:

Limnology is to consider about of the auxiliary and useful interrelationships of life forms of inland waters as they are influenced by their energetic physical, chemical, and biotic situations. The present chapter intended to help fill the gap on the scarcity of information concerning the pesticide residues impact on aquatic Organisms. Apparently, Water is the quintessence of life on soil and completely rules the chemical composition of all living beings. The ubiquity of water in biota, as the support of biochemical digestion system, rests on its interesting physical and chemical properties. The characteristics of water direct Lake Digestion system. The special thermal-density properties and liquid-solid characteristics of water permit the arrangement of a stratified environment that controls broadly the chemical and biotic properties of lakes. Aquatic water contamination was reported earlier by various sources in addition to pesticides such as acidic (Krishna Murthy *et al*, 1981; Bhaskar and Govindappa, 1985a), alkaline (Bhaskar *et al.*, 1984; Bhaskar and Govindappa, 1985b), altered pH (Bhaskar and Govindappa, 1985c; Bhaskar, 1994) in fish and prawn (Sailaja *et al.*, 2008); Water gives a tempered milieu in which extraordinary variances in water accessibility and temperatures are enhanced relative to conditions confronted by biota in airborne life. Coupled with a moderately

high degree of consistency, these characteristics have empowered biota to create numerous adjustments that develop sustained productivity.

The expanded presence of chemical contaminants within the environment is an irrefutable concern to human wellbeing and biological systems. Generally, by depending intensely upon expensive and difficult animal-based harmfulness tests, the field of toxicology has regularly dismissed examinations of the cellular and atomic components of harmfulness for the larger part of compounds data that, in the event that accessible, would strengthen hazard evaluation analyses. Eco-toxicology is nothing but the poisonous impacts of chemicals on the sea-going and earthly environment. To understand undesirable occasions within the common environment, by carrying out eco-toxicity testing and chance evaluation on modern chemicals that will be utilized, arranged, or otherwise reach the environment. In looking for to anticipate and anticipate contamination impacts, the most and helps progressively to create models which can be utilized to anticipate the destiny and impacts of chemicals inside an ecosystem.

Toxicology addresses constantly-changing concerns about the safety of our environment and natural resources. Toxicology research focuses on understanding mechanisms of toxicity, human and environmental risks from exposure, and means for reducing risks. Insecticides are substances used to kill insects. They are used primarily in agriculture to control pests that infest crops. Nearly all insecticides have the potential to significantly alter ecosystems, many are toxic to humans and/or animals, some are become concentrated as they spread along the food chain. The presence of these chemicals in both aquatic and terrestrial ecosystems has become an important issue globally.

The term pesticide covers a wide run of compounds counting bug sprays, fungicides, herbicides, rodenticides, molluscides, nematicides, plant development controllers and others. Present day medicate disclosure and toxicological investigate are beneath weight, as the fetched of creating and testing unused chemicals for potential toxicological hazard is rising. Broad assessment of chemical items for potential unfavorable impacts could be a challenging assignment, due to the huge number of chemicals and the conceivable perilous impacts on human wellbeing. Security administrative offices around the world are managing with two major challenges. To begin with, the development of chemicals presented each year in family items and solutions that got to be tried, and moment ought to secure open welfare. Consequently, elective and more productive toxicological hazard evaluation strategies are in tall request.

Productivity of aquatic ecosystem:

Aquatic environments are open and require a ceaseless input of vitality within the shape of natural matter. This natural matter is created nearly completely by photosynthesis and is either utilized by consumers or put away within the environment. Natural matter and vitality driving the environment are either created inside the waterway or lake or are imported from earthly or land-water interface communities to the waterway or lake. Inside the sea-going environment, natural matter is corrupted physically, as in coordinate photolysis, utilized by decomposer living beings, or ingested by slow eater (metazoan) life forms. Vitality and supplements must persistently be recharged in such open frameworks in which accessible vitality and other assets are continually being utilized and breathed to inorganic compounds.

Benthic animal communities:

The dissemination, plenitude, and efficiency of benthic life forms are decided by a few biological forms: (a) the authentic occasions that have permitted or anticipated a species from coming to a living space, (b) the physiological restrictions of the species at all stages of the life cycle, (c) the accessibility of vitality assets, and (d) the capacity of the species to endure competition, predation, and parasitism (Hutchinson, 1991). We ought to look at briefly characteristics of the differing qualities of benthic spineless creatures that possess inland waters.

Pesticides production in India (2014-2019):

There are 234 pesticides enlisted in India. Out of these, 4 are WHO Class Ia pesticides, 15 are WHO Class Ib pesticides and 76 are WHO Class II pesticides, together constituting 40% of the enrolled pesticides in India (Fig.1b). In money related year 2019, the pesticides generation measured to 217 thousand metric tons over India. The Indian chemical industry is exceedingly differentiated. With a scope of over 80 thousand items, the south Asian nation was the 6^{th} biggest maker of chemicals within the world and the third biggest in Asia. The following is a list of 24 pesticides registered and used in India, classified as Potential Carcinogens by the US EPA: Acephate, Alachlor, Atrazine, Benomyl, Bifenthrin, Captan , Chlorothalonil), Cypermethrin, Dichlorvos Diclofop-Methyl, Dicofol, Mancozeb, Methomyl, Metolachlor, Oxadiazon, Oxyflourfen, Permethrin, Phosphamidon, Propiconazole, Propoxur, Thiodicarb, Thiophanate Methyl, Triadimefon, Trifluralin.

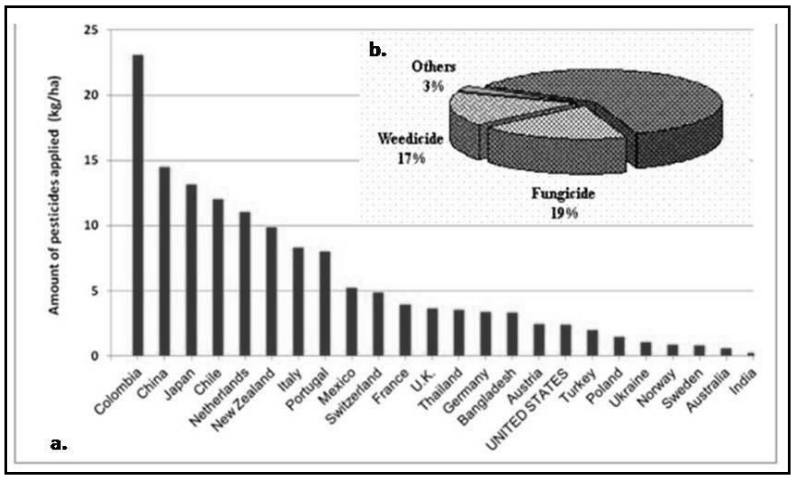

Figure 1a: Pesticide use throughout the world (Kg/hectare of cropland);
1b: Composition of Pesticides usage in India

Pesticide usage and exposure:

In India, pesticide manufacture was started in 1952. The consumption of pesticides has increased from 150 tons to 80,000 tons, since 1953 to 1983. At present, India is using 1/3 of pesticides that are consumed in third world countries in 25 per cent of agricultural lands. About 104 pesticides have been registered for use in India in agriculture, of which 53 are in use. In addition, about 60 different pesticides are also imported. The estimated pesticidal consumption in 1990 is about 1,200,000 tons and is expected to increase. Andhra Pradesh ranks number one among all the states with 25% of total usage of pesticides. Human exposure to agricultural pesticides and the subsequent contamination or poisoning may be occupational, non-occupational, intentional or unintentional. Also, exposure may be through ingestion (oral), through the skin (dermal) or through inhalation (respiratory). Occupational contamination or poisoning has been identified as the most serious problem associated with the use of agricultural pesticides, especially in developing countries (Olurominiyi and Monosson, 2007). Consequently, the pesticides have entered the environment to the undesirable levels and caused unquantified deleterious effects.

Significance of the present data:

Fishes are vital sources of proteins and lipids for people and household creatures, so wellbeing of angles is exceptionally vital for human creatures. Insecticides are the chemicals utilized to control creepy crawlies by killing or avoiding them from locks in undesirable behaviors or dangerous. The defilement of surface waters by insecticides is known to have sick

impacts on the development, survival and propagation of sea-going creatures. Distinctive concentrations of insecticides are show in numerous sorts of waste water and found them to be poisonous to aquatic living beings, particularly fish species (Sharma *et al.,* 2020).

This chapter presents further data concerning impacts (Acute, sub chronic and chronic) of the distinctive concentrations of pesticides (including insecticides) on different aspects of fish's science and physiology. Too, delineates behavior, hereditary and resistant system of fish. The data given in this survey encourages the assessment of potential harmful risks coming about from introduction to diverse levels of these compounds. Information may well be obtained valuable in natural chance evaluation of freshwater living beings and marine. The histopathological changes in angle tissues utilized as a natural pointer for contamination with pesticides with extraordinary reference to bug sprays. At last, Security of natural life and water quality is conceivable when rationalize by utilize of pesticides. Moreover, when Pesticides must choose reasonably and are utilized in combination with other bug administration apparatuses, and connected securely, the surface water pollution and defilement of our aquatic life may well be avoided.

Lethal and sub-lethal effects of pesticides on aquatic organisms:

The credits of pesticides include enhanced economic potential in terms of increased production of food and fibre, and amelioration of vector-borne diseases, and then their debits have resulted in serious health implications to man and his environment. Pesticides are in use from times immemorial. Ever since man started agriculture, started using pesticides in some form or other as plant protection agents e.g. nicotine, rotenone, natural pyrethrins and inorganic sulphur. Recent research and development brought about hundreds of new synthetic chemicals of varying toxicity and has led to not only benefit the agriculture but also the potential source of environmental pollution and exposure to pesticides could have negative consequences for human health.

