LIMNOLOGICAL STUDIES OF RIVER CHANDLOI (DISTRICT KOTA, RAJASTHAN) WITH SPECIAL REFERENCE TO ICHTHYOFAUNAL DIVERSITY

A Thesis

Submitted for the Award of Ph.D. degree

in ZOOLOGY

(Faculty of Science)

to the

University of Kota, Kota

By

Jyoti Sharma

Under the Supervision of

Dr. Prahlad Dube

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UNIVERSITY OF KOTA, KOTA

2021

CERTIFICATE

This is to certify that the work entitled **"LIMNOLOGICAL STUDIES OF RIVER CHANDLOI (DISTRICT KOTA, RAJASTHAN) WITH SPECIAL REFERENCE TO ICHTHYOFAUNAL DIVERSITY"** is a piece of research work done by Mrs. Jyoti Sharma under my guidance and supervision for the degree of DOCTOR OF PHILOSOPHY. She has completed the following requirements as per Ph.D. regulation of the University.

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ABSTRACT

Present investigation was carried out on Chandloi River in Kota, district Rajasthan. Chandloi River originates near Aalania village and meets the River Chambal near village Kashoroipatan.

The present study incorporates the various physico-chemical aspects and biological components. A brief account of the present investigation is as follows:

Present study was carried out from October 2018 to September 2020. Therefore 4 sampling sites (site 1, site 2, site 3 and site 4) were selected. The month wise water samples were collected from every sampling station during entire period of study and were taken to laboratory for further qualitative analysis of certain physico-chemical and biotic parameters. The data recorded from present River was statistically analyzed and the calculated values were noted.

The water Temperature varied between 15.5^{0}C to 25.6^{0}C in two years of study period. The minimum Temperature of 15.5^{0}C was recorded at site 3 in 2019 in Post Monsoon Season and maximum Temperature 25.6^{0}C was recorded at site 4 in 2018 in Pre Monsoon Season.

The water Depth varied between 92.25 Cm. to 310.25 Cm. in the Chandloi River in two years of study period. The minimum Depth of 92.25 Cm. was recorded at site 3 in 2018 in Post Monsoon Season and maximum Depth 310.25 Cm. was recorded at site 1 in 2019 in Monsoon season.

The water Turbidity varied between 8.5 NTU to 26.8 NTU in the Chandloi River in two years of study period. The minimum Turbidity of 8.5 NTU was recorded at site 3 in 2018 in Pre Monsoon Season and maximum Turbidity 26.8 NTU was recorded at site 4 in 2018 in Monsoon season.

The water pH varied between 8 to 9.2 in the Chandloi River in two years of study period. The minimum pH of 8 was recorded at site 3 in 2019 in Monsoon season and maximum pH 9.2 was recorded at site 4 in 2018 in Pre Monsoon Season.

The water Alkalinity varied between 119.9 mg/ L. to 396.3 mg/ L. in the Chandloi River in two years of study period. The minimum Alkalinity of 119.9 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum Alkalinity 396.3 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season.

The water Hardness varied between 123.4 mg/ L. to 139.5 mg/ L. in the Chandloi River in two years of study period. The minimum Hardness of 123.4 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum Hardness 139.5 mg/ L. was recorded at site 4 in 2018 in also Pre Monsoon Season.

The water concentration of Free Carbon Dioxide varied between 0.45 mg/ L. to 2.35 mg/ L. in the Chandloi River in two years of study period. The minimum Free Carbon Dioxide of 0.45 mg/ L. was recorded at site 4 in 2018 in Post Monsoon Season and maximum Free Carbon Dioxide 2.35 mg/ L. was recorded at site 2 and site 3 in 2019 in Monsoon season.

The water concentration of Dissolved Oxygen (DO) varied between 3.98 mg/ L. to 7.33 mg/ L. in the Chandloi River in two years of study period. The minimum Dissolved Oxygen of 3.98 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season and maximum 7.33 mg/ L. was recorded at site 3 in 2018 in Monsoon season.

The water concentration of Chloride varied between 35.4 mg/ L. to 150.13 mg/ L. in the Chandloi River in two years of study period. The minimum Chloride of 35.4 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum 150.13 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season.

The water concentration of Total Dissolved Solids (TDS) varied between 124.13 mg/ L. to 938.4 mg/ L. in the Chandloi River in two years of study period. The minimum Total Dissolved Solids of 124.13 mg/ L. was recorded at site 3 in 2018 in Post Monsoon Season and maximum 938.4 mg/ L. was recorded at site 4 in 2019 in Monsoon season.

The water concentration of Biological Oxygen Demand (BOD) varied between 7.07 mg/ L. to 119.63 mg/ L. in the Chandloi River in two years of study period. The minimum Biological Oxygen Demand 7.07 mg/ L. was recorded at site 3 in 2019 in Monsoon season and maximum 119.63 mg/ L. was recorded at site 4 in 2019 in Post Monsoon Season.

The water concentration of Nitrate varied between 47.43 mg/ L. to 100 mg/ L. in the Chandloi River in two years of study period. The minimum 47.43 mg/ L. was recorded at site 3 in 2018 in Pre Monsoon Season and maximum 100 mg/ L. was recorded at site 4 in 2018 in Post Monsoon Season.

The water concentration of Phosphate varied between 31.68 mg/ L. to 89.68 mg/ L. in the Chandloi River in two years of study period. The minimum 31.68 mg/ L. was recorded at site 3 in 2019 in Pre Monsoon Season and maximum 89.68 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season.

The Electrical Conductivity (EC) in water varied between 195.6 µmhos/ Cm. to 396.3 µmhos/ Cm. in the Chandloi River in two years of study period. The minimum 195.6 µmhos/ Cm. was recorded at site 3 in 2018 in Monsoon season and maximum 396.3 µmhos/ Cm. was recorded at site 4 in 2019 in Pre Monsoon Season.

Phytoplankton were represented 37 species belonged to 6 phylum, 7 classes and 25 families. 6 groups namely Chlorophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Cyanophyta and Dinoflagellata. Chlorophyta includes 14 species, Bacillariophyta 6 species, Xanthophyta 4 species, Euglenophyta 3 species, Cyanophyta 8 species and Dinoflagellata 2 species.

Zooplankton were represented 29 species belonged to 3 phylum, 6 classes and 16 families. 3 groups namely Rotifera, Protozoa and Arthropoda. Rotifera has 8 species, Protozoa has 7 species and Arthropoda has 14 species.

Ichtyofauna were represented 16 species by group Chordata, class Actinopterygii, 5 orders and 7 families. 5 orders namely Cypriniformes, Anabantiformes, Siluriformes, Cichliformes and Synbranchiformes. Order Cypriniformes has 7 species, Anabantiformes has 2, Siluriformes has 5, Cichliformes has 1 and Synbranchiformes has 1 species.

Benthic Fauna were represented 22 species by 4 phyla, 8 classes and 17 families. 4 groups namely Mollusca, Annelida, Arthopoda and Nematoda. Mollusca has 9 species, Annelida 6 species, Arthopoda 2 species and Nematoda includes 5 species.

Macrophytes were represented 22 species by group Magnoliophyta and 2 classes Liliopsida and Magnoliopsida and 16 families. Both these Classes Liliopsida and Magnoliopsida have 11-11 species each.

CANDIDATE DECLARATION

I, hereby, certify that the work, which is being presented in the thesis, entitled **"LIMNOLOGICAL STUDIES OF RIVER CHANDLOI (DISTRICT KOTA, RAJASTHAN) WITH SPECIAL REFERENCE TO ICHTHYOFAUNAL DIVERSITY"** in partial fulfillment of the requirement for the award of the Degree of Doctor of Philosophy, carried out under the supervision of Dr. Prahlad Dube, Former Head, Department of Zoology, Government College, Kota and submitted to the University of Kota, Kota represents my ideas in my oven words and where others ideas or words have been included I have adequately cited and reference the original sources. The work presented in this thesis has not been submitted elsewhere for the award of any other degree or diploma from any Institution.

I also declared that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will cause for disciplinary action by the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Date: Jyoti Sharma

Place: Research Scholar

This is to certify that the above statement made by Jyoti Sharma (Registration No. RS/1639/18) is correct to the best of my knowledge.

Date: (Dr. Prahlad Dube)

Place: Research Supervisor

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Date:

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CONTENTS

List of Tables

List of Figures

List of Map and Photographs

ABBREVIATION

S.no.	Abbreviation	Meaning
1	^0C	Degree Centigrade
2	BOD	Biological Oxygen Demand
3	Ca^{++}	Calcium ion
4	Cl^{--}	Chloride ion
5	Cm.	Centimeter
6	COD	Chemical Oxygen Demand
7	DO	Dissolved Oxygen
8	EC	Electrical Conductivity
9	ISI	Indian Standards Institution
10	JTU	Jackson Turbidity Unit
11	Km.	Kilometer
12	m.	Meter
13	Mg	Milligram
14	mg/ L.	Milligram per Liter
15	Mg^{++}	Magnesium ion
16	ml	Milliliter

17	nm	Nanometer
18	NTU	Nephelometric Turbidity Unit
19	pH	Hydrogen ion concentration
20	ppm	Parts per million
21	TDS	Total Dissolved Solids
22	TSS	Total Soluble Solids
23	WHO	World Health Organization
24	WQI	Water Quality Index
25	WQIB	Water Quality Index for Biodiversity
26	µg/ L.	Micro gram per liter
27	µm	Micrometer
28	µmhos/ Cm.	Micromhos per Centimeter

Introduction

CHAPTER- I

INTRODUCTION

Water quality

Water is the most important fundamental need and natural resource for human beings. It has been responsible for evolving life in our planet. It is a necessity for life and provides a variety of use from drinking water in cities to the irrigation of crops in agricultural areas. Water provide some recreational use as well as habitat for wildlife. Rivers and streams are very important natural environment and linked to human lives, animals and vegetation (Hasse and Blodgett 2009).

Water is basic substance in protoplasm and is the basis of life. The great circulation system of the earth represents by water being it as the sap of plants, the blood stream of animals and rain falls on the surface of the lands of rivers flowing to the sea. Many lower organisms live in direct contact with water, in higher animals the cells are in contact with the inter-cellular fluid containing water. It serves as transport medium for nutrients, hormones and enzymes inside the body. Water is an essential component of the environment and it sustains life on the earth. All animals and human beings depend on water for their growth, development and survival. About 2/3 of the earth surface is covered with water. Water is found to be 50% to 97% by weight to all plants and animals and about 70% of human body. Water constitutes 83% of human blood, 80% to 90% of protoplasm, 75% of muscle and 22% of bone.

Water quality refers to the ability of our water resources to support animal, plant and human life. Good water quality is necessary for providing us with drinking water that is safe and clean; for providing recreational opportunities like wading, swimming and fishing; for providing habitat for aquatic plants, animals and bugs; and for providing a place for us to connect with nature. Water is crucial concern for mankind since it is directly associated with human being. Water is regarded as polluted when it is changed in its quality or composition directly or indirectly as a result of human activities.

Water quality is important characteristics of water those physical chemical and biological factors that influence species composition, diversity, production, stability and physiological conditions of indigenous population of a water body (Boyd 1982). Two types of water bodies exist on our earth fresh water bodies and sea water bodies. Freshwater bodies may be classified into two types as lentic (standing water) and lotic (flowing water). Lakes, ponds, reservoirs, swamps and wetlands included under lentic water whereas springs, rivers, perennial monsoon streams are included under the lotic water.

Water pollution is any physical or chemical biological change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses (Miller 2002). Most of rivers have become polluted with industrial effluents, inorganic chemicals, sewage, organic wastes and other undesirable foreign matter. There are different sources of water pollution at point sources and non point pollution sources. Point sources are at specific location they are fairly easy to identify, monitor and regulate for example discharge of sewage and industrial effluents at through pipes, ditches or sewers into water bodies. Nonpoint sources are those that cannot be traced to any single site of discharge for example runoff of chemicals into surface water from cropland, Urban Street, livestock feedlots by surface runoff, subsurface flow or deposition from the atmosphere.

The pollutants in aquatic bodies are organic and inorganic wastes. Organic wastes as biodegradable which cause eutrophication changing the quality of water for example garbage. Non-degradable wastes are most persistent kinds of pollution since these can't be destroyed or decomposed biologically over long periods of time as glass, tin, plastics and polythene. The number of such materials especially polymers, chlorinated cyclic carbon compound and pesticides are increasing in the rivers which are serious threat to future of entire aquatic ecosystem and its fauna and flora. Clean water also provides recreational, industrial and agricultural uses (EPA 2001).

Waste materials and industrial effluents have collected in aqua bodies as streams, ponds and rivers. Increase in human population and immoral urbanization is alarming for human and has lead to the pollution of fresh water bodies to extent. Pollution of these may invite water born infectious diseases not only for humans but also for the depending organisms.

There are many variations in the quality of water. Some water bodies have higher concentration of ions of many different kinds whereas others have extremely low concentration of a few ions. Rapid growth of industries along with urbanization has not only decreases the water availability but also deteriorate the quality of water. Physical, chemical and biological characteristics of a water body determine how and far what water can be used and the species and ecosystem process it can support. According to W.H.O. scarcity contamination of water supply and poor sanitation are responsible for 80% of all sickness and diseases. Health of various organisms including human being depends on good quality of water.