In the process of development of agriculture, pesticides have become an important means for plant protection and to boost up food security as these chemicals play a significant role by keeping many dreadful diseases (Sachin kumar *et al.,* 2013). A vast majority of the population in India (56.7%) is engaged in agriculture and is therefore exposed to the pesticides used in agriculture (Gupta, 2004). Although Indian average consumption of pesticides is far lower than many other developed countries, the burden of pesticide residue is very high in India (Hashmi *et al.,* 2020, Ferreira *et al.,* 2020). The consumption of pesticides in India is about 600 g/ hectare, whereas that of developed countries is touching 3000 g/hectare. Pesticides have become common

contaminants in soil, air, water and in non-target organisms of our urban landscapes. Once appear, they can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish (Pradeepkiran and Bhaskar, 2016; Mariyadasu, 2013), birds, and other wildlife (USGS, 1995). Residues in food for humans and feed for livestock can be a consequence of direct application of a chemical to the food source, by the presence of pollutants in the environment or by transfer and bio-magnification of the chemicals along a food chain (Vivek *et al.,* 2016; Sachin kumar *et al.*, 2013).

Following the euphoria at their ability to kill pests, many farmers in USA and other industrialized countries sprayed their croplands very heavily with DDT aldrin, dieldrin, endrin, endosulfan etc., among organochlorines, parathion, fenitrothion, malathion etc., among the organophosphates and carbaryl among carbamates. This has led to excessive and indiscriminate use of pesticides. Even at the beginning, there were signs that such blanket spraying of croplands would lead to mass mortality of non-target organisms and undesirable perturbations of the environment (Ware, 2000). The mass mortality of trout in the Miramiche River in Canada, the Clear lake incident in California (Rudd and Herman, 1972) and several such other instances were discounted as having no relationship to the large scale use of pesticides. Evidence was slowly mounting that pesticides were causing untold damage to ecosystem, and that all was not well with pesticide use scenario. Matters came to a head with the publication of Rachael Carson's 'Silent Spring' in 1962. In her now celebrated book, Ms. Carson not only outlined the ill effects of the over-use of pesticides but also vividly described "what was in store for the human society, if unabated and indiscriminate use of pesticides were to continue". Since then a lot of work had been carried out on the undesirable effects and environmental perturbations that came in the wake of large scale use of pesticides. Sustained research effort, aroused public opinion and enlightened administration, quickly joined hands to gather facts and figures, and attempted a cost-benefit analysis of the use in the industrialized nations. This has led to not only the banning of some of the recalcitrant pesticides but it also resulted in efforts at better pest management techniques. Since then the environment in the western countries has made a remarkable recovery from the low ebb of the mid sixties and early seventies to the present times.

In developing countries (Fig.1a.), the use of pesticides has increased rapidly and one fifth of all pesticides are consumed by these countries only. By the mid 1960s, pesticide consumption has reached over 7,000 tons per annum, increased to the level of 16,226 metric tons (MT) in 1976-77. But food and agricultural regulation 1965 has not been amended for pesticide residues in food samples up till now (Tariq, 2005). The pesticide companies motivated the framers to use

more than the recommended dose of pesticides through media campaign for different crops. This may be one of the reasons for higher loads of pesticide residues found in different crops and vegetables (Tariq, 2005).

Compelling economic reasons necessitated continuation of the use of some of the environmentally problematic compounds in India. Not only persistent compounds like DDT and HCH are continued to be used in India, but the total quantity of consumption of these compounds has steadily increased hand in hand with the spread of green revolution in our country. The production of pesticides started in India in 1952 with the establishment of a plant near Calcutta. India is now the second largest manufacturer of pesticides in Asia after China and ranks twelfth globally for the consumption (Mathur, 1999). There has been a steady growth in the production of technical grade pesticides in India, from 5,000 metric tons in 1958 to 1, 02, 240 metric tons in 1998. In 1996-97 the demand for pesticides in terms of value was estimated to be around Rs. 22 billion (USD 0.5 billion), amounting to about 2% of the total world market. The pesticide market of India in the world is with US$ 0.6 billion per annum, which is 1.6% of the global market. Since pesticides are designed to kill or adversely affect living organisms, by their very nature, they pose risk to humans, non-target plants and animals. They not only contaminate the ecosystem but also bio-accumulate in the food chain and can be traced in plant and animal tissues causing serious health hazards. The increasing incidences of pesticide residues in the meat and milk are of a great concern for ensuring food safety and human health (Sachin kumar *et al.*, 2013).

The environmental fate and behaviour of pesticide residues is largely unknown, although much work has been carried out on the persistence of different types of compounds in the agricultural produce and agricultural soils of our country. Practically nothing is known about the occurrence of pesticide residues in our rivers, aquatic bodies and drinking water supplies. But for a few sporadic reports on the contamination of the drinking waters of Delhi and Nagapur nothing is known the common types of residues present, their concentrations and their seasonal fluctuations from other parts of the country. Soil is a potential pathway of pesticide transport to contaminate water, air plants, food and ultimately the human via runoff and subsurface drainage, interflow, leaching and transfer to plant and animals that constitute the human food chain (Anwar, 2004).

India did not wake up fully to the use of synthetic organic pesticides till 1971. When green revolution was ushered in, it has as its props increased use of pesticides and increased input of agricultural fertilizers, besides using better farm techniques. Since then, the use of

pesticides has been going up by leaps and bounds in our country too. The propensity of DDT and other hydrophobic compounds to accumulate in animal tissues has already been highlighted. These compounds being lipophilic accumulate in the fat depots and fatty tissues from which they are not easily mobilized or metabolized. In mammals the only time they are expressed out of the body is during lactation. There have been many reports of the occurrence of OC residues in mothers' milk and their transfer to the young human babies (Skaare *et al.,* 1988 and Kanja *et al.,* 1992). Recalcitrant pesticides of the OC group and others have been banned in the Western countries in the early seventies and since then their concentration in natural waters has been steadily coming down. Unfortunately, intense use of pesticides commenced in India with the dawn of the green revolution in the early seventies and because of compelling economic reasons the use of such non-proprietary low cost pesticides like DDT and HCH is being continued.

Ahmad (2004) emphasized the continuous monitoring of pesticide residue in food, environment and biosphere at large and its need for creating awareness of trend of level on contamination and to build up a data base upon which future plan could be decided. The misuse of pesticides has led to tremendous economic losses and hazards to human health. Human exposure to pesticides is usually estimated by measuring the levels in the environment i.e., soil, water and food (Tahir *et al.,* 2001, Ahmad, 2004, Anwar *et al.,* 2004, 2005). Indiscriminate use of pesticides and their persistence in environment have led to widespread contamination of food sources such as food grains, vegetables, fruits and animal products. Animal derived products, however, are likely to carry a greater load of pesticides due to their higher lipid content (Srivastava *et al.,* 2008). With the exception of occupationally exposed individuals, most exposure to these chemicals occurs via dietary intake (Ahlborg *et al.,* 1995), especially food of animal origin, but also through water, ambient and indoor air, dust and soil (Covaci *et al.,* 2002; Dua *et al.,* 2001; Manirakiza *et al.,* 2002).

Pesticides have been proved to have serious hazards to human health. Organochlorines in particular have high bioaccumulation (Fig.2) potential and low degradation rates; have been associated with a number of environmental effects. Due to their persistence pesticides are distributed in air (Strand and Hov, 1996; Wania and Mackay, 1996). The most common effects of the wide spread of organochlorine compounds in the environment are birth defects, neurological effects and behavioral effects, reproductive effects and cancer (Windham, 2002).

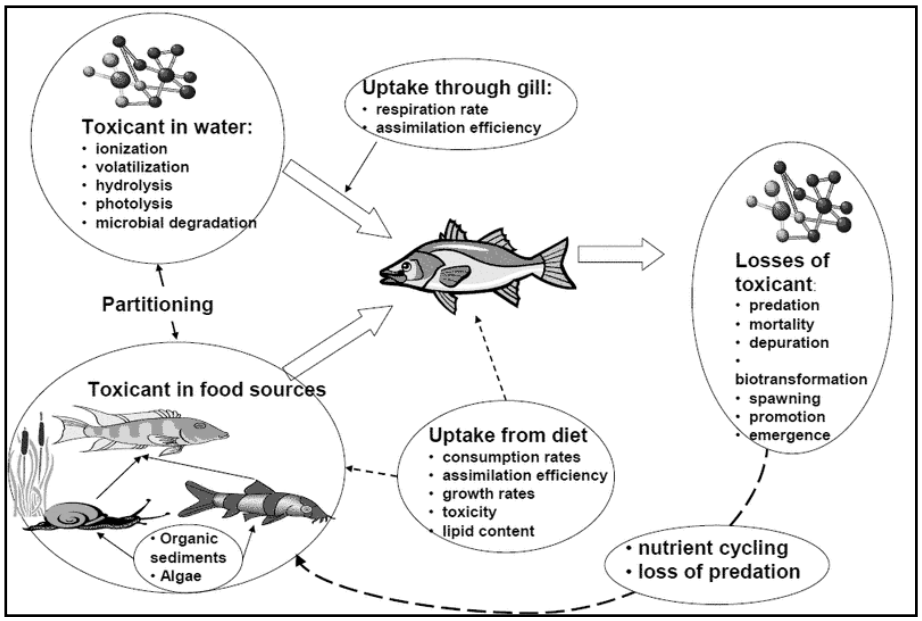

Figure 2: Bioaccumulation in Aquatic organisms

The World Health Organization (WHO) has estimated that each year, there are some 30, 00,000 cases of acute pesticide poisonings, with 2, 20,000 aquatic animal deaths. The majority of these incidents occur in developing countries, particularly in Africa, Asia and Central and South America. There are concerns about the possible human health impacts of exposures to chemicals and pharmaceuticals used to protect livestock from disease; these may enter food, soil and water supplies, the latter shared by animals and humans (WHO/UNEP, 2008). Surveillance or monitoring on the occurrence of residues in meat and their products was relatively a neglected area until last decade (Horrigan *et al.,* 2002). But with the advancement of technological intervention regarding livestock rearing, disease control and intensive crop production system, the chances of residues in foods of animal origin increased tremendously. This resulted to a potential risk of various life threatening diseases such as cancer, leukemia, reproductive disorder besides disruption of body's immune, endocrine and nervous system (Horrigan *et al.,* 2002).