Water quality assessment can be defined as the evaluation of the physical, chemical and biological nature of water in relation to natural quality, human effects, and identify uses. Water for its best utilization like irrigation and industrial purpose is the physico-chemical examination. It is the important factor to evaluate the status and helpful in understanding the complex processes, interaction between the biological processes in the water and climate. Although water covers more than 70% of the earth, only 1% of the earth's water is available as a source of drinking water is very important for life. We need water for drinking, bathing, washing, cooking, watering plants and many other things.

Water is a key compound and in determining the quality of our lives. Water is one of the most essential elements to good health. It is necessary for the digestion and absorption of food; supplies oxygen and nutrients to the cells; helps maintain proper muscle tone; rids the body of wastes; and serves as a natural air conditioning system to control the body temperature.

River Ecology

Running water is enormously diverse the range from small streams to Great River and occur under widely different condition of climate, vegetation, topography and geology. In order to make sense of biological findings from such disparate settings it is important to have frame work that reflects the physical dimension of the study system. Slop are steep in the head water and become less so as one proceeds down streams, resulting in concave longitudinal profile. The diverse geography provides for almost unlimited variation, a lengthy river that originates in mountains are typically comes in to existence a series of springs and rivulets. These coalesce in to a fast flowing, turbulent mountain streams, and the addition of tributaries result in a large and smoothly flowing river that winds through the low lands to the sea. Almost everything about river varies with position along its length. Discharge increase, resulting in changes in width, depth and velocity.

Biodiversity

The concept of biodiversity includes the entire biological hierarchy from molecule to ecosystem, or the entire taxonomic hierarchy. The biodiversity found on earth today consists of many millions of distinct biological species. The year 2010 had declared as the "International year of biodiversity". Biodiversity is often used as a measure of the health of biological systems.

Biologist defined biodiversity as the "totality of genes, species and ecosystem of a reason." For geneticists, biodiversity is the diversity of genes and organisms. By the United Nations convention Biological diversity includes diversity of ecosystems, species and genus and the ecological processes that support them. The most prevalent usage of the term biodiversity is a synonym for the variety of species, including their genetic diversity.

The capacity of freshwater ecosystem to support biodiversity the natural variety, abundance and distribution of species across the aquatic environment is highly degraded at a global level. The water index will standardize attempts to identify and mitigate corporate risk in relation to water. The Water Quality Index for Biodiversity (WQIB), developed by the United Nations Environment programmers. Global Environment Monitoring system is based on the most comprehensive global water quality database in the world. At the most basic geographic unit, WQIB scores can be interpreted over time at individual monitoring stations and compared to raw water quality monitoring data to interpret patterns observed.

Water sources such as rivers and lakes directly or indirectly contribute to both human welfare and aquatic ecosystem. Rivers also play an important role in the assimilation and transport of domestic and industrial wastewater, which represent constant pollution source and agricultural runoff. This is temporal and commonly affected by climate (Singh *et al*. 2004; Vega *et al*. 1998). Rivers are highly vulnerable to pollution; therefore it is important to control water pollution.

Limnology

Limnology is the study of inland aquatic ecosystem (Kumar 2005). The study of limnology involve aspects of the organic, physical, chemical and topological quality and functions of inland water (running and standing waters, fresh and saline, natural and man made). This includes the study of rivers, tanks, lakes, ponds, rivulets, springs, groundwater and wetlands (Wetzel 2001). Limnology is closely related to aquatic ecology and hydro-biology, which study aquatic organisms and their interactions with the abiotic environment.

The science studying the water bodies located on the surface of the continents is called limnology. It is considered as a part of ecology. It covers the biological, chemical, physical, geological and other attributes of all inland waters, both running as in rivers (lotic ecosystem) and standing as in lakes (lentic ecosystem). Francois-Alphonse Forel (1841-1912) was firstly proposed the term limnology. When publishing his research on Lake Geneva. Forel is regarded as the founder of limnology not because his work was chronological first, but because of its long continued significance. Natural waters is the main aspect of the limnology in the biogenic material. Ecological equilibrium between various living organism and surroundings is sustained by water.

The present limnological study of Chandloi River was carried out to as certain the magnitude of seasonal variations in physico-chemical and biological variants with reference to phytoplankton, zooplankton, ichtyofaunal diversity, benthic invertebrates, macrophytes and primary productivity at Chandloi River a tributary of Chambal River.

Phytoplankton

Phytoplankton are tiny self feeding component of the plankton community and key part of oceans, seas and freshwater ecosystems. Phytoplankton is a Greek word this means plant which a “wanderer” or “drifter”. Most phytoplankton are too small to be individually seen with the unaided eye. However, when present in high enough numbers some varieties may be noticeable as coloured patches on the water surface due to presence of chlorophyll within their cells and accessory pigment (such as phycobilliproteins or xanthophylls) in some species. About 1% of the global biomass is due to phytoplankton (Bidle and Falkowski 2004).

Phytoplankton typically range in size from 0.002 mm to 1 mm and include diatoms, dinoflagellates, radiolaria, cilliata and cyanobacteria (better known as “blue green algae”). It can be distinguished between limnoplankton (lake phytoplankton), potomoplankton (river phytoplankton) and heleoplankton (phytoplankton in ponds). They differ in size as the environment around them changes.

Phytoplankton consists of the assemblage of small plants having no or very limited powers of locomotion; they are therefore more or less subject to distribution by water movements. Certain planktonic algae move by means of flagella, or possess various mechanism that alter their buoyancy. However most algae are slightly denser than water and sink or sediment from the water. Phytoplankton are largely restricted to lentic (standing) waters and large rivers with relatively low current velocities. Phytoplankton can be divided into 10 classes- Blue-green algae (Cyanophyceae or Myxophyceae), Green algae (Chlorophyceae), Yellow-green algae (Xanthophyceae), Golden-brown algae (Chrysophyceae), Diatoms (Bacillariophyceae), Dinoflagellates (Dinophyceae), Cryptomonads (Cryptomonadineae), Euglenoids (Euglenophyceae), Brown algae (Phaeophyceae), Red algae (Rhodophyceae).

Phytoplankton also known as micro algae contain chlorophyll and require sunlight in order to live and grow. Most phytoplankton is buoyant and float in the upper part of the water body, where sunlight penetrates the water. They consume carbon dioxide and release oxygen. All phytoplankton photosynthesizes but some get additional energy by consuming other organisms. Phytoplankton growth depends on the availability of carbon dioxide, sunlight and nutrients. Phytoplankton also require inorganic nutrients such as nitrates, phosphates and sulphur which they convert into proteins, fats, and carbohydrates. When conditions are right phytoplankton populations can grow exclusively a phenomenon known as a "Bloom".

Phytoplankton are the foundation of the aquatic food web, the primary producers feeding everything from microscopic animal like zooplankton to multi ton whales. Small fish and invertebrates also graze on the plant like organisms and then those smaller animals are eaten by bigger ones. Thus the phytoplankton form the base of the aquatic food webs and are key players in the global carbon cycle and biological balance. At the same time they produce almost 70% of world's atmospheric oxygen. Phytoplankton are also the organisms most likely to be affected by global warming and climate change. Phytoplankton are highly sensitive to vary in physico-chemical attributes. As an outcome, it converts in their abundance, species, diversity or group of composition. It can provide important signs of health of water bodies. Phytoplankton diversity is controlled by seasonal variation so their variation provides a ground for monitoring and assessing the strategies of the river management (Karra *et al*. 2018 a).

Phytoplankton are significant natural inhabitants of all water bodies. They may provide information on possible new introduction and may serve as early warning for system to detect the pollution level (Singh 2015). The phytoplankton of an aquatic ecosystem is central to its normal functioning. Thus the species composition, biomass, relative abundance, spatial and temporal distribution of these aquatic biota are an expression of a particular water body. The magnitude and dynamics of phytoplankton are increasingly considered as bio-indicators to assess the trophic status of an aquatic ecosystem. Their variation provides a ground for monitoring and assessing the strategies of water sources and management.

Zooplankton

Zooplankton is defined as drifting ecologically important organisms that are an integral component of the food chain and also evaluate the ecological status of water bodies. Food webs, cycling of matter and energy flow are few process affecting all the functional features of an aquatic environment by zooplankton. Zooplankton population is very useful indicator for biological, physical and chemical process of aquatic system because they are dynamically affected by atmospheric state and answer quickly to changes in water quality. The most important types of zooplankton include the Radiolarians, Foraminiferans, Dinoflagellates, Cnidarians, Crustaceans (including larvae), Mollusks, Echinoderm larvae and Chordates. Zooplankton are the intermediate link between phytoplankton and fishes. Hence, diversity and seasonal variation studies of zooplankton are of great importance in water bodies.

Zooplankton are small floating or weakly swimming organisms that drift with water currents and with phytoplankton makeup the planktonic food supply upon which almost all oceanic organisms are ultimately dependent. Many animals from single-celled radiolaria to the eggs or larvae of herrings, crabs and lobsters are found among the zooplankton. Some organisms such as protozoa, rotifers, tintinids, larvaceans and copepods spend their all lives as plankton. They are called permanent zooplankton or holoplankton, whereas some animals live and feed as plankton until they leave to become adults in their proper habitats. They are called temporary zooplankton or meroplankton.

Zooplankton are a vital component of freshwater food webs. The smallest zooplankton are eaten by the larger zooplankton which in turn are eaten by small fish, aquatic insects and so on. Herbivorous zooplankton graze on phytoplankton or algae and help maintain the natural balance of ecosystem. Hence zooplankton are very important for the water habitat. Most of zooplankton are so minute they are visible only with the microscope although some species can reach length of 8 feet.

Fishes

Fish generally refer to several aquatic animals but actually all of them are not fishes such as star fish, shellfish, cuttlefish, jellyfish, etc. Particularly in aquaculture, the true fish are called "fin fish" to differentiate them from other animals. An ectothermic fish has a streamlined body for rapid swimming that extracts oxygen from water by using gills or that uses an accessory breathing organ to breathe oxygen. This fish has two sets of paired fins, usually one or two (rarely three) dorsal fins, an anal fin and a tail fin. This also bears jaws and the skin (that is usually covered with scales) and lays eggs. There are exceptions in each of these criteria (Pandey 2013).

Fishes poses notochord, tubular nerve chord, paired gills, segmentation of the body parts, post and tail, ventral heart, and an endoskeleton to be the member of the Chordata. In order to be a vertebrate, it poses backbone. This backbone support and protects the spinal cord.

Most fishes are ectothermic (cold-blooded), allowing their body temperature to vary as ambient temperature change, though some of the large active swimmers like white shark and tuna can hold a higher core temperature. Fish are abundant in most bodies of water. They can be found in nearly all aquatic environments. To survive in freshwater the fish need a range of physiological adaptation. The Pisces is the largest group among vertebrates in terms of number of species. Indian region alone have 2500 species of fishes, out of which 930 are freshwater and the rest are marine (Jayaram 1999).

Fish diversity, which provides food security to the poorest of communities of India, is not only important to fishermen community but also for the better health of water resources. Human life and livelihood largely depend on the status of fish resources. The fresh water fish is the most intimidate taxonomic groups of their high sensitive com-putative and subjective alteration in aquatic habitats (Sarkar *et* *al*. 2008). Fish biodiversity includes all unique species, their habitats and interaction between them. Due to the life history traits fishes are suitable as early warning signals of anthropogenic stress on natural ecosystem dynamics or conversely as indicators of ecosystem recovery and of resilience. Their presence in large number and variety in lentic bodies is a good indication that water is virgin and suitable for human consumption and utility.

Fishes provide a wide range of nutritional gains, including fish meat, fish protein, manure, shagreen, isinglass, glue and other products. Fishes occupy at a significant position in socioeconomic fabric of South Asian countries by providing the population not only the nutritious food and also as an employment opportunity. They are sensitive to many stresses from parasites to diseases to acidification.

Consumption of organisms by fish is a salient feature, which can regulate trophic structure and thus, influence the stability, resilience and food web dynamics of aquatic ecosystems; changing as fish pass from one life stage to another. Fish communities can regulate the carbon-fixing capacity of nutrient rich water body and thus indirectly mediate the flux of carbon between a water body and atmosphere.

As fishes respond sensitively not only to pollution, but also to a number of other human impacts (physical modification, recreational and other) so they potentially be used for holistic indication system for river ecosystem health. Because of their capacity of bio accumulation of toxicants not only from water but also from the available food. *Labeo rohita* is one of the Indian major carps took to check the pollution status of the river and bio accumulation of chromium, cadmium, zinc, copper, and lead (Mahamood *et al.* 2021).