Pesticide residues:

Unfortunately after use, pesticides do not stay in their place of application but move to the other parts of the environment and ultimately to the aquatic environment, this leads to the mass mortality of non-target organisms and undesirable perturbations of the environment (Ware, 2000). Due to this, some of the recalcitrant pesticides were banned and better pest management techniques were introduced. The wide spread occurrence of residues or metabolites of pesticide

was reported to be related to its persistence in the environment. Consequently the residues of pesticides began to appear in foodstuffs, in human milk, placenta and accompanying fluid (Saxena *et al.,* 1987 and Tilak *et al.,* 2001). Also in the disruptions of ecosystems and development of pesticide resistance in target and non-target species were reported.

The toxic impact of pesticides on different biological processes in diverse animals is well documented. Pyrethroids are extremely toxic to fish and other aquatic organisms and affect the survivability of an organism, causing irritability and mortality in fishes. Pesticide residue concentration will gradually lose as a result of breakdown; Most of the aquatic organism is affected by pesticides to a greater extent than the terrestrial non-target organisms (Reddy *et al.,* 2015; Adi and Matcha, 2016; Edwards, 1974). Leaching and evaporation and the residue are the amount that remains after application (Cox, 1995). While some pesticides are persistant in the environment, others have short term residual activity and therefore do disappear from the environment or produce low residue concentration. Pesticide residues may enter the food chain causing serious health hazards to human and livestock (Khan *et al.,* 2007). Some of these compounds could pose potential threats to adjacent aquatic ecosystems. Although, it is necessary to continue monitoring programs to understand the transport, environmental fate and effects of these contaminants.

Impact on non-target organisms:

Pesticides are found as common contaminants in soil, air, water and on non-target organisms in our urban landscapes. These chemicals can harm plants and animals ranging from beneficial soil microorganisms and insects, non-target plants, fish, birds and other wildlife. Pesticides can kill birds in several ways, including direct effects of acute poisoning by ingestion of granules, baits, treated seeds, and direct exposure to sprays. Indirect death of birds may result from consumption of treated crops, contaminated water, or feeding on contaminated prey. Wildlife poisoning depends on a pesticide's toxicity and other properties (eg. water-soluble pesticides may pollute surface waters), the quantity applied, frequency, timing and method of spraying (eg. fine spray is prone to drift), weather, vegetation structure, and soil type.

Impact on environment:

Pesticides are the only group of chemicals that are purposely applied to the environment with an aim to suppress plant and animal pests and to protect agricultural and industrial products. Pesticides can contaminate soil, water, turf and other vegetation. In addition to killing insects or

weeds, pesticides are toxic to a host of other organisms including birds, fish and beneficial insects (Pasha, 2016; Sachin kumar *et al.,* 2013, vivek *et al.,* 2015). However, majority of pesticides are not specifically targeting the pest and during their application they also affect non-target plants and animals. Repeated application leads to loss of biodiversity. Many pesticides are not easily degradable, they persist in soil, leach to groundwater and surface water and contaminate wider environment. Depending on their chemical properties, they can enter the organism, bio-accumulate in food chain and consequently influence the environment.

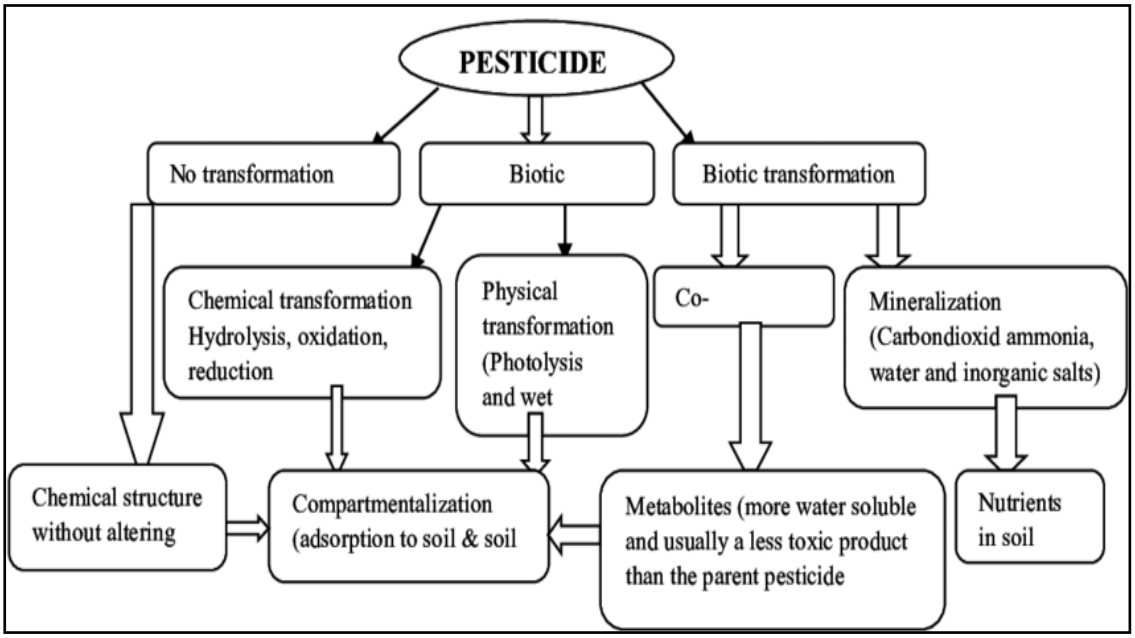

Figure 3: Mechanism of pesticide residues transformation in water ecosystem

Sachin kumar *et al.,* (2013) observed that the pesticides exposure are increasingly linked to immune suppression, hormone disruption, diminished intelligence, reproductive abnormalities and cancer. There is overwhelming evidence that some of these chemicals do pose a potential health risk to humans and other life forms and unwanted side effects to the environment (Forget, 1993; Igbedioh, 1991). No segment of the population is completely protected against exposure to pesticides and the potentially serious health effects, though a disproportionate burden is shouldered by the people of developing countries and by high risk groups in each country (WHO, 2008). Horrigan *et al.,* (2002) estimated that nearly 10,000 deaths annually to use of chemical pesticide worldwide, with about three-fourths of these occurring in developing countries. Pesticides being used in agriculture are released into the environment and come into human contact directly or indirectly affecting human life (Wadhwani and Lall, 1972; Kasyap and

Gupta, 1973). Exposure to pesticides results in acute and chronic health problems (Hollingworth *et al.,* 1995).

Feed and fodder offered to animals are often contaminated with pesticide residues (Raikwar and Nag, 2006) and after feeding, these residues pass through the body systems. Pesticide poisoning in humans were extensively studied (Hamilton *et al.,* 2004). As per the World Health Organization estimates, pesticides causes one million pesticide poisoning cases and 20,000 deaths every year globally. Therefore, there is a need of study on causes of environmental contamination, by pesticide residues in milk, meat and other dairy products, health hazards associated with dietary exposure of successful in meeting the goals of self-sufficiency in pesticides as well as prevention and control strategies for occurrence of pesticides in animal products in Indian scenario.

Conclusion:

The main focus of the report is majority of pesticide residues are known to bioaccumulate in the lipid tissues of fish, frogs and other animals, and transfer via food chain to the human bodies, the grave risk to the health of the people who consume these fish, frogs and animals, seems to be considerable. The need to protect the people from undue exposure to the pesticide residues through the food chain cannot be over emphasized. The appearance of pesticide residues will also show impact on reproductive impairment of the commercially important fish, frog and the carnivores, especially the birds. Though we cannot avoid the use of pesticides, measures should be taken for the conservation of the water quality and also the aquatic resources. Since most of the farmers are illiterates and does not know about the adverse effects of the indiscriminate use of pesticides, there is dire need to educate the illiterate rural farmers about the adverse effects of overuse of pesticides through the regional, print and electronic media. As scientific society, it is also our responsibility to enlight the farmers to use the pesticides in a limited and scientific manner. It is also our responsibility to show alternatives to the use of chemical control methods which should be economically viable to the farmers. Integrated pest management like programmes needs to be enlightened in the illiterate farmers. Finally, the only solution to pollution is the dilution.

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SHORT NOTES ON ROTIFERA: A VALUED BIOINDICATOR

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Abstract:

Aquatic ecosystems are made up of abiotic and biotic interactions. These factors are interrelated to each other. They form cumulative environmental condition for that ecosystem; the status of that ecosystem can be categorized into oligotrophic, mesotrophic and eutrophic in nature. Among the various different kind of flora and fauna existed in waters, the zooplanktons plays an important role to govern the systematic functions to maintains the ecosystem proper. Among the zooplanktons, rotifers are one of the planktonic group plays an extraordinary performance in regulating ecosystem proper. These bulks of organism also considered as an evitable tool to understand the status of ecosystem time to time. Use of these organisms as bio-indicator for trophic structure and pollution grade of ecosystem is always accepted. The group of rotifer or individual species might be considered as a valued bio-indicator of water quality based on the various indices and the correlation between various physical, chemical and biological factors like dynamics and diversity of the said organism.

Keywords: Zooplankton, Rotifer, Brachionus, Bioindicator, Eutrophication, Water quality.