Benthic invertebrates

Benthic Fauna refer to the organisms that inhabit the bottom substrates (sediments, debris, logs, macrophytes, filamentous algae, etc.) of freshwater habitats for at least part of their life cycle. There range from microscopic (micro invertebrates < 10 micron) to a few tens of centimeters or more in length (macro invertebrates >

0.5 mm). They lack a backbone and inhabit all types of waters including lentic, lotic and muddy habitats. Most aquatic benthic invertebrates are insects, but other benthic fauna include nymph stages of mayflies, dragonflies, damsel flies, caddisflies, leeches, worms, crustaceans such as crayfish, mollusc such as clams and snails (Thompson 2005). Some aquatic invertebrates spend their entire lives living in water, although many just live in the water when they are immature. As they reach maturity, larvae metamorphose and leave the water, spending their life on land. Many benthic invertebrates feed on algae and bacteria, which are on the lower end of the food chain. Some of them eat leaves and other organic matter that enters the water. Benthic invertebrates form a large and diverse group of animals. More than 75% of the known animal species in the World belong to this group.

Benthic invertebrates are the most popular and commonly used group of freshwater organisms in assessing water quality. They offer many advantages in bio monitoring although a practice for well balanced monitoring programs such as qualitative sampling and community analysis is required (Yoon *et al*. 2001). Benthic invertebrates is an important part of the food chain, specially for fish, thus are an important link for transferring energy and nutrients between trophic levels and driving pelagic fish and crustacean production. Benthic communities have been the best measure of water quality and organic pollution because of their sustain presence and relatively long sedimentary habitats, comparatively large size and varying liberality to stress (Sharma *et al*. 2013). They have been used in conservation biology. Benthic invertebrates contribute to many important ecological functions, such as decomposition, nutrient cycling, as well as serve an important role in aquatic food webs as both consumers and prey. Agricultural and urban land uses greatly alter both the physical and the chemical aspects of benthic invertebrates habitat, impacting the structure of invertebrate communities.

Macrophytes

Macrophytes are those plants that grow in or near water and are either emergent, submerged or floating. These modifies themselves to survive in aquatic environment. Their distribution is specific and depends up on the water quality and environmental condition. In lakes and rivers macrophytes provides suitable breeding and sheltering place for fishes and macro invertebrates, substrate for aquatic invertebrates, produce oxygen and act as food for some fish and wildlife. Macrophytes are unchangeable biological filters and carry out purification of the water bodies by accumulating dissolved metals and toxins in their tissues (Shah and Vyas 2015). The variation in water chemistry can be assessed by surveying the abundance of macrophytic communities. The trophic nature is mainly influenced the variety of communities and indicator species occur at the sources.

The macrophytes restoring the extension of phytoplankton and help in the reuse of the organic matter. The submerged species of macrophytes at the margin also act as green manure favorable the abundance of zooplankton and benthic fauna (Bhute and Harney 2017; Prasad and Das 2018). Macrophytes in freshwater play vital ecological balance and help in the stabilization and regulation of trophic state and cycling mineral in the aquatic ecosystem. They serve as the bio indicator for the possible degree of damage in aquatic ecosystem. They have a significant effect on soil chemistry and light levels as they slow down the flow of water and capture pollutants and trap sediments. Excess sediment will settle into the benthos aided by the reduction of flow rates caused by the presence of plants stems, leaves and roots. Amazon Water Lily is the largest macrophyte in the world and Duckweed is the smallest macrophyte. Certain macrophytes which are not hydrophytes but mostly prefer the river habitat. Among them some are found exclusively in river and some may grow in other habitats but mostly prefer river beds. These macrophytes particularly shrubs and trees provide shelter for the birds (Reddy and Chaturvedi 2016). Macrophytes often grow more vigorously where nutrient loading is high. Macrophytes constitute a diverse assemblage of taxonomic groups and can be ecologically described as:-

(1) Floating unattached plants in this group is at or near the surface, roots if present hang free in water and are not anchored at the bottom.

(2) Floating attached plants having leaves which float on surface, but their stems are below and their roots harbour the plant in the substrate.

(3) Submerged plants are found when entire plant is under the surface of the water.

(4) Emergent plants are those plants whose roots grow under water but their stems and leaves are found on the water.

Aquatic macrophytes play a vital role to make healthy ecosystem and serve as primary producers of oxygen through photosynthesis, it provides a substratum for algae, protection for benthic fauna and breeding ground for fishes.

Reveiw of Literature

CHAPTER- II

REVIEW OF LITERATURE

Water resources are essentially important for natural ecosystem and human development. All life on earth depends on water, without it life is impossible. Fresh water is a critical, finite, vulnerable, renewable natural resource on the earth and plays important role in our living world. Due to increase in the population of our country and need to meet the increasing demand of irrigation, industries and human consumption the available water resources of the country are shrinking and the water quality too is deteriorating.

Activities like discharge of sewage effluents, waste water from houses, toxic metals as well as metal chelates from different sources and also indiscriminate use of heavy metal containing fertilizers and pesticides in agriculture resulted in deterioration of water quality rendering serious environmental problems posing threat to human beings and sustaining biodiversity. It is therefore necessary to check the water quality at regular interval of time. An assessment of aquatic plankton, fishes, macro-invertebrates and plants provide an indication of water quality.

A number of studies on water quality of freshwater resources have been conducted at global level. Earlier works have been discussed in various works in detail therefore, comparatively recent studies have been discussed in the present chapter. Although, important research papers are also reviewed. Mostly, published work from 1990 up to 2021 is discussed in detail.

Physico-chemical analysis of water

Quality of water is a serious concern because water is essential for life next to the air. Investigations regarding physico-chemical attributes of water has been a favourite subject for hydro biologists, geologists, chemists, biologists, limnologists, fisheries experts, environment biologists, etc. Many of such works have been reviewed by earlier researchers, for example Karr (1999), Mohanta and Patra (2000), Dube (2002). In this chapter works have been reviewed from 1990 to recent.

Joshi and Bisht (1993) studied assessment of water quality by its chemistry includes measure of many elements and molecules dissolved or suspended in the water and can be used to detect imbalances may indicate the presence of certain pollutants are suggested. Lamikanra (1999) studied water is vital to our existence in life and its importance in our daily life makes it imperative that through physio-chemical examinations conducted on water.

Clean water provides recreational uses as well as habitat for wildlife and necessary for various industrial and agricultural uses. The United States face water quality issues from urbanization to agricultural pollution or a combination organic of many "complicated" factors (EPA, 2001). Miller (2002) studied water is soul of nature and if polluted will perish the world. Water pollution is any chemical biological or physical change in water quality that has a harmful effect on living organisms or makes water unsuitable for desired uses.

Unnisa and Khalilullah (2004) studied rapid growth of industries along with urbanization has not only decreases the water availability but also deteriorate the quality of water. Natural surface water bodies like rivers and streams are subjected to pollution comprising of organic and inorganic constituent. Singh *et al*. (2004) studied the ecosystem services of water sources such as rivers and lakes directly or indirectly contribute to both human welfare and aquatic ecosystem. Rivers also play an important role in the assimilation and transport of domestic and industrial wastewater, which represent constant pollution sources, and agricultural runoff, which is temporal and commonly affected by climate. Rivers are highly vulnerable to pollution; therefore, it is important to control water pollution. W.H.O. (2004) studied the public health significance of water quality can not be over emphasized. Many infectious diseases are transmitted by water through the fecal-oral route. Diseases conducted through drinking water kill about 5 million children annually and make 1/6th of the world population sick.

Bhardwaj (2005) studied the rapid increase in the population of the country and the need to meet the increasing demands of irrigation, human and industrial consumption, the available water resources in many parts of the country are getting depleted and the water quality has deteriorated. Indian rivers are polluted due to the discharge of untreated sewage and industrial effluents. Water quality tends to policy makers, to shape sound public policy and implement the water quality improvement programme efficiently (Jameel and Hussain 2005; Padmanabha and Belagali 2005). Dube (2005) has studied physico-chemical characteristics of semi permanent pond at Baran, Rajasthan, India.

Alom and Zaman (2006) studied physico-chemical characteristics of a large lentic water body in Rajshahi, Bangladesh. People use the water body for domestic purpose and irrigation. This large dighi is regarded by people as a sacred water body and is reserved as a bird sanctuary. Presently this dighi is under semi-intensive pisciculture. Parashar *et al*. (2006) studied the physico-chemical parameters like temperature, pH, DO, total hardness, total alkalinity and turbidity of Upper Lake. Better water quality was found in winter season than summer. Extent of pollution that has occurred due to urbanization, anthropogenic activities; increased human interventions in the water bodies have been ascertained.

Haque *et al*. (2007) studied water is the main part of fresh water and plays an important role to serve as many purposes like aquaculture, irrigation and livestock usage. The physical, chemical and biological properties of water are deteriorated day by day causing water toxicity. Toxicity is related to chemical property which refers to its potential and to have a harmful impact on living organism. Kamal *et al*. (2007) studied quality of water generally refers to the component of water, which is to be present at the optimum level for suitable growth of plants and animals. Various factors like temperature, turbidity, nutrients, hardness, alkalinity, dissolved oxygen play an important role for the growth of plants and animals in the water body, on the other hand biological oxygen demand, chemical oxygen demand indicate the pollution level of the water body. Water provides recreational use as well as habitat for wildlife. Rivers and streams are very important natural environment and linked to human lives, animals and vegetation.

Bhat *et al*. (2009) studied the physico-chemical properties of some Urban Ponds of Lucknow U.P. Fresh water is a critical, finite, vulnerable, renewable resource on the earth and plays an important role in our living environment, without it, life is impossible. Since the beginning of the industrial revolution, increasing human population, economic activities as well as shortcoming in their management have resulted in more pollutants being introduced into watercourses. Rivers and streams are usually exposed to loads of polluting substance that come from sources such as sewerage and effluent from waste water treatment plants, as well as from diffuse discharge sources such as surface water runoffs. Physico-chemical analyses cannot yield enough information on the whole health of the river ecosystem (Gurr and Nnadi 2009).

Viswanathan *et al*. (2010) studied physical, chemical and biological aspects of water quality had profound impact on aesthetical and usability to consumers, they are linked and inseparable to ensure water quality kept at utmost. Wu *et al*. (2010) studied biological methods for assessing rivers and streams water quality have many attractions for example, biological community can integrate many different environmental factors over a long period of time, hence able to demonstrate environmental changes of the surrounding area and because the biological community demonstrate ecological integrity as a whole direct evaluation on the overall quality of the water bodies is possible.

Simpi *et al.* (2011) studied water quality using physico-chemical parameters Hosahalli Tank in Shimoga district, Karnataka. It is difficult to understand the biological phenomena fully because the chemistry of water revels much about the metabolism of the ecosystem and explain the general hydrobiological relationship. Patil *et al.* (2012) studied the quality of groundwater depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region. Industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and groundwater.

Gangwar *et al*. (2013) studied water quality of River Ramganga. Water Quality Index (WQI) is a useful tool for quick estimation of quality of any water resource. Assessment of WQI of River Ramganga included physico-chemical parameters that indicate the extent of pollution. The main causes of deterioration in water quality were lack of proper sanitation, unprotected river sites, high anthropogenic activities and direct discharge of industrial effluents. So the water quality of River Ramganga is unfit for drinking purposes. Smitha *et al*. (2013) studied physico-chemical analysis of River Kapila. Water of River Kapila was contaminated with municipal waste and other organic pollutants resulting in moderately high concentration of TDS, hardness, nitrate and sulphate. The accumulation of these pollutants can be dangerous for both aquatic and human life.

Sarwade and Kamble (2014) studied physico-chemical parameters of River Krishna Sangli, Maharashtra. Urbanization found to be root cause of water contamination. Animals use same water for drinking and can also contaminate through direct defecation and urination. On the other hand heavy metals, acids, dyes, alkalie and other chemicals change pH of water which becomes toxic to aquatic flora and fauna. Maximum productivity depends on optimum level of physico-chemical parameters. Jadhav and Singare (2015) studied the physico-chemical properties of sediments are affected by the untreated waste. Sediments act as a natural buffer and filter system in the material cycles of water and the sediment quality, quantity or both have an impact on the ecological quality. The aquatic productivity is also impacted due to the metabolic activity of benthic organisms which are present in the sediments. There is an interchange of important macro nutrients going on continuously between the sediments overlying water.

Khadse *et al*. (2016) studied water of Chenab River and its tributaries are least polluted and is suitable for drinking after conventional treatment. The WQI rating of Bichleri Stream water is medium as it carries waste water and may not be useful for domestic use without treatment. Kumar *et al*. (2016) studied River Beas is a habitat of the endangered fresh water dolphins (*Platanista gangetica minor*). Three principal components of all the water quality parameters explained 100%

variance. Factor analysis delineated three factors underlying the water quality. Factor 1 comprised pollution related parameters, Factor 2 was a natural water quality, Factor 3 comprised NO3-1, a fertilizer related parameter. Mishra *et al*. (2016) studied water quality of Hindon River which is a main tributary of River Yamuna. Water of the Hindon River is unfit for human use, irrigation and other life supporting activities which are mainly on account of direct discharge of untreated waste water by industries and municipal sources.