Introduction:

The occurrence and faunal compositions of rotifers are chiefly freshwater and their abundance is accompanied to the suitable surroundings for their survival. The freshwater ecosystems are majorly classified into Oligotrophic (low organic matter, relatively deep and oxygen rich with low content of calcium), Eutrophic (rich in nutrients and organic material, phytoplankton shallow water and season wise fluctuation in dissolved oxygen), and Dystrophic (abundant partially decomposed organic matter; humus marshland). This organisms might be

classified in four types with reference to their form and habitat references, Planktonic (found in littoral waters), Sessile (attached to submerged plants), Loricates (hard or semi hard body shell), and Bdelloid (soft bodies, common in ponds). The importance of rotifer species in throphic dynamics in freshwater ecosystems has been recognized. The said organisms not only regulate the productivity in waters but also immense role in energy flow, nutrient cycling, trophodynamics helps to indicate the ecological status aquatic ecosystem. The said organisms are considered as precious biological indicator to illustrate the trophic status of water quality of their environment within limnosaprobity (Sladecek, 1983). Present literature is attempted to study the distribution, density, their role in ecosystem and bioindicator value in aquatic ecosystem to depict the interrelation among various environmental variables. Rotifers might be among useful biological element used for the assessment of ecological status of water body; in fact rotifer abundance as well as species composition and distribution, often reflects trophic status (Tasevska *et al.*, 2012).

Rotifer Composition:

Rotifers are minute, microscopic elongated life form also known as Rotatoria, belongs to minor invertebrate phyla as they are ranges from 50 µ to 2000 µ (Wallace *et al.*, 2006), this soft bodied metazoans first describe by John Harris, nearly 200 year before (Hudson and Gosse, 1886). It is readily identified from other planktons due to presence of their anterior ciliated wheel known as corona. Dutrochet, 1812, considered the rotifer as a distinct biological group separated from protozoa (Segers, 2007). The freshwater rotifer occupies about 95% species as their original habitat and less than 5% species occurs in continental maritime environment (Sharma, 1996). The phylum rotifer includes, about 2500 species spread over 200 genera, nearly 1400 species from Europe, 620 species from Australia (Sharma, 2001c), About 59 rotifer species in sub-Antarctic, 50 species in maritime Antarctic and 13 species in continental part, with highest number of Monogononta (122) found in sub-Antarctic and Bdelloida (32) species in continental Antarctic, currently 176 species of rotifer is known from Antarctic habitats (Convey, 2005). Anderson (1889) reported 47 species of Indian rotifer in India, though first taxonomic report was prepared by Sharma and Michael, (1980), they reported 241 species from India, detailed review by Sharma in 1991, taxonomic notes prearranged by Dhanapathi, (2000). Sharma, (1998), reported 330 species of rotifer. Bulks of rotifer recorded from India are tropicopoliton (occur in tropical and sub-tropical latitudes but can occasionally be found in suitable habitats in temperate regions) Dhanapathi, (2000). Among the new species illustrated from India, *Brachionus durgae*,

Dhanapathi, 1974 from Andhra-Pradesh is also reported from Japan (Sudzuki, 1992), South Africa, South America (Segers *et al.,* 1994) and is considered as Tropicopoliton. Rotifers are known as pioneer organisms because they first emerge in newly formed water bodies (Kippen, 2005). A rich rotifer fauna is very frequently present in different types of stabilization pond, polluted rivers, and lentic ecosystems like village ponds (dung water) (Sladecek 1983). Only widely spread rotifers species are planktonic and their life cycle is influenced by temperature, food and photoperiod (Pal *et al.,* 2015). They respire aerobically, but can tolerate anaerobic condition for short period. Most plankton communities show 50 to 500 individuals of rotifer per liter, but mountain lakes may have less than 20. The dense population in unpolluted water reached 5800 per liter (Pennack, 1953).

Role in Ecosystem:

They are one of the most vital in zoo-planktonic organism. They are acting as primary consumers in aquatic ecosystem and feed on numerous kinds of phyto-planktons and free swinging algae as well as particulate organic substances too. Zooplankton grazing on phytoplankton can transfer more than 50% of carbon fixed by primary production to higher trophic level (Hart *et al.,* 2000; Laws *et al.,* 1988 and Scavia, 1980). In general the rotifer community comprises an essential participation in aquatic food chain. They can populate vacant niches with extreme rapidity and convert primary production into a form usable for secondary consumers producing up to 50% of the total plankton biomass (Nogrady *et al.,* 1993). Rotifers acts as essential food for fishes, at early stages of their exterior feeding, therefore forms several links in food webs and inhabit diversity of trophic level in aquatic ecosystem (Nikolsky, 1963). Rotifers are highly nutritive to planktovours fish; its protein supports fast growth of fish larva and immature (Kitto and Bechara, 2004). They have role as link between non-planktons and carnivorous zooplankton, playing role in cycling of organic substances (Mishra and Saxena, 1998). Rotifer plays a key role in trophodynamics, ecological energetic, cycling of material and aquaculture productivity due to extremely high reproductive rate characterized by parthenogenetic production (Herzig, 1983). Rotifers respond rapidly to changes the ecological condition (Gutkowska, *et al.,* 2013). The variation in the distribution of zooplankton is due to abiotic parameters (temperature, salinity, stratification, and advection), the biotic parameters (food limitation, predation and competition) or a combination of both (Beyst *et al.,* 2001; Christou, 1998; Escribano and Hidalgo, 2000). The survival, growth and heavy metal processing efficiency of rotifers observed is indicative of a greater extent of adaptability, evolution and

tolerance of the organisms in increasingly polluted ecosystem (Rehman *et al.,* 2008). Segers, (1995), opined that Lecanidae is second largest family among rotifer with about 160 valid species. Rotifer also occupies different niches such as planktonic, benthic and epiphytic and littoral regions of freshwater bodies whereas the planktonic rotifer like genus Brachionus is widely used as a toxicity test organism (Sarma *et al.,* 2010).

Rotifer as saprobity indicator:

A comprehensive bio-monitoring process involves both biological and physico-chemical approach and gives the exact status of aquatic ecosystem (Virani and Makode, 2011). Rotifers are good indicator of saprobity, it is distinctly aerobic invertebrates and indicate the situation only within limnosaprobity, not within eusaprobity (Sladecek, 1983). As an indicator rotifer were first used by Kolkwitz and Marsson, (1902, 1909). The observation on Indian indicator species was firstly made by Arora, 1961, 1966). Rotifers are considered as important bio-indicator in depicting the trophic status of water quality (Fuller *et al.,* 1977; Pejler, 1981, 1983; Maemets, 1983 ; Sladecek, 1983; Berzins and Pejler, 1989 , 1987). According to Saksena, (1978), certain living organism serve the purpose of monitoring the environmental pollution as they are tolerant to adverse environmental condition and they are capable of measuring the actual response of organisms or populations to the ecological quality, these organisms are called as bio-indicator. A biological indicator is meant to give a useful biological measure, that is sensitive enough, can be used for diagnosis, control, prevention and reclamation (Ghetti and Ravera, 1994). Bhandarkar *et al.,* (2008); Bhandarkar and Paliwal, (2012, 2019), in different productive water bodies and manure enriched tropical pond. Bhandarkar, (2015), observed that the dominance of Brachionus species in culturally eutrophied polluted water. Some species flourish in highly eutrophied water while others are very sensitive to organic and chemical waste). *B. angularis f. bidens, B. calyciflorus, B. calyciflorus f. amphicerus, Trichocerca cylindrical* and *F. terminalis* occur in eutrophic water (Lilliecroth, 1950). According to Thunmark, (1945), *B. angularis, Trichocerca cylindrical, Polyarthra euryptera* are the indicator species of eutrophy while, *B. quadridentatus, B. urcens, Keratella quadrata, Trichocerca capucina, Filina longiseta, F. terminalis* are found in eutrophic water (Berzins, 1949). Pejler, (1957), reported Brachionus species, *Keratella cochlearis, K. quadrata, Trichocerca cylindrical, Polyarthra euryptera, Filinia longiseta* in mesotrophic to eutrophic waters. Arora (1961), recorded Rotaria rotatoria from polluted water. Davis (1968, 1969), reported abundance of Brachionus is conclusive of eutrophic waters. Karabin (1985), Brachions species, *Anuraeopsis fissa, Keratella quadrata, Filinia longiseta,*

Trichocerca pusilla. Bahura *et al.,* (1993), reported that B. calyciflorus as indicator of eutrophication. Sampaio *et al.,* (2002), the higher densities at downstream sites may indicate that *B. calyciflrous* is a pollution tolerant genera. The other species of Brachionus found at downstream site fed with waste water are *B. angularis, B. bidentata, B. budapestenesis, B. caudatus, B. diversicornis, B. plicatilis, B. quadricornis and B. quadridentatis.* Dhanapathi, (2000), found that they increase in large quantity rapidly under environmental conditions. High rotifer population in the lake water indicates pollution due to direct entry of untreated domestic sewage (Arora, 1966). Eutrophication (nutrient availability) influences the predominance of rotifer and copepods (Kumar *et al.,* 2004). The inadequate information available from India, does not allow any general deduction regarding rotifer indicators from water bodies of varying trophic status. However, *Brachionus rubens, B. angularies, B. urseolaris, Fillinia longiseta, F. opalionisis, Rotaria neptunia, R. rotatoria and Philodina* species are often reported to occur under eutrophic to hyper eutrophic conditions. Besides *Brachionus caudatus, B. calyciflorus, Anuraeopsis fissa, Keratella tropica, Asplanchna brightwelli, Phompholyx sulcata, Polyarthra vulgaris, Conochilus unicornis* and *Sinantherina sociolis* are commonly noticed in alkaline eutrhophic waters (Sharma, 1996). Brachionus and Keratella was indicator of eutrophication (Baruha *et al.,* 1993). Schindler and Noven, (1971), reported enormous growth of rotifers in water bodies indicating eutrophic conditions. Rotifer functioned as a limiting factor for phytoplankton density with high density of Brachionus species is attributed as a causative agent for control of phytoplankton (Somani, 2002). In polluted and eutrophied lentic water body rotifer reached 33900 individuals per liter at a depth of one meter. Bacteria, small algae, flagellates and detritus filtered form the water are the most common food, in polluted waters the main sources are suspended solids and even colloids from the waste water to gather the bacteria decomposing organic matter. According to Stevenson (1994) and Mukhopadhyay *et al.* (2007), the density of *B. calyciflorous* is increase with rising concentration of waste water. Family Brachionidae is dominant but no records of any known indicator species of rotifer for polysaprobic among documented species (29) from Omi River which is unpolluted (Fafioye and Omoyinmi, 2006). Liu-Fengaui (1996), the small population of copepod is directly proportional to the large population of rotifer species appeared in water with high eutrophication. The dominancy of rotifer species indicates organic pollution due to direct entry of untreated sewage from catchment area (Arora, 1966). *B. patulus, K. quadrata and K. cochlearis* inhabit oligotrophic often acidic water (acidophilic), *Lacane bulla, L. hamata and L. lunaris, Ascomorpha ovalis, Mytilina ventralis* reported from oligotrophic water (Chandrasekhar and Siddiqi, 2008). Trichocerca is