Gupta *et al.* (2017) studied effect of physico-chemical and biological parameters on the quality of river water of Narmada. Study was considered for the development of water quality index using eight parameters with three methods. This was observed that the water quality was found to be excellent to good in the season summer and winter and poor to unsuitable for human consumption in the season monsoon along the river Narmada. The fall in the quality of water in monsoon was due to poor sanitation, turbulent flow, soil erosion and high anthropogenic activities. Sahu *et al*. (2018) studied Nitrate a compound of nitric acid, is the most highly oxidized form of nitrogen found in aquatic environment. It is an essential nutrient for many photosynthetic autotroph and in some instances, functions as a growth-limiting nutrient. It is used by algae and other aquatic plants to form plant protein which, in turn, can be used by animals to form animal protein and its high quantity in water bodies cause water eutrophication and blooms.

Jannat *et al*. (2019) studied physico-chemical properties of surface water of Mokeshbeel, Gazipur, Bangladesh. Some physico-chemical parameters like pH, temperature, and TDS met the standard acceptable limit in Bangladesh, while TSS, BOD and COD were very high in concentration compared to the national and international standards. The results of this study indicated a very bad quality of water in Mokeshbeel. Thus it could be posed a health and environmental risk to the communities that rely on the Beel, in particular to the flora and fauna and finally the human being. Nair (2020) studied the availability of good quality water is an indispensable feature for preventing diseases and improving quality of life, therefore it is necessary to know details study about different physico-chemical parameters such as hardness, pH, sulphate, chloride, DO, BOD, COD, alkalinity, nitrates and phosphates used for analysis and testing of water quality.

Mishra and Kumar (2021) studied in River Narmada, the input waste water is enriched with the large number of organic and inorganic contaminants that cause severe biotic risk, influences biogeochemical cycle and deteriorating ecological health of river. Presence of coliform bacteria in polluted river water resulting in unsuitability for human consumption.

Phytoplankton studies

Phytoplankton are the microscopic aquatic plants forming the prime component in the food chain of aquatic ecosystems. In any aquatic environment, phytoplankton constitute the most important group for the production of particulate material in the food web and also act as the first link in all aquatic food webs and fueling all of the higher organisms with the products of their photosynthesis. They reduce atmospheric carbon dioxide and thus play a crucial role in controlling climatic changes and global warming. The density and diversity of phytoplankton and their association as biological indicator is significant in the assessment of water quality including water pollution.

More and Nandan (2000) studied hydrobiological studies of algae of Panzara River (Maharashtra). They found that the algal genera, *Oscillatoria, Scenedesmus* and *Navicula* are the species found in organically polluted waters. Ponds in the study is characterized by abundance of Chlorophyceae followed by Cyanophyceae which indicates the absence of pollution. Lakshminarayan and Someshekar (2001) studied the physico-chemical characteristics of Hill Stream have significantly contributed to alter the magnitude of biological dynamics and showed interrelationship either positive or negative in existed ecosystem. The present co-relation coefficient showed the inverse relationship between phytoplankton and temperature, pH, alkalinity, CO_2, biological oxygen demand (BOD), Ca, Mg, Na, K and Cl but showed the positive relationship with velocity and dissolved oxygen (DO) that indicated that plankton’s growth depend on DO and the flow characteristic of running water.

Pathan (2002) studied some physico-chemical parameters and primary productivity of River Ganga. He reported Cyanophyceae group was the dominant among all phytoplankton groups. Phytoplankton shows positive correlation with transparency, pH, alkalinity and DO. The population of plankton fluctuates in different seasons and months. Dube (2002) studied various aspects of lotic and lentic freshwater ecosystems such as quality of water, its physico-chemical and biological characteristics, phytoplankton, zooplankton, macrophytes and animal of different taxonomic categories. He reported 22 phytoplankton species in shallow water bodies in Kota region.

Arjaria (2003) studied physico-chemical profile and plankton diversity of Ranital Lake, Chhatarpur, M.P. According to the study, the phytoplankton is dominated mainly by the species of Cyanophyceae, Chlorophyceae and Diatoms, which belong to the tolerant species. Sirsat *et al*. (2004) studied the plankton study is very useful tool for the assessment of water quality in any type of water body and also contribute to an understanding of the basic nature and general economy of the river. Four major groups of phytoplankton Chlorophyceae, Bacillariophyceae, Cynophyceae and Euglenophyceae were studied for diversity and seasonal abundance. Among the groups of phytoplankton, the population density showed variations due to their adaptability to seasonal changes in water quality.

LeQuere *et al*. (2005) reported that moderate flow of water provides benefits to increase phytoplankton population during winter and early summer months. The lower values for the plankton communities during monsoon season may be attributed to high in flow of water from the catchment area changing the hydrology of the river system as a result of dilution. Kumar and Hosmani (2006) studied algal biodiversity in fresh waters and related physico-chemical factors in two lakes of Mysore district. Euglinophyceae are poorly represented, Bacillariophyceae were the most dominant and occurred throughout the study period. Cyanophyceae dominated during winter season. Chlorococcales were less significant.

Mathivanan *et al*. (2007) studied plankton of River Cauvery water (Tamilnadu), the qualitative and quantitative evaluation of the variation in river water showed high quantity of phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Myxophyceae and Euglinae. This study revealed that the water of River Cauvery is highly polluted by direct contamination of sewage and other industrial effluents. Desai *et al*. (2008) studied phytoplankton diversity in Sharavati River Basin, Central Western Ghats. During this study total of 216 species of 59 genera belonging to Bacillariophyceae, Desmidials, Chlorococcales, Cynophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae were recorded.

Ali *et al.* (2009) studied an ecological study with special reference to phytoplankton (algal) component River Gomti in Jaunpur city. The phytoplankton (algal) community of river was represented by four algal group Cyanophyceae, Chlorophyceae, Euglenophyceae and Bacillariophyceae. Out of 44 algal species, 16 species of Cyanophyceae and Chlorophyceae each, 1 species of Euglenophyceae and 11 species of Bacillariophyceae were recorded from different sites of the river. Phytoplankton population showed a positive correlation with pH, DO, alkalinity, phosphate and nitrate and negative correlation with temperature and chloride. Many of the algal species, of the total 44 reported from the river like *Aulosira, Microcystis, Oscillaloria, Chlamydomonas, Chlorella, Pediastrum, Euglena, Cyelotella, Nevicula, Nitzschia* were recognized as pollution indicators.

Dube *et al*. (2010 b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and 24 species of phytoplankton were recorded. Sharma (2010) studied ecological study of Kishore Sagar Tank of Kota, (Rajasthan). A total of 24 species of phytoplankton belonging to 5 phylum (Chlorophyta, Bacillariophyta, Cyanophyta, Xanthophyta and Euglenophyta). Sharma and Mankodi (2011) studied the diversity of various type of plankton like, phytoplankton and zooplankton in Narmada River. The phytoplankton were represented by Bacillariophyceae, Chlorophyceae, Cynophyceae and Euglenophyceae, out of which generic diversity of Bacillariophyceae was more.

Ghosh *et al.* (2012) studied diversity and seasonal variation of phytoplankton community in the Santragachi Lake, West Bengal. A total of 29 phytoplankton taxa belonging to Chlorophyta (10), Cyanobacteria (8), Charophyta (5), Bacillariophyta (4) and Euglenozoa (2) were recorded. Chlorophyta species dominated mostly in variety and percentage composition while Euglenozoa species representatives had the least expression. Bio indication showed a low diverse community in the monsoon period with better water quality than in pre and post monsoon.

Bhatnagar and Bhardwaj (2013) studied the seasonal algal diversity and the physico-chemical properties of water of Chambal River. This study shows the presence of a total of 65 algal species. Some algal forms are good indicator of water pollution and their presence show signs of water pollution. The algal forms consisted of a total of 65 taxa belonging to Chlorophyceae (32 species), Cyanophyceae (18 species), Bacillariophyceae (12 species) and Euglenophyceae (3 species). Negi and Rajput (2013) studied phytoplankton community structure in Ganga River at Bijnor. They reported 43 genera of phytoplankton belonging to 5 groups as Chlorophyceae 16 genera, Bacillariophyceae 12 genera, Cyanophyceae 10 genera, Euglenophyceae 4 genera and Xanthophyceae 1 genera. Chlorophyceae exhibited maximum abundance and generic diversity and Xanthophyceae exhibited minimum abundance and generic diversity. Subhashree and Patra (2013) studied phytoplankton of River Mahanadi of Odisha. This study revealed that diversity of species Chlorophyceae 53.45% whereas Cyanophyceae 20.78% and Bacillariophyceae 25.77% were composed.

Mukati *et al*. (2014) studied phytoplankton ecology in Narmada River of West Nimar, M.P. India. 10 species of phytoplankton have been collected from various freshwater habitats in the West Nimar. Phytoplankton belonging to Cyanophyceae (4 species), Chlorophyceae (3 species), Trebouxiophyceae (1 species), Ulvophyceae (1 species), Zygnematophyceae (1 species) were reported from River Narmada. This study revealed Cyanophyceae has a dominant class.

Singh (2015) deals seasonal study of phytoplankton diversity of Gomti River Lucknow, (U.P.) India. Various genera of algae belonging to Chlorophyceae *Chlamydomonas, Spirogyra, Oedogonium, Ulothrix, Hydrodictyon, Vaucheria, Scenedesmus, Desmidium, Zygnema, Mongeotia spp., Microspora spp., Gonium sociale, Pediastrum, Ranunculus aquatilis.* Seven genera of Bacillariophyceae *Stauroneis pusilla , Cosmarium formosuhum, Micrasterias desmids, Synedra ulna,* *Navicula sphaerophor, Nitzschia stagnorum, Synura spp.* Myxophyceae *Volvox aureus, Oscillatoria, Stigonema* have been recorded. Phytoplankton are significant formal natural occupier of all water bodies. Monitoring programme of phytoplankton are very important. They may provide information on possible new introductions and may serve as early warning system to detect the pollution level. *Chlamydomonas, Ranunculus aquatilis, Microspora spp., Volvox aureus* were the most abundant followed by *Ulothrix, Hydrodictyon, Desmidium*. High concentration of diatoms at Daliganj bridge and Nishatganj bridge indicate polluted zone of the river. *Oscillatoria and Stigonema spp.* at polluted sites can be used as an indicator of organic pollution in the river. This study is very important from pollution indicator point of view.

Ansari *et al*. (2015) studied phytoplankton diversity and water quality assessment of ONGC Pond, Hazira. Total 73 genera of phytoplankton belonged to 4 classes Euglenoplyceae, Chlorophyceae, Bacillariphyceae and Cyanophyceae were identified. Chlorophyceae class was dominated among the four classes. Trivedi and Karode (2015) studied diversity of phytoplankton in Kshipra River at Triveni station, Ujjain (M.P.). They reported 21 genera belonging to Chlorophyceae, 14 belonging to Bacillariophyceae and 10 to Cynophyceae were recorded and *Rivularia spp.* is most dominant species among the Bacillariophyceae group.

Kumar and Khare (2015) studied the analysis of diversity of plankton (phytoplankton and zooplankton) and their seasonal variation of density in the Yamuna River at Kalpi, district Jalaun, U.P. Phytoplankton were belong to 35 species of 25 genera of different groups like Chlorophyceae (12 species of 11genera), Euglenophyceae (3 species of 2 genera), Bacillariophyceae (5 species of 5 genera) and Cyanophyceae (15 species of 7 genera). Chlorophyceae dominated over rest of the phytoplankton population. Kather Bee *et al*. (2015) studied plankton diversity and water quality of Ambattur Lake, Tamilnadu. Water quality of the freshwater habitats provides substantial information about the existing resources which depends on the influences of physico-chemical parameter and biological features. According to the report, 22 species of plankton consisting phytoplankton and zooplankton were recorded and fluctuations among physico-chemical parameters. Shukla *et al*. (2015) studied phytoplankton diversity in River Ganga at Allahabad, U.P. Plankton identify in the river mainly composed of the members of Bacillariophyceae, Chlorophyceae and Cyanophyceae classes.

Solanki and Shukla (2016) studied preliminary study of phytoplankton diversity in River Naramada valley of Jabalpur region (M.P.). A total 30 algal taxa belonging to 16 genera have been collected and identified from different seasons. The number of various member of class Chlorophyceae with 12 taxa (40%), Euglinophyceae with 3 taxa (10%), Bacillariophyceae with 7 taxa (23%), Trebouxiophyceae with 1 taxa (3%), Ulvophyceae with 1 taxa (4%), Zygematophyceae with 1 taxa (3%) and Cyanophyceae with 5 taxa (17%). Dhanam *et al*. (2016) studied physico-chemical parameters and phytoplankton diversity of Ousteri Lake in Puducherry. A total of 34 planktonic species belonging to 26 genus under the 4 classes. Among these Cyanophyceae comprised of 15 species (belonging to 11 genera) followed by Chlorophyceae 9 species (belonging to 7 genera), Bacillariophyceae 7 species (belonging to 6 genera) and Euglenophyceae 3 species (belonging to 2 genera) were recorded. Cyanophyceae algal growth is dominated over Chlorophyceae, Bacillariophyceae and Euglenophyceae.

Gupta *et al*. (2016) studied the seasonal fluctuation of plankton and to examine the healthiness of water by analyzing the diversity and density of plankton in Keerat Sagar Pond at Mahoba district. Phytoplankton population in various sites of Keerat Sagar Pond indicated the order of dominance among the group with regards to their density and diversity as Chlorophyceae > Baccillariophyceae > Myxophyceae. Maximum density of phytoplankton were found in the months of summer due to scarcity of water while minimum density was found in the months of winter and monsoon season due to low evaporation and inflow of water in the pond.

Saroja and Gopal (2017) studied variations in the phytoplankton communities like Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae and Dinophyceae in two Lakes of Udupi district, Karnataka have been discussed. This lake during a certain period supported 26 species of Cyanophyceae, 30 species of

Chlorophyceae, 7 species of Euglenophyceae, 8 species of Bacillariophyceae and 2 species of Dinophyceae. The growth of phytoplankton influenced by physico-chemical parameters such as water temperature, dissolved oxygen, water pH, biological oxygen demand, chemical oxygen demand, nitrates, phosphates, etc.

Goswami *et al*. (2017) studied the quantitative study of plankton diversity in three Urban Ponds (P-1, P-2 and P-3) of Kolkata in West Bengal. Three classes of phytoplankton (Chlorophyceae, Cyanophyceae and Euglenophyceae) were recorded from all three ponds during the study period. Chlorophyceae was encountered as the most significant group of phytoplankton with a contribution of 65% in P-1 followed by Cyanophyceae (20%) and Euglenophyceae (15%) of total population. Similarly it was also dominant in both P-2 and P-3 with a contribution of 68% followed by Cyanophyceae (19%) and Euglenophyceae (13%) respectively. Hossain *et al*. (2017) studied diversity of plankton communities in the River Meghna. He reported Chlorophyceae with 16 genera, Dinophyceae with 2 genera, Bacillariophyceae with 13 genera, Cyanophyceae with 2 genera, Myxophyceae with 5 genera, Englenophyceae with 1 genera and Xanthophyceae with 2 genera.

Karra *et al*. (2018 a) reviewed the studies of phytoplankton in Lotic Water of India and concluded that phytoplankton are good indicator of environmental changes and their variation provides a ground for monitoring and assessing the strategies of the river management. Sharma *et al*. (2018) studied critical review of studies related to diversity and seasonal variation of phytoplankton. Phytoplankton produce their own food and thus are very important part of food chain and food web. They act as very good indicator of health of water resources specially some algal forms are good indicator of water pollution and their presence show signs of water pollution.

Meena (2019) studied ecological studies of a village Pond of Similiya, district Kota, Rajasthan. She claimed quantitative seasonal study of zooplankton and phytoplankton. 23 species of phytoplankton enlisted belonging to class Chlorophyceae (11 species), Bacillariophyceae (2 species), Cyanophyceae (7 species), Xanthophyceae (2 species) and Euglenophyceae (1 species).

Sharma *et al*. (2019) studied checklist of phytoplankton in the Chandloi River, Kota Rajasthan, India. They listed 5 families, 28 genera, 43 species of fresh water phytoplankton found in the river in different seasons. Class Chlorophyceae was the most abundant with 17 species belonging to 12 genera whereas class Dinophyceae found lowest rank among all classes with 3 species belonging 3 genera.

Yan *et al*. (2020) studied community compositions of phytoplankton and eukaryotes during the mixing periods of a drinking water reservoir: Dynamics and interactions. They recorded variations of phytoplankton and water eukaryotes were closely associated with each other during winter in the Jinpen drinking water reservoir. Significant spatial temporal changes were revealed in the composition of the eukaryotic and phytoplankton communities. The co-occurrence of phytoplankton indicated that the community structure varied remarkably over time. Moreover, Bacillariophyta and Chlorophyta were the most abundant taxa, with a total relative abundance of more than 97% throughout the studied periods, which were primarily composed of M*elosira spp.*, C*yclotella spp.* and C*hlorella spp*. respectively.

Karra (2020) studied limnological studies of River Chandraloi district Kota, Rajasthan with special reference to diversity and seasonal variation in planktons. In this study 19 species of phytoplankton was represented by 5 major groups Chlorophyceae, Bacillariophyceae, Cynophyceae, Xanthophyceae and Euglenophyceae. Chlorophyceae was the largest dominating group and Cynophyceae was second largest dominating group. Borics *et al*. (2020) studied freshwater phytoplankton diversity: models drivers and implications for ecosystem properties. In this study, they reviewed various aspects of phytoplankton diversity, including definitions and measures, mechanisms maintaining diversity its dependence on productivity, habitat size and temperature, functional diversity in the context of ecosystem functioning and molecular diversity.

Ahmed *et al.* (2021) studied phytoplankton assemblage in the River Ganges. Phytoplankton consisted mainly of 49 taxa of 34 genera belonging to

Bacillariophyceae, Chlorophyceae, Cyanophyceae and Chrysophyceae. The members belonging to Bacillariophyceae and Chlorophyceae were the two dominant classes, which comprised up to 75% of the total phytoplankton.

Zooplankton Studies

Zooplankton are a diverse group of hetero-trophic organisms that consume phytoplankton, regenerate nutrients via their metabolism and transfer energy to higher trophic levels. These are the main sources of natural food for fish which is directly related to their survival and growth and are base of food chains and food webs in all aquatic ecosystem. Zooplankton is a good indicator of changes in water quality because it is strongly affected by environmental conditions and responds quickly to changes in physical and chemical conditions as well as environmental conditions. Zooplankton communities respond to a wide variety of disturbances including nutrient loading, acidification, sediment input, etc. It is a well-suited tool for understanding water pollution status.

Maria- Heleni *et al*. (2000) studied the zooplankton diversity of River Aliakmon, (Greece) and reported 79 species of zooplankton. They also observed that the zooplankton diversity was influenced by a variety of abiotic factors temperature, dissolved oxygen, nitrogen and phosphorus. Sivakumar *et al.* (2001) made qualitative and quantitative analysis of Copepods and Cladocerans of the freshwater bodies in and around Dharmapuri district of Tamilnadu. They recorded four Copepod species and seven Cladoceran species. They also observed the higher population density of Copepoda and Cladocera in winter season than in the summer season.

Dube (2002) studied various aspects of lotic and lentic freshwater ecosystems such as quality of water, its physico-chemical and biological characteristics, phytoplankton, zooplankton, macrophytes and animal of different taxonomic categories. He reported 14 zooplankton species in shallow water bodies in Kota region. Das (2002) studied the dynamics of net primary production and zooplankton diversity in brackish water Shrimp culture Pond in Northern part of Ganjam district, Orissa. Significant negative correlation was noticed between net primary production and zooplankton population. Copepods and Rotifers were found to be the dominant groups among zooplankton. The zooplankton population varied with different seasons of the year with rainy and summer seasons showing the minimal density in zooplankton population.

Arjaria (2003) studied physico-chemical profile and plankton diversity of Ranital Lake, Chhatarpur, M.P. Zooplankton diversity is one of the most important ecological parameter in water quality assessment. The zooplankton was represented by 10 genera covering different groups. Saha (2004) studied zooplankton diversity in five major coalfield areas in Jharkhand and revealed 26 species of zooplankton. Cladocerans and Rotifers were abundant groups (9 species each) followed by 7 species of Copepoda and 1 species of Ostracoda. The evenness showed insignificant relationship with species diversity index, while species richness showed negative relationship with species diversity index values. The overall diversity of plankton was low due to high alkalinity of water which results due to fly ash deposition.

Zafer and Sultana (2005) investigated the density of zooplankton in the River Ganga at Kanpur, India. They observed that the density of zooplankton was found to be high during summer and minimum in the monsoon season. Jayabhaye and Madlapure (2006) studied the zooplankton diversity in Parola Dam, (Hingoli), Maharashatra and reported 28 zooplankton species, out of which 14 species belong to Rotifera, 5 species belong to Copepoda, 3 species belong to Ostracoda and 6 species to Cladocera.

Mathivanan *et al.* (2007) studied plankton of River Cauvery water (Tamilnadu). The qualitative and quantitative evaluation of the variation in river water showed high quantity of zooplankton population throughout the study period. Rotifers formed dominated group over other group’s organisms. This study revealed that the water of River Cauvery is highly polluted by direct contamination of sewage and other industrial effluents. Gaikwad *et al.* (2008) studied the diversity of zooplankton in the water bodies of North Maharashtra region. They recorded a total of 19 species including 6 species of Copepoda, 5 species of Cladocera and 8 species of Rotifera.

Rajashekhar *et al.* (2009) studied zooplankton diversity of three freshwater lakes with respect to trophic status from Gulbarga district, North East Karnataka and identified total of 39 species of zooplankton. Dube *et al.* (2010 a) investigated on community structure of zooplankton groups of Kishore Sagar Tank. In that investigation they recorded total 36 species of zooplankton which belong to 7 groups. Dube *et al*. (2010 b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and a total 60 species of plankton (twenty four species of phytoplankton and thirty six species of zooplankton) were recorded. Sharma (2010) studied ecological study of Kishore Sagar Tank of Kota, (Rajasthan). A total of 18 species of zooplankton reported belonging to 2 phylum (Rotifera and Anthropoda).

Sharma and Mankodi (2011) studied the diversity of various types of plankton like phytoplankton and zooplankton in Narmada River. The zooplankton were represented by Rotifera, Cladocera, Copepoda and Ostracoda, out of which generic diversity of Rotifera was more. Sharma *et al.* (2012) studied fresh water Cladocera of South Rajasthan, India. This study showed Cladocera are an important component of the Crustacean zooplankton. Zooplankton samples from 77 different water bodies of South Rajasthan were analyzed to investigate the Cladocera inhabiting these water bodies. During this study 54 species of Cladocerans were reported, belonging to 6 families that is the Sididae, Daphinidae, Moinindae, Bosminidae, Macrothricidae and Chydoridae. It was noticed that rich nutrients, the presence of weeds and shallow waters favoured rich diversities of Cladocerans.

Jakhar (2013) studied Zooplankton have close links with the surroundings environment throughout their life cycles and they demonstrate rapid changes in their populations when disturbance occurs such as eutrophication. Therefore they are potential indicator species for water pollution.

Negi and Mamgain (2013) studied zooplankton diversity of Tons River of Uttarakhand State, India. A total of 23 genera of zooplankton belonging to 7 major groups Ciliphore, Cladocera, Copepod, Porifera, Rotifera, Ostracod and Zooflagellate. Malhotra (2014) studied the variations in zooplankton population in relation to industrial effluents. Various pollution indicating physico-chemical parameters have been correlated with zooplankton indicating the effect of DO, BOD and pH on zooplankton population and diversity.

Kumar and Khare (2015) studied the analysis of diversity of plankton (phytoplankton and zooplankton) and their seasonal variation of density in the Yamuna River at Kalpi, district Jalaun, U.P. Registered zooplankton were belong to 22 species of 16 genera of different groups like Protozoa (3 species of 3 genera), Rotifera (12 species of 6 genera), Cladocera (5 species of 5 genera) and Copepoda (2 species of 2 genera). Rotifers Population was dominant during entire study span.

Shukla and Solanki (2016) studied the zooplankton composition, variation and diversity indices in River Narmada at Jabalpur region. Zooplankton diversity is one of the most important ecological parameters in water quality assessment and good indicator of the changes in water quality. Zooplankton formed important quantitative component of net plankton of the five groups; Protozoa dominantly contributed to their abundance while Copepoda> Rotifera> Cladocera> Ostracoda were sub-dominant groups. Due to their large density, shorter life span, drifting nature, high group or species diversity, different tolerance to the stress and often respond quickly to environmental change and water quality, zooplankton are being used as indicator organisms for the physical, chemical and biological process in the aquatic ecosystem.

Krishna and Kumar (2017) studied seasonal variations of zooplankton community in selected Ponds at Lake Kolleru region of Andhra Pradesh, India. A total 16 species recorded with 9 Rotifera, 3 Cladocera and 4 Copepods. In the Rotifers the genus *Brachionus* is the dominant in group. In ecologically zooplankton is one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter. Karra *et al*. (2018) studied a review on the studies of zooplankton in the lotic water of India. Zooplankton communities respond to a wide variety of disturbance including nutrient loading and also play a key role in the aquatic food chain. It is a well suited tool for understanding water pollution status.

Manickam *et al.* (2018) studied impact of seasonal changes on zooplankton biodiversity was conducted in the Ukkadam Lake at Coimbatore city, Tamilnadu, India. The population density of various group of zooplankton was observed and it was found to be following order Rotifera > Copepoda > Cladocera > Ostracoda. The high and low population densities were recorded in summer and early monsoon season respectively. This higher zooplankton population density in summer might be due to the temperature acceleration in the Ukkadam Lake. It indicates that the temperature has influence on the zooplankton diversity. Therefore, increased temperature due to global climate change might have influence on the zooplankton product.

Meena and Dube (2018) studied a critical review of zooplankton of Lentic Water Bodies in India. Zooplankton are the plankton consisting animals and the immature stages of larger animals. Due to their large densities they are being used as the indicator organisms of physical, chemical, and biological process of aquatic system. Sharma and Dube (2018) studied a critical evaluation of literature on zooplankton research in India. Zooplankton population is very useful indicator for biological, physical and chemical process of aquatic system because they are strongly affected by environmental conditions and respond quickly to changes in water quality. Zooplankton are the intermediate link between phytoplankton and fish.