indicator of purely oligotrophic water. It is generally acknowledged that *Synchaeta stylata, Ascomorpha ovalis,* and *Conochilus unicornis* are oligotrophic species, and there are many species in mesotrophic water, which are generally transitional species. Brachionus species, *Anuraeopsis fissa, Pompholyx sulcata, P. complanata, Trichocerca cylindrica, T. pusilla, Filinia longiseta, K. cochlearis, K. quadrata,* and *Polyarthra euryptera* dominate in eutrophic water. Duggan *et al.* (2001) confirmed that different rotifer species exist in water of different nutritional content; Polyarthra species thrives in oligotrophic water, whereas *B. calyciflorus and F. longiseta* are eutrophic species. Yoshida *et al.* (2003) considered that the maximal growth rate and the critical food concentration of small rotifers were lower than in larger species. The small rotifers accounted the majority, including common oligotrophic indicators such as *Lecane ludwigii, L. arcula, Notholca labis, Monostyla hamata, M. furcata, Monomata longiseta, Cephalodella exigua, Scaridium longicaudum, Metadiaschiza trigona, Ascomorpha saltans,* and *Conochilus hippocrepis* as well as mesosaprobity species such as *B. calyciflorus, B. angularis,* and *F. longiseta.* L. Yin *et al.* (2018) *K. cochlearis,* and *Synchaeta oblonga* consumes algae, Trichocerca species suck the cell contents of filamentous algae (Pourriot, 1977), and *Anuraeopsis fissa* mainly eat detritus (Wen Xi and Zhang, 2006). Sowunmi and Jeje (2004), rotifer recorded higher abundance in response to edible phytoplankton. The species like *B. quadridentatus,* Lapedella have better tolerance for alkanities, *Platias quadricornis,* epiphanus and *R. rotatoria* recorded form eutrophic and heavily polluted waters (Pattnaik, 2014). Similarly, *Anuraeopsis fissa, B. forficula, Dipleuchlanis propatula* and *Lacane stenroosi* also represents the warm stenothermal nature (Sharma, 2000). Rotifer can survive well adapted in harsh Antarctic environment, relatively high production at low temperature. Rotifer is an important component of Antarctic freshwater and potential indicator of climate change. Ability of high reproduction and anhydrobiosis are well adapted (Poceiacha, 2010). Rotifers play an important role in energy flow and nutrient cycling in aquatic ecosystem, especially when the abundance of large zooplankton such as crustaceans is low (Sanders *et al.,* 1989). Hillbrict-Ilkowska (1988) the rotifer are mostly suspension feeders, filtering or sedimenting the fine particles directly into the mouth via water current created by cirri. They are responsible for the carbon transfer between the microbial food web consisting of bacteria, heterotrophic and mixotrophic flagellates and ciliates and algae, crustacean zooplankton and fish (Alcaraz and Calbet, 2007) therefore, rotifer community structure which varies from lake to lake can be used to indicate the real-time environmental health status (Umi *et al.,* 2018). With their high assimilation efficiencies, rotifer converts a considerable portion of their food into biomass, making it available to higher trophic

level (Starkweather, 1987). Rotifer species composition and abundance are suggested to be strongly associated with the ecosystem health status and individual species may reflect the level of eutrophication (Rogozin, 2000). Eutrophication can cause changes in the species composition and increased abundance of tolerant rotifer species (Spoljar *et al.*, 2011). Increasing rotifer abundance in eutrophic conditions could probably due to enhanced bacterial production due to high composition rate of accumulated dead phytoplankton biomass (Karabin, 1985). High trophic conditions are associated with high abundance of blue green algae, Brachionus is reported to have high tolerance to cynobacterial toxins (Karabin *et al.,* 1997) and have ability to utilize colonial blue green algae as food and exhibit a great tolerance to their blooms (Fulton *et al.,* 1987). Some rotifers and small cladocerans might be competing for same resources simultaneously; the big cladocerans could prey on rotifers (Brandl, 2005). The deduction of cladocerans by planktovorous fish, which are usually abundant in eutrophic condition, could also be one of the reasons for the high velocity of rotifer survival in eutrophic water (Gilbert and Stemberger, 1985). Reducing beneficial micro-algal species and enhancing inedible blue green algae could decrease the abundance of zooplankton (Imam and Balarade, 2012). Uzma (2009) acknowledged that the presence of more than five Brachionus species reflects eutrophication of water body. Poorer rotifer density might be due to reduced efficiency of energy transfer between phytoplankton and zooplankton (Pederson *et al.,* 1976). Density and biomass of rotifers increased with increasing trophic state. In the oligotrophic localities the number of rotifer species does not exceed 200/L on the contrary, in eutrophic areas the number of rotifer density ranges from 1000 to 2000/L. According to Starkweather *et al.* (1987), Monogonaont rotifer can reach remarkable densities in eutrophic water. The rapid turnover rate of rotifer populations allows them to contribute significantly to nutrient recycling in aquatic habitats (Markarewicz and Linkens, 1979; Ejsmont-Karabin, 1983). Rotifers at times strongly compete with microcrustacens zooplankters for food (Gilbert, 1985) and serve as a prey for other rotifers like Asplanchna (Gilbert and Stemberger, 1985), cyclopoid and calnoid copepods (Williamson, 1983), insect larvae (Moore and Gilbert, 1987) and fish (O'Brien, 1979).

Indicator of Water Quality:

Species composition and abundance of rotifer can be influenced by number of physical, chemical and biological factor such as, temperature, dissolved oxygen, turbidity, pH, nutrient availability, quantity and quality of food, predation and completion in their habitat (Ismile and Zaidin, 2015; Panwar and Malik, 2016; Wang *et al.,* 2016). Dissolved oxygen is also an

important function in determining occurrence and abundance of rotifer communities. Pejler (1957), and Pourriot (1965) pointed out that cold stenothermal forms are more tolerant of low oxygen content in the water than eurythermal species. Auel and Verheye (2007) reported that hypoxia (low oxygen concentration) could reason of negative physiological impact on species of rotifer and decrease their population. Meshram (2005) reported that hardness is necessary for normal growth and development of aquatic animals. Wanganeo (1998) reported large quantities of carbon dioxide harbors very diminutive population. Many species of rotifer having preference for more alkaline water, the species like Brachionus make higher population during period of high alkalinity (Dhanapathi, 2000). Alkaline water contains few species but large number of individuals and diversity in acid water (Pennak, 1953). Many species of rotifers are having preference for more alkaline waters. Rotifer shows outstanding growth peak of population density in summer with high abundance of macrophytes (Ferreiro *et al.,* 2011). The highest diversity is in summer with more species richness, evenness and abundance of individuals like *B. diversicornis, B. forficula* and *K. Tropica* (Karuthapandi *et al.,* 2015). Yeole *et al.* (2007) observed high diversity during summer. Chakravarty and Kumar (1991) [108] and Bath and Kaur (1998), classified that *B. forficula and B. calyciflorus* are warm stenothermal forms. Dhanapathi (2000) observed that the species with well developed lorica such as Brachionus, Keratella, Mytilina, Platyas and Asplanchana species build higher population during the period when alkalinity is also high, while high alkalinity values influence the growth and abundance of loricate forms, cannot act as limiting factor for others. Sharma **(**1996) reported the alkaline hard waters with abundance of *Brachionus* species and *K. tropica*. The low temperature and high electrical conductivity decreased the density, species richness, evenness and diversity (Karuthapandi *et al.,* 2015). Some workers have reported populations' peaks in late summer and early autumn (Whitman *et al.,* 2004; Castro *et al.,* 2005; Paulose and Moheshwari, 2007). Shyeshefer *et al.* (2008) attributed high rotifer peak in summer season to high temperature, long photoperiod and higher intensity of light. Rutner-Kolisko (1974) stated that the species which can tolerate highly variable biotopes are called as Eurytopic, while those capable of tolerating limited range are termed as Stenotopic. He pointed out that rotifers thrive well in low oxygen conditions as majority of them are detritus feeders. Chittapun *et al.* (2007) found that rotifers maintained negative correlations with dissolved oxygen and total hardness. Tamas and Horvarth (1978) estimated that there is no influence of chemical ions such as calcium and magnesium on rotifer density. Shah *et al.* (2015)concluded that the rotifers were abundant during warm environmental conditions and lower in colder conditions, also, the rotifers were abundant in sites

having high anthropogenic pressure. Water temperature has always been regarded as the key parameter that affects rotifer occurrence and seasonal succession (Berzins and Pejler, 1989). Thermal adaptability varies among rotifers, even within the same genus, and the highest growth rate occurs as water reaches the optimum temperature (Herzig, 1987). Rotifer species occurrence and abundance are closely related to pH in fresh water. According to the pH preferences, rotifers can be divided into three groups: alkaliphilic, euryionic, and acidophilic. Generally, there are many species but little abundance in acidic water, whereas the reverse is true in alkaline environments (Zhang and Huang, 1991), as was clear in their research. Segers (2008), the most diverse rotifer assemblages can be found in soft, slightly acidic, oligo- to mesotrophic waters. According to Arora and Mehra (2003), Rotifer population density is positively related with Phosphorus and Nitrogen. Based on densities, rotifers showed the strongest response to increased phosphorus levels. (Lauridson and Hansson, 2002), the total phosphorus as a most important nutrient indicates the ecosystem trophic state and may partly determines the species presence and dynamics of rotifer assemblages (Berzins and Pejler, 1989c). Rotifer is useful as models in eco-toxicology because they often play a key role in the dynamics of fresh water and costal marine ecosystem (Wallace and Snell, 1991). The toxicity of heavy metals has been assessed using toxicity test with rotifer. Schaefer and Pipes (1973), demonstrated that short term mortality test with Philodina species to evaluate the toxicity of heavy metal. Population level variables (peak population densities and rate of population increase per day) decreased with increasing concentrations of heavy metal; the peak population density was also sensitive to metal stress.