Sharma and Dube (2019) studied Population dynamics and seasonal variation of Rotifers in Chandloi River, Kota, Rajasthan. It listed 16 genera and 31 species of fresh water Rotifers found in the river in different seasons. Population dynamics and distribution of Rotifers maximum number were found in during summer, followed by winter and minimum during monsoon. Dabhade and Chhaba (2019) studied zooplankton diversity around Washim region of Maharashtra. They recorded a total of 27 zooplankton species from the different sampling site of Washim region comprising of 11 species of Rotifers, 06 Copepods, 09 Cladocera and 01 Ostracods. The community structure of zooplankton showed a mix composition of mesotrophic to eutrophic species. Meena (2019) studied ecological studies of a village Pond of Similiya, district Kota, Rajasthan. A total of 27 species of zooplankton belonging to class Ciliata (6 species), Monogonata (8 species) and Crustacea (13 species).

Shayebi *et al*. (2020) studied abundance and diversity of zooplankton in the lower reach of the Opobo River, Rivers State Nigeria. Zooplankton species abundance showed that the zooplankton species varied spatially and seasonally. The highest number of zooplankton species (11 species) was recorded during the wet season (July), while the lower zooplankton species (8 species) was recorded in the month of March. Flooding during the July period (wet season) as a result of high rainfall may also have contributed positively by recruiting zooplankton from other water bodies where by causing an increase in the zooplankton community during the wet season.

Dahare (2020) studied the diversity of various types of zooplankton was in the fresh water Pond of Sindewahi, Maharashtra. The zooplankton were represented by various phyla like Protozoa, Helminthes, Rotifera, Annelida, Arthropoda, etc. Arthropods have been reported maximum in number of varieties and percentage amount in the total zooplankton followed by Rotifera. The range of zooplankton between 174 to 769 n/ L. and average was 378.42 n/ L.

Mishra (2020) studied 28 species of zooplankton in Lony Dam Reservoir which shows its moderate bio-diversity. The qualitative analysis of zooplankton has shown that the Rotifers, Protozoans, Cladocerans and Copepods were the major components of its total bulk in Lony Dam. The maximum magnitude of zooplankton abundance was found in summer months and minimum was noted in early monsoon months. Karra (2020) studied limnological studies of River Chandraloi district Kota, Rajasthan with special reference to diversity and seasonal variation in plankton. 26 species of zooplankton was represented by 6 major groups (Protozoa, Rotifera, Branchiopoda, Cladocera, Ostracoda and Copepoda).

Lee *et al*. (2021) studied zooplankton fluctuations in the surface waters of the Estuary of Large Subtropical Urban River. 14 higher taxa or other categories of zooplankton were identified with the following being most common taxa:

Decapoda, Copepoda (including Calanoida, Cyclopoida and Harpacticoida) and "other larvae". The Copepod comprises 44 taxa (including 8 only identified to genus) belonging to 3 orders, 17 families and 29 genera, the 5 most abundant of which were *Bestiolina spp., Corycaeus spp., Parvocalanus crassirostris, Acartia spp.* and *Paracalanus parvus*. Sarkar and Pal (2021) studied zooplankton diversity in the River Jaldhaka, West Bengal, India. A total 16 zooplankton genera belonged to Protozoa (5 genera, 31%), Rotifera (5 genera, 31%), Copepod (3 genera, 19%) and Cladocera (3 genera, 19%) were recorded, presence of Rotifers *Brachionus, Filinia* and *Polyarthra* are indications of slightly eutrophic conditions of the river water.

Fishes Studies

Fishes are gill bearing aquatic craniate animals that lack limbs with digits. Fish provides nutrients and micro nutrients that are essential to cognitive and physical development. Fishes are one of the most threatened taxonomic group, because of their high sensitivity to the qualitative and quantitative alteration of aquatic habits. As a consequence, they are often used as bio indicator for the assessment of water quality, river network connectivity or flow regime.

Bhatt (2000) deals book reviews in India. 2500 fish species have been reported of which 930 (40%) are freshwater inhabitant. Sakhare (2001) investigated the occurrence of 23 fish species belonging to 7 orders in Jawalgaon Reservoir in Solapur district of Maharashtra. The fishes belonging to order Cypriniformes were dominant with 11 species followed by order Siluriformes with 4 species, while orders like Osteoglssiformes, Perciformes and Channiformes each were represented by 2 species and the rest of the orders by single species.

Biradar (2002) studied frequency distribution of fish species at various sampling sites. On the basis of occurrence of the species in all sampling sites they were categorized into dominant (species occurred >80%), abundant (species occurred 60%-80%), less abundant (species occurred 40%-60%) and rare (<40%). Yazdani and Singh (2002) studied fish fauna of Ujani. They found 54 species belonging to 15 families.

Wagh and Ghate (2003) studied 62 species of fish in the Mula and Mutha Rivers flowing through Pune. Sewage and industrial pollution of river waters besides prevalence of exotic fish appear to be the seasons for the depletion of fish species. Om Prakash (2004) studied fish species of Northern part of Raipur district, Chhattisgarh. He documented 64 species belonging to 40 genera, 19 families and 7 orders. Desai and Shrivastava (2004) reported 48 species belonging to 32 genera and 15 families in Ravishankar Reservoir in Dhamtari district, Chhattisgarh.

Khedkar (2005) studied fish species of Nathsagar Reservoir from Paithan, district Aurangabad. He observed 67 fish species belonging to 7 orders and 19 families. Study of the fish condition in relation to the physico-chemical parameters provides a better understanding on the healthiness of ecosystem. Bakawale and Kanhere (2006) studied fish fauna of River Narmada in West Nimar, M.P. He found 150 species belonging to 26 families. Verma and Kanhere (2007) studied ichtyofauna of the River Narmada in Western zone. He enlisted 84 species belonging to 45 genera. Since taxa (family, genus and species) differ in their tolerance to pollutants, particular taxa make useful, "indicators" of water conditions.

Sarkar *et al.* (2008) studied conservation of freshwater fish resources of India. Fish forms highest species diversity among all vertebrates and their loss is one of the world's most pressing crises as human life and livelihood largely depend on the status of biological resources. The freshwater fish is one of the most threatened taxonomic groups due to their high sensitivity to the quantitative and qualitative alteration in aquatic habitats. He enlisted many fish species of India. Dahire (2008) studied fish diversity in the riverine resources of Janjgir-Champa district of Chhattisgarh. He enlisted 67 fish species under 41 genera, 19 families and 7 orders. Fish encompass different trophic levels, have a long life cycle and high mobility and can be used to integrate the effects of habitat change and environmental pollution over a long period.

Singh and Johal (2009) studied fish diversity of River Ganga of India in the vicinity of Allahabad. This river stretch supports 76 fish species belonging to 53 genera 24 families and 10 orders. Bisht *et al.* (2009) studied ecology and fish fauna of some of the tributaries of Ganga River system. Small hill-streams are highly torrential with huge attitudinal variation. These streams provide variety of habitat for subsistence of varied and large fish fauna. The habitat has been identified as one of the primary criteria on which many biological communities are organized.

Vijaylaxmi *et al*. (2010) studied freshwater fishes distribution and diversity status of Mullameri River, a minor tributary of Bheema River of Gulbarga district, Karnataka. The result of the study reveals the occurrence of 14 fish species belonging to 5 orders. The order Cypriniformes was dominant with 7 fish species followed by order Siluriformes with 4 species and the order Channiformes, Mastacembeliformes and Osteoglossiformes each with one species.

Atkore *et al.* (2011) studied patterns of diversity and conservation status of freshwater fishes in the tributaries of River Ramganga in the Shiwaliks of the Western Himalaya. In total, 43 species belonging to 8 families and 5 orders were recorded which included 29 species belonging to the threatened category. Family Cyprinidae was represented by the maximum number of species. Sharma *et al.* (2011) studied on limnological characteristic, Planktonic diversity and fishes (species) in Lake Pichhola, Udaipur, Rajasthan (India). 15 species of fishes belonging to 6 family and 13 genera were reported from Pichhola Lake namely *Notopterus notopterus, Catla catla, Cirrhinus cirrhinus, Ctenopharygodon idellus, Labeo gonius, Labeo rohita, Puntius sarana sarana, Puntius ticto, Chela cachius, Garra gotyla gotyla, Aorichthys seenghala, Mystus cavasius, Heteropneustes fossilis, Xenentodon cancila and Gambusia affinis.*

Kumar and Dua (2012) studied fish diversity of River Ravi in Indian region. The main threats to fish diversity of the Ravi are: flow modification, degradation of habitat, availability of water, building of dam and emergence of two canals. In that study 38 fish species were recorded from the River Ravi. Of these, 9 species are vulnerable species and 2 are endangered species (according to IUCN conservation status).

Bakwale and Kanhere (2013) studied the fish species diversity of the River Narmada in Western Zone. The fish diversity is correlated with biological and various physico-chemical parameters that regulate the productivity and distribution of different species of the fishes. The fish population is abundant and majority of fishes are exploited for human consumption. The survey indicated that 51 species of fish were found in this zone of the river. The major fish abundance was noticed as major carps, minor carps and cat fishes. The several species of fish belonging order Clupiformes, Cypriniformes, Beloniformes, Opiocephaliformes, Mastacambelliformes, Siluriformes and Perciformes. In which maximum 37 species belonging to the order Cypriniformes. Some species of fishes like *Cirrihinus cirrihosa, Aspidoparia jaya, Colisa fasciatus, Labeo bata, Oreichthys cosuatis, Osteobrama cotio,* etc. showed a declining trend in this stretch. The fish species diversity was decreasing.

Galib *et al.* (2013) studied fish diversity of the River Choto Jamuna, Bangladesh. A total of 63 species of fishes have been recorded belonging to 41 genera, 23 families and 9 orders. Cypriniformes was recorded as the most diversified fish group in terms of both number of species and individuals observed. He found 41.26% species were threatened in Bangladesh including 15.87% vulnerable, 15.87% endangered and 9.52% critically endangered species. Overall values of diversity, richness and evenness indices were found to be 3.717, 6.954 and 0.897 respectively. Cypriniformes was recorded as the most diversified fish group in terms of both number of species and individuals observed.

Sarkar *et al*. (2013) studied biodiversity of freshwater fish of a protected river in India: comparison with unprotected habitat. Results showed that in the protected area, a total of 87 species belonging to 8 orders, 22 families and 52 genera were collected; while a maximum of 59 species belonging to 6 orders, 20 families and 42 genera were recorded from the unprotected areas. Cyprinids were found to be the most dominant genera and *Salmostoma bacaila* was the most numerous species in the sanctuary area. Other numerous species were *Eutropiichthys vacha*, *Notopterus notopterus*, *Clupisoma garua* and *Bagarius bagarius*. The results indicated more species, greater abundances, larger individuals, and higher number of endangered fishes within the sanctuary area when compared to the unprotected area. Analysis on the mean abundance of endangered and vulnerable species for the evaluated areas in the sanctuary versus unprotected ones indicated significant differences in fish abundance.

Khedkar *et al.* (2014) studied DNA bar-codes for the fishes of the Narmada, one of India's Longest Rivers. This study describes the species diversity of fishes of the Narmada River in India. A total of 820 fish specimens were collected. Fish were taxonomically classified into 90 possible species based on morphological characters, and then DNA bar coding was employed using COI gene sequences as a supplemental identification method. A total of 314 different COI sequences were generated and specimens were confirmed to belong 85 species representing 63 genera, 34 families and 10 orders. Findings of this study include the identification of five putative cryptic or sibling species and 43 species not previously known from the Narmada River basin. 5 species are endemic to India and three are introduced species that had not been previously reported to occur in the Narmada River.

Satapathy and Misra (2014) studied the fish diversity of the River Pilasalunki situated in Phulbani district, Odisha. A total of 23 fish species belonging to 9 families were recorded. Out of the recorded species 35% are enlisted as vulnerable, 52 % as lower risk near threatened category. Maximum number of fish species were collected from slow flow site (31.6%) followed by silty sand beds (17.6%), deep water zone (15.8%), gravel habitat (15.8%), fast flow zone (10.5%) and least in shallow water zone. Vishwakarma *et al*. (2014) deals with the fish diversity of Barna River and its tributary in Raisen district, Madhya Pradesh, Central India. 33 fish species belonging to 5 orders, 9 families and 21 genera. The order Cypriniformes was found dominant (24 species) followed by Perciformes and Ophiocephaliformes (3 species) both, Mastacembeliformes (2 species) and Beloniformes (1 species). The most abundant family was Cyprinidae, having 250 individuals (75%) followed by Cobitidae with 32 individuals (10%). Some endangered and rare fish fauna are also reported in that investigation.