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ALGAL BLOOMS: CAUSES, EFFECTS AND CONTROL MEASURES

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Introduction:

Water is the life of every living being. It is transparent, tasteless, odorless, colourless chemical substance, which is main constituent on earth's stream, lake, ocean and main constituent of living being. A remarkable diverse assemblage of plants, animals and microbes live in inland waters, with nearly all major groups of living organisms found in one sort of aquatic ecosystem.

Water can become polluted by a number of sources, ranging from sewage treatment plants and factories to mining activities, paved roads and agricultural runoff, according to the U.S. Environmental Protection Agency. Water pollution has a wide variety of effects on plant life and on the environment in general. Pollution in water not only harms plant growth but also allows plants to absorb dangerous chemicals from the water and pass them on to animals that rely on them for survival. Water pollution can have dire consequences for plants, animals and even ecosystems as a whole. The specific effects vary depending on what pollutants enter the environment. Sometimes, water pollution causes an explosion of new plant growth by providing necessary nutrients and food. Other times, it can harm or kill plants by changing growing conditions, such as by raising or lowering the environment's acidity.

Microscopic algae are fundamental to life on earth. These tiny plants provide the fuel that drives marine and freshwater foodwebs and via photosynthesis, they gobble up carbon dioxide to help counteract emissions, and provide us with oxygen to breathe. However abnormal and excessive algal growth so called algal blooms would be detrimental as much. The algal blooms could include a variety of adverse impacts on environmental, social, cultural and economic environment. The present study shows what is mean by algal blooms, how it will occur, effects on environments and control measures.

The phenomenon of algal blooms, "when the population of algae in a river rapidly grows and dies, can be devastating to local wildlife, ecosystems and people".

Why algal blooms occur?

Freshwater bodies around the world can be used as drinking water reservoirs or recreational areas, the blooming phenomenon have gained attention as possible health hazards. The problems associated with toxic cynobacterial blooms in these different areas diverse, from environmental choking due to excessive consumption of oxygen, to purely aesthetic problems in recreational areas when the blooms are colourful and often smelly scum on the surface of the water. The causes of the algal blooms are eutrophication and climate change (increasing temperature, variation in light intensity, etc.) are the two main factors; likewise when nutrients (mainly phosphorous, nitrogen and carbon) from sources such as lawn, farmlands, pet waste and certain soaps and detergents flow downriver to the water, electric power generation, industry, transportation and build up at a rate that overfeeds the algae that exist normally in the environment.

Early algal blooms usually develop during spring months when water temperature is higher and there is increased light. The growth is sustained during the warmer months of the year. Drought, water extraction for irrigation, human and stock consumption and the regulation of rivers and dams all contribute to decrease flow of water in our river systems. Water moves slowly or become ponded, which encourage the growth of algae. When water body is stratified, bottom waters often become depleted with oxygen which may lead to increased nutrient release from sediments; pulses of nutrients from the colder bottom layer may fuel up the algal growth in the top layer.

Effect on ecosystem, humans and economy

Algal blooms associated with worldwide ecological bursts.At some point, algal blooms crash when conditions become unsuitable. The resulting dead algae break down, providing ideal food source for bacterial multiplication which sucks the oxygen out of water; at this point, oxygen level become low both day and night. If the area is low oxygen is extensive, such as a whole lake or many kilometres of river system, fish and other animals may not be able to escape to more suitable oxygen levels and major fish deaths typically occur. Harmful algal blooms sometimes create toxins that are detrimental to fish and other animals. After being consumed by small fish and selfish, these toxins move up the food chain and can impact larger animals like sea

lions, turtles, birds and through these animals even humans too. Fishing and shellfish industries are hurt by algal blooms that kill fish and contaminate shell fish. Annual losses to these industries are estimated to be in the tens of millions of dollars.

Economic effects of harmful algal blooms may arise from public health costs associated with people often get sick by eating shellfish containing toxins produced by algal blooms, participating in recreational activities such as swimming, kayaking, fishing or wading through water; breathing in contaminated tiny water droplets or mist from recreational activities or drinking contaminated water. Airborne harmful algal blooms may also cause breathing problems, illness and in some cases, trigger asthma attacks in susceptible individuals. At present, it causes about $82 million in economic losses to the seafood, restaurant and tourism industries each year. It reduce tourism, close beaches and shellfish beds and decrease in catch from both recreational and commercial fisheries, declines in coastal and marine recreation and the cost of monitoring and management.

Algal blooms in drinking water sources can drastically increase treatment costs; billions of dollars to clean up polluted water bodies. The tourism industry loses close to $1 billion each year, mostly through losses in fishing and boating activities in US, as a result of water bodies that have been affected by blooms.

Control of algal blooms:

Whether a harmful algal bloom represents the greatest threat to inland surface water quality is debatable, through their relative importance as a transformational threat to future inland water quality assessment and management appears more certain. It is clear that harmful algal blooms present the most significant threat to surface water quality in some freshwater ecosystem during time period in many parts of the world.

Ideally the problem should be tackled at the source; we can all take action to reduce nutrients pollution which causes algal blooms. This means reducing nutrients loads to our waterways which has already been progress in our cities where sewage treatment plants have been upgraded to reduce nutrient and polluted water level. Also decreases dependency on the fertilizers, pesticides and insecticide which will extensively use in the agriculture.

Algal blooms control helps prevent these environmental, health and safety impacts. Sustainable management aims to reduce inflow of nutrients into water bodies. Long term success requires extensive changes in policies and human activities. So it can take many years to improve water quality significantly. Mixing circulates water to achieve destratification in reservoirs. The

process involves mixing water to eliminate stratifies layers. Epilimnion and Metalimnion are usually circulated to control algal growth. The aim is to clear surface water from iron, manganese and anoxisodors that usually occur in the hypolimnion layer. This makes conditions less favourable for algal growth in certain layers. Hydrogen peroxide is a compound used as an effective treatment against algal blooms. It is suitable for smaller water bodies such as large ponds and small lakes for easy monitoring of compounds impact as well as aquatic life. Ultrasound boom treatment technology focuses ultrasonic sound waves in water bodies to look for algal blooms and to control their growth if discovered- reducing algae growth by up to 90%.

Local, state, tribal and researchers are involved in efforts to prevent harmful algal blooms and associated illness including (i)monitoring for algal blooms and associated toxins in recreational water, drinking water, (ii) reducing nutrient loads in freshwater, (iii) conducting health surveillance, (iii) collaborating among agencies to better coordinate activities within state and across nation, (iv) providing guidance for safe levels of algal bloom toxins in water used for drinking and bathing and (v) engaging with citizen, scientists and other industries to monitor for harmful algal blooms.

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WETLAND ECOSYSTEMS

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Introduction:

Wetlands are amongst the most productive ecosystems on the Earth and provide many important services to human society.wet land is the collective term used for marshes, swamps, bogs, lakes, rivers, estuaries and oceans. A wet land is a land area that is saturated with water either permanently or seasonally.

Figure 1: A view of Ayyanakere Lake, Chikkamagaluru

As per the Ramsar Convention definition, wetlands are areas of marsh, fern, wet land or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt including areas of marine water the depth of which at low tide does not exceeds six meters. Wetlands are vital for human survival. Wetlands can thought of as biological supermarkets, upon which countless species of plants and animals depend for their survival.

They provide the drinking water, water purification, flood storage, transport, recreation, research, education, and climate stabilizers. India has totally 67,429 wet lands covering an area of about 4.1mha.out of these 2,175 are natural and 65,254 are manmade.

Figure 2: Birds Sighted at Ayyanakere Lake, Chikkamagaluru

Wet lands in India account for 18.4% of the country's geographical area of which 70% is under paddy cultivation. Across the world, they are getting extinct due to many reasons, including anthropogenic and natural processes. Loss of many wetlands is mainly due to population growth, urbanization, agricultural activities, deforestation, pollution and climate change. With these, Wetlands are permanently destroyed and lose any potential for rehabilitation.

Importance of wet lands:

India has a wealth of wetland ecosystem that support diverse and unique habitats .these wetlands provide numerous products and services to human being. Goods provided by wet lands mainly include pollutant removal and improve water quality, water supply, reduce the impact of floods, ground water recharge, reducing erosion, recreational opportunities and providing habitat for several wild life species. One of the primary functions of wetland is maintenance of water quality in lakes, rivers, streams and ground water through pollutant removal. Wetlands are natural filters that can remove, retain or transform variety of pollutants.

Through biological and chemical process, wetlands intercept surface runoff and remove or assimilate sediment transport. Some wet lands can act as sinks for certain pollutants. Wetlands play major role in breaking down suspended solids and neutralizing harmful bacteria. Wet lands remove pollutants such as phosphorous heavy metals and toxins which were trapped in the sediments of the wet lands. The most significant benefit of wetland is flood control these complex habitats have the potential to collect, store, and slowly release run off and flood water gradually over time. Wetland vegetation plays a major role in erosion control. Wet lands everywhere provide important leisure facilities like fishing, bird watching and swimming. Many species of birds, fish, mammals, reptiles and amphibians rely on wetland habitat for breeding, foraging, and sheltering.

Figure 3: Egrets Sighted at Ayyanakere Lake, Chikkamagaluru

Wetlands can be thought of as biological super markets they provide drinking water for animals; wetlands have also played an important role in providing irrigation and domestic water in both rural and urban areas. Wet land benefit agriculture ground water recharge, many animals that live in other habitats use wet lands for migration or reproduction.wet lands retain water during dry periods thus keeping the water table high and relatively stable.

Figure 4: Different birds in wetlands

Threats to wetlands:

The wild life institution of India survey reveals that 50% of wet lands have been lost in the five decades. They are disappearing at the rate of 2%to 3% every year. Human influences have caused significant changes in the function and quality of many wetlands. Loss of many wetlands is mainly due to population growth and urbanization. The urban population has increased eight fold, This growth exerted tremendous pressure on wetlands for meeting water and food demand of growing population .The major pollutants associated with Urbanization are sediment, nutrients, road salts ,heavy metals, waste water from houses and industries alter the ecology of wetland ecosystem. High nutrients level cause extended Eutrophication, Which results in the algal bloom, algal bloom depletes dissolved o_2 leading to mortality of benthic organism. Excess algae can shade underwater preventing photosynthesis and resulting in death of remaining animals and plants .many of the original wetlands are drained and converted to paddy fields. Unrestricted dumping of sewage and toxic chemicals from Industries has polluted many fresh water wetlands .over withdrawal of ground water has led to salinization of wetlands.

Figure 5: Polluted wet land

Water in most of the rivers, lakes, streams, and ponds has been degraded due to agricultural runoff of pesticides and fertilizers and industrial and municipal waste water discharges, untreated industrial effluents have become a major threat to the survival of wetlands. Apart from the above major threats, religious ritual wastes, immersion of idols, introduction of exotic species, and encroachment are some of the other dangers threatening the existence of wetlands across the country. Increased air temperature, shift in precipitation, increased frequency of storms,droughts, and floods could affect the wet lands.

Wetland management and conservation:

Wet lands are vulnerable to over exploitation due to their abundance of fish, fuel, and water. The rate of loss and deterioration of wet lands is accelerating in all regions of the world. The pressure on wetlands is likely to intensify in the coming decades due to increased demand for land and water as well as climate change.

Wetland management may be natural or manmade, to protect, restore, manipulate or provide for their functions and values.wet land management includes, sediment removal and erosion control, nutrient transformation and removal, metal and other pollutant reduction, storm water runoff reduction through infiltration, reduction of water temperature, and protection of wetland species. Wetlands are not delineated under any specific administrative jurisdiction. The primary responsibility for the management of these ecosystems is in the hands of the Ministry of

Environment and Forest. Although some wetlands are protected after the formulation of Wild life protection Act, the others are in grave danger of extinction.wet land conservation in India is indirectly influenced by an array of policy and legislative measure Efforts to conserve wet lands in India began in 1987.There are many rules and policies to regulate the wetlands they are Ramsar convention in 1971. National wetland conservation programme (NWCP), the central Wetland conservation and management rules (2010), National Environment policy (2006) and National plan for conservation of Aquatic Ecosystem (NPCA) 2015. Laws created in the last half century have affected to stop the loss of wetlands, but the loss continues.

Conclusion:

Wetland ecosystem support diverse and unique habitats.wet lands not only support large biological diversity but also provide a wide array of ecosystem goods and services. Wetlands provide multiple services including irrigation, domestic water supply, flood control and ground water recharge Unfortunately, they are also ecologically most sensitive ecosystems and are under threat due to increased anthropogenic pressures, including pollution, overfishing, siltation, climate change, mining, dumping and encroachments. India has a strong framework of laws and policies governing wetland conservation. Still no significant progress has been made on the conservation and wise use of wetlands. Only selected wetlands have been protected under the wetland conservation programmes, while the remaining ones continue to be in neglected state. Existing legal and institutional framework is not adequate to conserve the wetland resources in the country. Spreading awareness by initiating educational programs about the importance of wet lands in local schools, colleges and among the general public to safeguard the wetlands from further deterioration in the vicinity of the water bodies is necessary to restore already degraded wetlands.

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https://www.ramsar.org

LIMNOLOGICAL STUDIES IN ULHAS RIVER IN AMBERNATH – BADLAPUR BELT

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Abstract:

Ulhas River is one of the main water body supplies water for Ambernath-Badlapur population and also supplies fresh water fish for food. It is polluted with effluents from industries. Present study was carried out to understand the situation on certain physico-chemical characteristics and Ichthyofaunal diversity along the Ambernath. Three stations were selected in Ulhas River and assessed the water parameters like pH, CO_2, DO, Temperature, Salinity and also observed fish diversity. The study revealed that river was moderately polluted and variation was observed in parameters. Fish diversity study revealed about 11 species of fishes from 4 families dominating with Cyprinidae.

Keywords: Water parameters, Fish diversity, Ulhas River, Cyprinidae

Introduction:

Fresh water habitat occupies a relatively small portion of earth's surface as compared to marine and terrestrial habitats, but their importance to man is far greater than their area (Odum, 1971). Aquatic organisms are widely distributed but its abundance and diversity vary greatly from place and from season to season according to the environmental condition of water bodies. Fishes constitute a major portion of aquatic fauna especially in freshwater habitats. They are cold blooded, typically with gills and fins are primarily dependent on water as a medium in which they live. Rivers experience violent fluctuation in composition, chemical characteristics and discharge. Unidirectional flow of rivers restricts the existence of certain types of fauna. Urbanization and other land water management practices have led to catastrophic changes in population of aquatic organisms

The Ulhas River, which runs from Karjat to Thane creek, at a distance of over 50 km, is one of the most polluted river in Maharashtra. There are over 800 industries on a 20km stretch along the river between Ambernath and Dombivali. In Ambernath Taluka streams of Ulhas river are polluted with effluents of industries, anthropological waste, urbanization etc. Water quality monitoring will help to identify the survival rate of aquatic organism in those water bodies. Present paper deals with the physicochemical parameters and fish biodiversity in Ulhas river in Ambernath-Badlapur belt

Materials and Method:

Water samples were collected for physicochemical analysis at regular intervals for a year from 3 station around Ulhas river flowing through Ambernath area. (Fig.1)

Stn 1: Where Barvi river meets the Ulhas river

Stn 2: River flowing nearby Jambhul ghave, Ambernath

Stn3: River below new bridge which connects Badlapur Gaon and Badlapur city

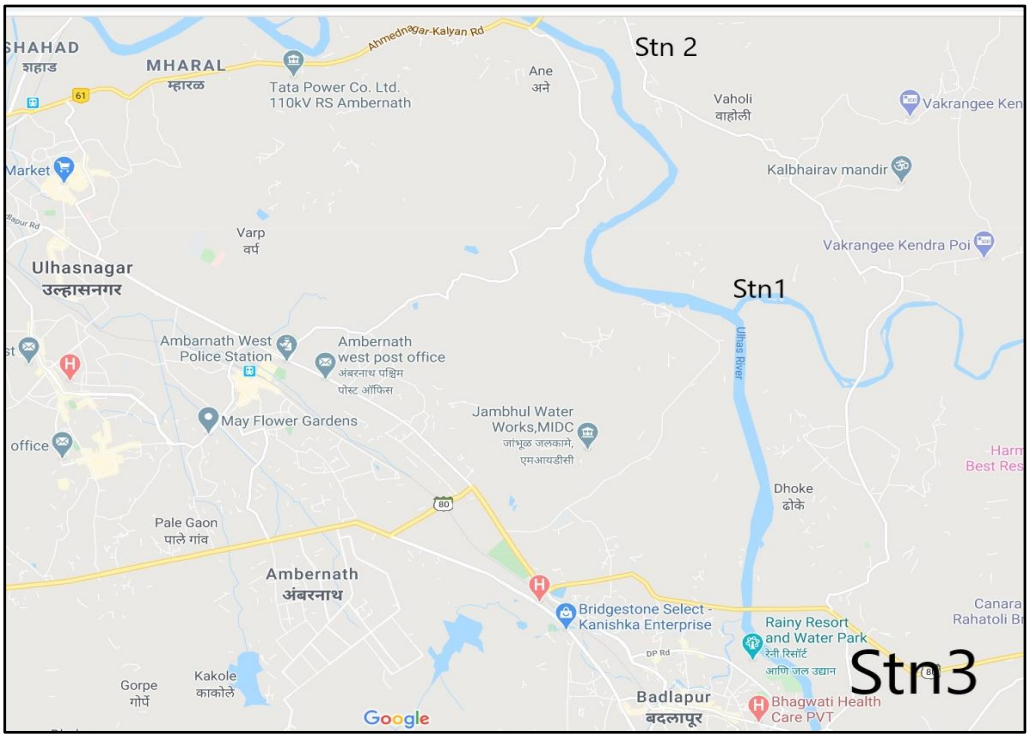

Figure 1: Map showing 3 stations used for collection of water

Water samples were collected from all the stations at same time of a day just below the water surface. Atmospheric temperature was noted. For analysis of the physicochemical

parameters of water, standard methods prescribed in limnological literature APHA (1998) were used. Temperature was determined at the site while total hardness, CO_2, pH, Hardness, Salinity and DO were determined in the laboratory.