Pathak *et al.* (2014) studied ichtyofauna of Western region of Narmada River, Madhya Pradesh. Narmada River is the largest Westward flowing river of India. It is also referred as the life line of Madhya Pradesh. During the study period, 58 fish species have been identified belonging to 38 genera, 16 families and 6 orders. The fishes caught are divided into commercially important species like *Labeo rohita, Catla catla, Cirrhinus mrigala*; locally important species like *Tor spp., Channa spp., Mystus spp.,* etc. and ornamental fishes like *Nandus nandus, Nemacheilus botia, Salmostoma bacaila, Colisa fasciatus,* etc. *Tor tor* and *Chitala chitala* once abundant in the river, now are registered under endangered condition.

Banyal and Kumar (2015) studied fish diversity of Chambal River, Rajasthan state. The Fish fauna of the Chambal River is rich and diverse. Various types of carps, catfish, and mullet reside in the river waters. 54 species of fishes were reported from the Rajasthan part of the Chambal River. Bano *et al*. (2015) studied fish biodiversity and conservation aspects in an aquatic ecosystem in River Narmada. Ichtyodiversity refers to a variety of fish species, depending on context and scale; it could refer to alleles or genotype within piscine population, to species of life forms within a fish community and to species or life forms across aqua regimes. 40 fish species, 25 genera, 15 families and 6 orders were recorded in the three stations of Narmada near Hoshangabad region. Among them the Cyprinidae contribute 63.64% of their total population. Due to some anthropogenic activities fish diversity of this river is in decline mode.

Sarkar *et al*. (2015) studied a review on the fish communities in the Indian Reservoirs and enhancement of fisheries and aquatic environment. In India, reservoirs are playing a crucial role in the fisheries. Fish communities are often used as indicators of environmental quality. In terms of fish diversity altogether 117 fish species were recorded from Indian Reservoirs exhibiting rich fish diversity. These reservoirs have both positive and negative impacts on fishes and other aquatic environment. Therefore, this study was emphasized on synthesizing the available information on fish diversity and community structure of the potential Indian Reservoirs and its effects on fisheries and other aquatic environment in reservoirs in India.

Jain *et al.* (2016) studied diversity of ichtyofauna in Central India. Biodiversity is the variation in the genetics and life forms of populations, species, communities and ecosystem. Biodiversity affects the capacity of living system to respond changes in the environment and is essential for providing goods and services from ecosystems. Fish diversity depends on geographical position, varied aquatic ecological conditions, health of aquatic bodies and optimum exploitation of the commercial fish species, enforcement of laws, rules and regulations and their implementation and fish habitat restoration programs. They enlisted many fish species in Central India.

Bhaumik *et al.* (2017) deals a case study of the Narmada River system in India with particular reference to the impact of dams on its ecology and fisheries. They studied currently, three dams have been built in Madhya Pradesh and one is under construction in Gujarat. A comparison of pre-impoundment and post-impoundment eco-environment and fisheries revealed changes in water quality, productivity, and aquatic flora and fauna of the river system. Among the fish species like *Tor tor, Labeo fimbriatus* and *Labeo dyocheilus* suffered the most. The percentage contributions to total yield of carp, catfish, and miscellaneous groups have significantly changed, indicating falls of 17%, 36% and an increase of 410%, respectively. Percentage contributions to catches of *Macrobrachium rosenbergii* and *Tenualosa ilisha* have also declined by 46% and about 75% in the estuarine stretch of the river system.

Shukla *et al*. (2017) studied fish species diversity of Benisagar Dam, Satna (M.P.) India. Fish fauna of Benisagar Dam consists of 31 species belonging to 11 families. Among the collection 04 species of order Clupeiformes, order Cypriniformes consist of 20 species, order Beloniformes consist of 03 species, Perciformes consist of 03 species and order Mugilidae consist of 01 species. Saini and Dube (2017) studied fish diversity of River Narmada, Jabalpur region (M.P.). 29 species of fishes were recorded in these sampling stations. The major fish abundance was noticed major carps, minor carps and cat fishes. The several species of fish belonging to order Cypriniformes, Beloniformes, Ophiocephaliformes, Perciformes and Siluriformes are recorded too. Out of these Cypriniformes is the most dominant group with recorded 22 species of fishes. Some species of fishes like *Cirrhinus cirrihosa, Labeo bata* showed a declining trend in the stretch.

Sayeswara Ha (2017) studied current status of ichtyofaunal diversity of Tunga River at Mandagadde Bird Sanctuary, Shivamogga, Karnataka, India. A total of 16 species of fishes belonging to 4 orders, 8 families, and 12 genera were recorded from the study area. 6 species sighted in family Cyprinidae and Channidae, Cichlidae and Ciloridae were represented by 2 species each. Banyal and Kumar (2017) recorded 5 species of fishes belonging to order Cyriniformes from Vatrak Stream of Rajasthan. Taxonomic details along with ecology of the fish fauna and stream morphology are also discussed. Rathore *et al.* (2017) studied fish biodiversity and fisheries potential of Reservoir Udaisagar (Udaipur, Rajasthan). The reservoir has a fairly rich fish fauna and so far 31 species representing 9 families have been recorded in that investigation, of these 12 species predominantly contributed to the commercial fisheries of this reservoir. During study period, the Indian major carps dominated the catch by contributing 90% to the total landings from this reservoir. Besides Indian major carps, minor carps and catfishes were reported to be 8.84 and 0.9 %, respectively. Among the Indian major carps, the *Catla catla* (70%) dominated the groups followed by *Labeo rohita* (25%) and *Cirrhinus mrigala* (5%).

Selakoti (2018) studied fish diversity in a Kumaun Himalayan River, Kosi, at Almora, Uttarakhand. 12 species of fish fauna were observed. All the recorded fish species belonged to the families Cyprinidae and Botinae. Cyprinidae was the dominant family having 9 fish species out of the 12 species. The family Botinae comprised of 3 fish species. Hasan *et al*. (2018) studied fish biodiversity of River Dakatia and its conservation aspects in Bangladesh. 72 fish species were recorded including 12 orders and 27 families. Cypriniformes constitutes highest number of fish population (28%). Cyprinidae shares the highest percentage (19%) among the recorded family. Catfish was found to be the biggest group (27%) among the recorded 14 common groups. The biggest habitat was found to be River-Estuary (43%). Among the identified threatened fish species (20) of River Dakatia, 11 species (55%) were recorded as Vulnerable (VU), 8 species (40%) as Endangered (EN) and 1 species (5%) as Critically Endangered (CR).

Shelke (2018) studied the ichtyofaunal diversity of Girna River. A total of 35 fish species belonged to 08 orders, 27 genera of 17 families were recorded. Order Cypriniformes was most dominant group represented by 20 (57.14%) species followed by orders Perciformes with 06 (17.14%) species. Siluriformes with 03 (8.57%) species, Synbranchiformes 02 (5.71%) species, Beloniformes 01 (2.85%) species, Synodontidae 01 (2.85%) species, Scorpaeniformes 01 (2.85%) species and Osteoglossiformes 01 (2.85%) species. Thus the Girna River has good potential for fish fauna. Out of 35 fish species 29 have least concern status, 01 are near threatened, 02 are Vulnerable, 02 are not evaluated and one is data deficient.

Rawal (2018) studied diversity of Hill Stream fishes in Sahastradhara region of Narmada River Maheshwar, district Khargone, Madhya Pradesh. Total 8 species of Hill Stream fishes obtain from the Sahastradhara sampling station of Narmada River. Sarkar (2018) studied seasonal fish faunal diversity and water quality of Jamuna River in South Bengal region. Altogether 46 fish species belonging to 18 families and 36 genera were collected. Family Cyprinidae (24 species) comprised 56% and Notopteridae (1 species); Clupeidae (1 species), Cobitidae (1 species); Claridae (1 species); Heteropneustidae (1 species); Synbranchidae (1 species); Gobidae (1 species); Eletridae (1 species); Anabantidae (1 species); Belontidae (1 species); Channidae (1 species); Mastacembelidae (1 species) comprises 2% each of total catch whereas Bagridae (2 species); Siluridae (2 species); Ambassisae (2 species); Mugilidae (2 species) comprised 4% each of the total catch, out of the 46 species documented, 8 species showed significant variation in catch data in pre monsoon, monsoon and post monsoon period. *Cirrhinus reba, Labeo boga* catch significantly increased in post monsoon period compared to pre monsoon and monsoon period.

Banyal and Kumar (2019) studied the fish diversity of Mahi River in Rajasthan. Order Siluriformes and Perciformes each represented with 5 species, order

Osteoglossiformes, Synbranchiformes, Clupeiformes represented with 2 species each, whereas Beloniformes only by 1 species. Sharma *et al*. (2019 b) studied a critical evaluation of literature on freshwater fishes research in India. Fish biodiversity includes all unique species, their habitats and interaction between them. Due to the life history traits fishes are suitable as early warning signals of anthropogenic stress on natural ecosystem dynamics or conversely, as indicator of ecosystem recovery and of resilience. Their presence in large number and variety in lentic bodies is a good indication that water is virgin and suitable for human consumption and utility.

Sood *et al*. (2019) studied on the impact of Tilapia (O*reochromis mossambicus*) on the ichtyodiversity. Tilapia are popular exotic fish in freshwater resources. It is invasion harmful for other indigenous fishes species. Thus Tilapia study is very important for aquatic diversity. Sharma *et al*. (2019 a) studied checklist of freshwater fishes in the Chandloi River Kota, Rajasthan. They listed 6 orders, 6 families, 11 genera, 13 species of freshwater fishes found in the river in different seasons. Family Cyprinidae is found to be most diverse and dominant family. This family have 6 genera with 8 species. Genus *Labio* is the most diverse and dominant genus in that habitat with 3 species.

Essien-Ibok and Isemin (2020) studied fish species diversity, abundance and distribution in the major water bodies (Qua Iboe River, Imo River and Cross River) in Akwa Ibom State, Nigeria. A total of 356 of fishes comprising 20 species belonging 12 families in Qua Iboe River. 129 fish fauna belonging to 5 species and 4 families in Imo River. Cross River recorded 19 species belonging to 16 genera representing 13 families. Thus the three major ecosystems in the region are capable of a pronounced fishery. Hossain *et al*. (2020) studied Tropical Hilsa shad (*Tenualosa isisha*) contributes significantly to the society and economy of Bangladesh, India and Myanmar. Variations in seasonal productivity linked with nutrients and phytoplankton abundance are important factors for predicting Hilsa habitat and their migration patterns in the deltaic regions and shelf waters of Bay of Bengal.

Pathak and Lavudya (2021) studied diversity of fresh water fishes in Narmada River, Madhya Pradesh. A total of 176 species from freshwater habitats out of which 13 orders, 46 families, 107 genera and 176 species recorded. The order Cypriniformes represented the highest diversity with 79 species followed by Perciformes (35 species), Siluriformes (32 species), Clupeiformes (11 species), etc. Freshwater fish diversity information could also provide a baseline for future more complex ecological studies and planning the conservation and sustainable use of inshore inland water resources. Sharma *et al.* (2021) studied diversity of ichtyofauna of Maheshwar Dam in Narmada River, Madhya Pradesh. 36 fish species were recorded which belong to 7 order, 12 families and 22 genera. Out of the 6 orders Cypriniformes (44.44%) was dominant with 16 species followed by Siluriformes (27.77%) with 10 species, order Ophiocephaliformes (11.11%) with 4 species, order Perciformes (5.56%) with 2 species, order Mastacembeliformes (5.56%) with 2 species, Beloniformes (2.77%) and Clupeiformes (2.77%) represented by one species each.

Benthic Fauna Studies

Benthic fauna refers to various organisms found on (epifauna) and in (infauna) the seabed sediment-dwelling. Most organisms in the benthic zone are scavengers or detritivores. Benthic invertebrates are very important as they are good indicators of water quality and source of food for aquatic animals. Benthos are also critical for the breakdown of organic matter. Species use organic matter as their food source making them a key player in nutrient cycling process. Also the filter feeders that live in this zone, such as mussels, are responsible for removing pollutants and sediments suspended in the water. By contributing to nutrient cycling and pollutant and sediment removal, benthos are directly responsible for maintaining healthy water quality.

Rosenberg and Resh (1993) studied several biological communities including micro phytobenthos, macrophytes and fishes have been considered in assessments of water quality. However, the use of benthic invertebrate communities as indicators of environmental degradation or restoration has become widespread and reliable for bio-assessment since the benthos broadly reflects environmental conditions. In addition they are sedentary therefore body burdens reflect local conditions, allowing detection of a variety of perturbations in a range of aquatic habitats. Resh *et al.* (1996) studied benthic invertebrates are commonly used in water quality assessments because they have close link to the chemical and physical states of their habitats and allow for a simple method to identify water quality issues. They are widely used because of the large number of diverse species that have different tolerances to water quality, long life cycles and a well-known taxonomy. Species with long life cycle allow for long term changes to be tracked and a well known taxonomy allows for easy identification of organisms in the field and lab.

Karr (1999) studied relationships between benthic invertebrates communities and river ecosystem conditions make community structure a good indicator of overall river health. Use of benthic invertebrates assemblages for bio-assessments of water quality conditions is commonly used. Yoon *et al*. (2001) studied benthic macro invertebrates are the most popular and commonly used group of freshwater organisms in assessing water quality. They offer many advantages in bio-monitoring.