The water parameters were analysed by following method

Parameter	Method to be used
pH	Potentiometer/indicator
DO	Azide modification
Salinity	Salinometer
Free CO2	Titrimetric
Temperature	Thermometer

The fishes were collected by local fishermen using cast net and hand net. The fishes were identified from the field and those difficult to identify brought to laboratory and identified with the help of identification key (Munro, 1941) and confirmed with fish base database.

Results:

Table 1: Physical parameters of three stations

Season	Temperature			pH		
	Stn 1	**Stn2**	**Stn3**	**Stn1**	**Stn2**	**Stn3**
Summer	27.6	27	27	6.9	6.8	6.5
Monsoon	26.4	26	26	7	7	7

NB: Values are average of three readings

Table 2: Chemical parameters of three stations

Season	Co2 (mg/l)			DO(mg/l)			Salinity (g/dm^3)		
	Stn 1	**Stn2**	**Stn3**	**Stn 1**	**Stn2**	**Stn3**	**Stn 1**	**Stn2**	**Stn3**
Summer	12	8	8.5	6	5.6	1.4	0.4	0.1	0.2
Monsoon	14	11	16	7.8	7.5	1.8	0.5	0.3	0.4

NB: Values are average of three readings

Table 3: Fish diversity in both stations 1 and 2 during the study period

Sl. No.	Common Name	Marathi name	Scientific name	Family
1	Long billed half beak	Ghodomasa	*Rhynchorhampus georgii*	Hemiramphidae
2	Needle fish	Toll fish	*Belone cancilla*	Belonidae
3	Orange chromide	River pompret	*Etroplus maculates*	Cichildae
4	Pearl spot	kalundar	*Etroplus suratensis*	Cichildae
5	Walking cat fish	Magur	*Clarias batrachus*	Clariidae
6	Filament barb	Pitholi	*Puntius filamentosus*	Cyprinidae
7	Ticto barb	Kumbarni	*Puntius ticto*	Cyprinidae
8	Mullya Garra	Mullya	*Garra mullya*	Cyprinidae
9	Indian carp	Catla	*Catla catla*	Cyprinidae
10	Rohu	Rohu	*Labeo rohita*	Cyprinidae
11	Silver Carp	Silver fish	*Hypophthalmichthys molitrix*	Cyprinidae

Discussion:

The increasing industrialization and urbanization have resulted in pollution of water and in deterioration of its quality. As the effluent of chemical companies at MIDC Badlapur is directly in the Ulhas river it is polluting the water level in river. During present study it was observed that the release of domestic waste water, agricultural run-offs and industrial effluents have resulted in deterioration of water quality and loss of its potability at stn III. The healthy aquatic ecosystem is dependent on the biological diversity and is reflected by its physicochemical characteristics. pH plays an important role in productivity of lake. pH value of water is an important indication of water quality (Table 1). pH is reduced because of law photosynthetic activity and increase in carbon dioxide. For organism to survive pH of water samples is slightly alkaline as reported by APHA. Talwar *et al.* (2013) reported that high value of pH is due to sufficient quantities of carbonates in the water samples. High Values of CO_2 (Table 2) clarifies the statement. Salinity is a significant factor affecting aquatic species distribution and diversity. But in present study there was no much variation between salinity of two stations. As both of the stations were Fresh water and there is no mixing of saline water. DO values in stn 3 were less than 3mg/l. (Table 2) which indicates higher pollution causing negative effects on aquatic system as reported by (Patil *et al.*, 2011)

Present study gives evidence that increased DO level is affecting the organism. Unfavorable physicochemical factors, especially anthropogenic factors disturb the fish diversity and the number of species was less in water body in both stn 1 and stn2. Stn 3 does not observed any fish species. Only some species of snails and insects were the fauna present and eutrophication was seen in the water body

Conclusions:

1. Polluted areas with heavy influx of organic and innumerable industrial waste has been drastically reduced the biodiversity in the both the station1 and 2.
2. The waste water treatment plants need to be set up at a distance of 2 km for survival of river, pre-processing of the drainage wastes before its release in water body.
3. Awareness about the river and its importance is necessary among peoples living surrounding to reduce the anthropogenic waste for the survival of river and Ichthyofauna along with other aquatic organism in water ecosystem.
4. Also, it is mandatory to exercise precaution before water is used for any house hold purposes or it may lead to much adverse effect.

Acknowledgement:

The author gratefully acknowledges Mumbai University for funding by MRP and also Principal and Management SICES College, Ambernath (W) for support. Also like to thank Mr. Kiran Kamble, student for helping doing lab work of Salinity experiment.

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AN OBSERVATION OF WETLAND PLANTS AT NARMADA CATCHMENT AREA, KHANDWA DISTRICT, M.P., INDIA (PART I)

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Abstract:

Wetland plants play a very significant role in the water ecosystem. The present paper revealed 41 species of wetland flora at Narmada catchment. The arrangement of genera and species within each family are arranged alphabetically. The number against the families shows number of genera and species found in the study area.

Keywords: Wetland plants, Narmada catchment area, Khandwa, M.P.

Introduction:

The Narmada forms the northern boundary of East Nimar for most part of its length but the two forest tracts of Chandgarh and Selani lie north of the river. The bed of the Narmada during the first part of its course in the East Nimar region is hemmed in by high cliffs of basalt to the North and a network of ravines to the South. Most of the areas of lower Chhota Tawa are covered with forests. The forested tract of Khandwa Tehsil South of Narmada extends further East into Harsud Tehsil.

At Punasa 'Indira Sagar Dam' is constructed whose reservoir covers 913.48 km.^{2} About 40 km South of the Narmada a low range of foothills traverses the region diagonally until the extreme North West. The fertile valleys of the Abna and Sukta rivers lie in the southern part of the region which is open and contains no forest or hill.

Materials and Methods:

The present survey was done during 2016 - 2018 and in this connection the area was surveyed. The Wetland flora present at the site was recorded under various categories of small

trees, shrubs, herbs and climbers. Plants were identified with standard literature (Cooke, 1957; Haines, 1974; Chopra et *al*, 1956; and Shastri 1977)

Table 1: Enumeration of families, genera and species

Sr. No.	Family	Botanical Name
1.	Ranunculaceae	*Clematis brachiata* Thunb.
2.		*C. gouriana* Roxb. ex DC
3.		*C. heynei* M.A. Rau et al
4.		*C. roylei* Rehder
5.		*C. smilacifolia* Wall.
6.		*Naravelia zeylanica* (L.) DC.
7.		*Ranunculus sceleratus* L.
8.		*Thalictrum foliolosum* DC.
9.	Dilleniaceae	*Dillenia pentagyna* Roxb.
10.	Annonaceae	*Miliusa tomentosa* (Roxb.) Sinclair
11.		*M. velutina* (Dunal) Hook. *f*. and Thoms.
12.	Menispermaceae	*Cissampelos pareira* L.
13.		*Cocculus hirsutus* (L.) Diels
14.		*C.pendulus* (Forst.) Diels
15.		*Tinospora sinensis* (Lour.) Merr.
16.	Nymphaeaceae	*Nelumbo nucifera* Gaertn.
17.		*Nymphaea nouchali* Burm. *f.*
18.		*N. pubescens* Willd.
19.	Brassicaceae	*Cardamine hirsuta* L
20.		*C. trichocarpa* Hochst. ex A. Rich.
21.		*Cochlearia cochlearioides* (Roth) Sant.
22.		*Lepidium didymium* L.
23.		*L. sativum* L.
24.		*Rorippa nasturtium-aquaticum* (L.) Hayek
25.		*R. indica* (L.) Hiern S. indicum L.

26.	Capparidaceae	*Capparis decidua* (Forssk.) Edgew.
27.		*C. grandis* L.*f.*
28.		*C.sepiaria* L.
29.		*C. zeylanica* L. (*C. horrida* L.f.)
30.		*Crateva adansonii* DC.
31.		*C.religiosa* Forst. *f*
32.	Polygalaceae	*Polygala abyssinica* R.Br.ex Fresen.
33.		*P.arvensis* Willd.
34.		*P.chinensis* L.
35.		*P. crotalarioides* Buch.- Ham. ex DC.
36.		*P. elongata* Klein ex Willd.
37.	Caryophyllace	*Drymaria cordata* (L.) Willd. ex Schult.
38.		*Polycarpaea aurea* Wight and Arn. UR
39.		*Vaccaria pyramidata* Medicus
40.	Portulacaceae	*Portulaca oleracea* L.
41.		*P. quadrifida* L.

Result and Discussion:

A familywise analysis of all the 41 plants shows that Ranunculaceae emerges as the largest family contributing 8 species, followed by Brassicaceae (7 species), Capparidaceae (6 species), Polygalaceae (5 species). Other important families are Menispermaceae (4 species), Nymphaeaceae and Caryophyllaceae (3 species each), Annonaceae and Portulacaceae (2 species each) and Delleniaceae (1 species). The present study also reveals that mostly herbaceous plants (21 species) are used by tribals of East Nimar, to treat many ailments. Climbers/twiners rank second (10 species) followed by the Trees (7 species), shrubs (3 species).

Acknowledgement:

I am sincerely thankful to the University Grants Commission, Central Regional Office, Bhopal (M.P.). Gratefully acknowledge my deep gratitude to my supervisor Dr. C.M.Solanki and Dr. Sudip Roy for encouragement. The author is thankful to the Dr. Mukesh Jain, Principal S.N. Govt. P.G. College, Khandwa for providing necessary facilities.

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Limnology

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Published By:
Bhumi Publishing, India

ISBN 978-93-88901-01-7