Reese and McDonald (2002) studied benthos own their abundance and position as “middlemen” in the aquatic food chain, they plays a critical role in the natural flow of energy and nutrients. As benthic invertebrates die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain. Biological assessments rely on indicators or metrics, to measure the condition of aquatic communities to perturbations. Kumar (2002) studied the compelling reasons for the apparent popularity of fresh water invertebrates in current bio monitoring practice. The distribution of benthic invertebrates is closely related to the nature of bottom feeding habits, availability of food, etc.

Sharma (2003) studied the organism lives in bottom of water bodies are termed as benthos. The benthos plays an integral part of the food web, which has become an important aspect of limnology. Benthic fauna are specially of great significance for fisheries. That they themselves act as food of bottom feeder fishes. Kumar (2003) studied benthic invertebrates are best indicator for bio assessment which provides a more reliable assessment of long term ecological changes in the condition of an aquatic system. Davis *et al*. (2003) stated that benthic invertebrates are good indicators of watershed health because they live in the water for all or most of their life, are easy to collect, differ in their tolerance to amount and types of pollution habitat alteration, can be identified in laboratory, often live for more than one year, have limited mobility and are integrator of environmental condition. The use of natural benthic invertebrate assemblages is one of the best understood, most convenient and most economical water quality monitoring systems and can be used to complement physico-chemical monitoring of water quality.

Lamoureaux *et al.* (2004) studied the structure of benthic invertebrates communities depends on abiotic and biotic factors that vary across spatial scales from regional to habitat specific. Kopciuch and Berecka (2004) studied benthic invertebrates is an ideal taxon must respond predictably, in ways that are readily observed and quantified to environmental disturbance.

Moore and Palmer (2005) studied agricultural and urban land-uses greatly alter both the physical and the chemical aspects of benthic invertebrates habitat, impacting the structure of macro-invertebrates communities. Tyagi *et al.* (2006) studied abiotic environment of the water body directly affect in the distribution, population density and diversity of the benthic community. Benthic invertebrates have also been identified and the highest species number was recorded near tributaries due to the availability of food while the lowest are in the impacted areas where there are pollution discharges and gravel excavation.

Stoddard *et al.* (2006) studied a range of reference conditions and their presence is often considered as an indicator of a healthy river. Grouping of sensitive taxa such as presence of EPT, which measures the proportion of individuals in the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are also used as an indicator of a healthy river. Bonada *et al.* (2006) studied macro-invertebrate communities are the bioassessments of river ecosystem health. Bioassessment protocols are based on the premise that biotic communities respond to changes in habitat and water quality resulting from anthropogenic disturbance and that such community responses are integrate indicators of the state of the biotic and abiotic variables representing river health. Azrina *et al*. (2006) studied macro-invertebrates composition, abundance and distribution are influenced by water quality. The distribution and diversity of benthic invertebrates are interrelated to water quality, evident from the rising richness of these invertebrates in tune with levels of organic pollution. Their relative abundance has been used to make inferences about pollution loads.

Carlisle *et al*. (2007) studied benthic invertebrate populations in rivers can assist in the assessment of the overall health of the river and can be used as a barometer of overall biodiversity in aquatic ecosystems. Merritt *et al.* (2008) studied benthic invertebrates are typically less mobile than fish, they provide a more localized assessment of their representatives of many Insect orders, as well as Crustaceans, Gastropods, Bivalves and Oligochaetes and they contribute many important ecological functions.

Silva *et al.* (2009) studied the community characteristics of benthic invertebrates such as diversity and richness are often used as indicator of the degree of pollution of water bodies to supplement and deepen the meaning of physico-chemical information. Metcalfe-Smith (2009); Bere and Tundisi (2010) studied benthic communities as bio indicators also provide information about the cumulative impact of the various pollutants in an ecosystem. Water quality management using benthic invertebrates in evaluating the impacts of specific pollutants in aquatic environments.

Sharma (2010) studied ecological study of Kishore Sagar Tank of Kota, (Rajasthan). A total of 21 species of macro invertebrates reported which followed phylum Mollusca, Nematoda, Annelida and Arthopoda. Barbour and Paul (2010) studied biological assessment of benthic invertebrates are a common technique used to evaluate the biological integrity of flowing water bodies. When using a biological assessment inference can be made about the status or quality of the environment derived from structural and functional attributes of individuals, populations, communities and ecosystems.

Slavevska-Stamenkovic *et al.* (2011) studied water quality assessment based on the macro invertebrate fauna in the Pcinja River case study. During the investigation of the bottom fauna from the Pcinja River 40 families from 13 animal groups were recorded. Trichoptera (10), Ephemeroptera (6) and Diptera (5) were the most diverse groups with families. The other groups were found to be less diverse. The number of families decreased in the longitudinal direction. The upper and middle part of the river was characterized by a higher taxa richness (16-22 families) in comparison with the lower stretch of the Pcinja River (13 families).

Vesna *et al.* (2012) studied many invertebrates feed on algae and bacteria, which are on the lower end of the food chain. Some of them leaves and other organic matter that enters the water. As benthic invertebrates die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain. Sharma *et al*. (2013) studied benthic communities have been the best indicators of water quality and organic pollution because of their constant presence and relatively long sedentary habitats, comparatively large size and varying tolerance to stress.

Ishaq and Khan (2013) studied benthic invertebrates continuously “monitor” water quality and reflect long term water quality conditions. They have been found as the most common faunal assemblages for bio assessment and provide more reliable assessment of long term ecological changes in the quality of aquatic system compared to its rapidly changing physico-chemical characteristics. Mohan *et al*. (2013) studied aquatic benthic invertebrates responds to a variety of environmental conditions of rivers and streams and therefore may be used as bio-indicators for assessing water quality parameters. Benthic organism provide a valuable indicator of past and present condition of the water quality and prone to be the most useful in assessment of pollution because of their life cycle length, center position in food chain and is of collection, shorting preservation. Thus, the pollution ecology of the benthic community becomes a very important biological tool for environmental impact assessment and management. They are highly important as fish food and generally have high rate reproduction.

Ansari *et al*. (2014) studied organic enrichment and benthic fauna - some ecological consideration. Increased organic enrichment brings changes in physical environment and biological parameter and the consequent changes in benthic community. Benthic fauna show characteristic response gradient with distance from the source of organic inputs in space and time. Population increases with moderate input of organic enrichment. On the other hand, an excessive organic load create stress condition for benthos. Changes in the trophic structure and sedimentary stability along the gradient are accompanied by changes in the genera and families.

Olomukoro and Oviojie (2015) studied benthic macro invertebrates fauna of Obazuwa Lake in Benin city, Nigeria. They recorded a total of 748 benthic invertebrates composing of 46 taxa, 13 groups and 25 families. Dominant taxonomic taxa varied considerably; Hemiptera (64.56%), Coleoptera (48.43%), Mollusca (29.06%), Oligocheata (19.28%), Nematoda (16.03%) and Odonata (15.83%). The variations in texa and number of individuals between stations were not significantly different ($P > 0.05$).

Parmar *et al*. (2016) studied benthic invertebrates are an important part of oceanic biomass and are responsible for the majority of productivity and nutrient cycle in a marine ecosystem. These invertebrates have a rapid rate of growth and react to even low levels of contaminants and other physico-chemical and biological changes. From a research perspective they give important signs of environmental change. Haider *et al*. (2017) studied the abiotic environment of the water body directly influences the distribution, population, density and diversity of the benthic communities. In scientific culture and management of fisheries resources, there is a great need of understanding regarding benthic fauna as they play a vital role in regulating the aquatic environment. They found four groups of benthos that is Oligochaeta, Chironomidae, Mollusca and unidentified were distinguished during the study period in freshwater Homestead ponds of Dinajpur, Bangladesh. Oligochaeta was dominant among different groups of benthos.

Sharmin *et al.* (2018) studied the abundance of benthic organisms was observed from a Migratory bird visiting Lake in JahangirNagar University. A total of 22 species belonging to three phyla (Mollusca, Annelida and Arthropoda) and 14 families was recorded with maximum abundance in summer season and minimum in winter season. Molluscan population (41%) was dominant in benthos, followed by Annelida (31%) and Arthropoda (28%).

Semwal and Mishra (2019) studied benthic invertebrates play important ecosystem roles in the cycling and outflow of nutrients. The benthos transforms organic detritus from sedimentary storage into dissolved nutrients that can be mixed into overlying waters and used by rooted plants and algae to enhance primary productivity.

Bhadury *et al*. (2020) studied biodiversity of benthic fauna in Chilika Lagoon. Benthic communities represents the major component of aquatic sedimentary biodiversity and play important roles in major ecosystem processes beside serving as excellent proxy for tracking environmental and anthropogenically induced changes. Among benthic macro fauna Gastropods, Bivalves and Polychaetes are major players in terms of abundance and diversity. In case of micro benthos Nematodes and Foraminifera constitute major components in terms of abundance and diversity in Chilika Lagoon. Singh and Sharma (2020) studied benthic invertebrates owing to their wide variation of response to environmental changes have been extensively utilized to evaluate the water quality and health of the aquatic ecosystems. Seasonal sampling of the benthic invertebrates can indicate the effects of anthropogenic activities on the community. A total of 29 taxa of benthic invertebrates was found in the wetland Dodital, Garhwal Himalaya, India. Some species *Enchytreaus spp.* (Oligochaeta), *Isoperla spp.* (Plecoptera), *Orthrotrichis spp., Mystacides spp.* (Trichoptera) were identified as excellent bio-indicator on the basis of their abundance for assessing the health of the high altitude wetland.

Negi *et al.* (2021) studied biodiversity of mites in Khankra gad a Spring-Fed tributary of River Alaknanda in Uttarakhand. A total of 2537 Hydrachnidia samples were collected, belonging to 6 families Torrenticolidae, Sperchontidae, Feltriidae, Hygrobatidae, Lebertiidae and Aturidae. A total of 19 aquatic mite species were recorded in Spot-1 and 25 species in Spot-2 throughout the study period. Aquatic mites showed maximum density in December and minimum density in July.

Macrophytes Studies

An aquatic plant large enough to be seen by the naked eyes growing in or near water. They may be either emergent with upright portions above the water surface, submerged or floating. Macrophytes provide cover for fish and substrate for aquatic invertebrates. They also produce oxygen and provide food for some fish and other wildlife. Macrophytes respond to a wide variety of environmental conditions are easily sampled, do not require laboratory analysis and are used for calculating simple abundance metrics. The depth, density, diversity and types of macrophytes present in a system are indicator of water body health.

Dawson *et al*. (1999) studied assessment of the tropic status of rivers using macrophytes. Aquatic macrophytes can act as a measurable indicators of the ecological conditions of surface waters. Notably, the submerged species strongly dependent on water quality have proved to be vulnerable to change in the aquatic environment. Virola *et al*. (2001); Thomaz *et al*. (2003) studied environmental factors associated with the richness and species composition of macrophytes. Thus, an assembly of such organisms in a river or lake can be an effective indicator of the integrated combination of the pressure and stress disorders that affect their habitat. Aquatic macrophytes are one of the important biotic entities in aquatic ecosystem as they provide food, oxygen and shelter to the other aquatic organisms.

Heegaard (2004) studied macrophytes are limited to a set of characteristics of a specific habitat and that they respond differently to environmental conditions. They can be used as management tools in monitoring the quality of water bodies.

They also influence the water quality by using nutrients and by accumulating heavy metals. Germ *et al*. (2004) determined 39 macrophytes species in the Krka River. Among submerged macrophytes *Potamogeton nodosus, Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton filiformis* and *Najas marina* were abundant species composition changed significantly form Novo mesto downstream as a consequence of lower water quality. *Najas minor* that was only found in one stretch has the status of a vulnerable species in Slovenia.

Sharma *et al*. (2005) studied response of selected aquatic macrophytes towards textile dye waste waters. Among the various plant species *Phragmites* is the only macrophyte species tolerant to textile waste waters and therefore it has been used for polishing partially treated textile waste waters in a constructed wetland at Sanganer. However, the highly sensitive species such as *Ceratophyllum, Azolla, Lemna* and *Spirodela* may also be used as a marker for assessing toxicity of textile dye waste waters; more particularly *Lemna*, since it allows comparison of toxicity of textile waste waters with other pollutants. Ghavzan *et al*. (2006) studied aquatic macrophytes are known to suppress the development of wind wave in shallow waters. Reduced wave heights leads to the reduction of the re-suspension of bottom sediments. This function that aquatic macrophytes may have seems important in deciding the water quality of rivers.

Devi and Sharma (2007) studied the diversity of the macrophytes in Awangsoipat Lake (Bishnupur), Manipur. Transparency, nutrient concentration and land are the different factors responsible for proper growth and distribution of macrophytes in the reservoirs and rivers. Silva *et al*. (2008) studied aquatic macrophytes not only play an important role in maintenance of aquatic ecosystem, but also they absorb different dissolved nutrients, nitrogen and phosphorus from polluted water in maintaining the resilience of ecosystem. The study of the macrophytes gives us valuable information about health of aquatic environment.

Sondergaard *et al*. (2010) studied submerged macrophytes are considered to be suitable eutrophication indicators and are sensitive to local environmental conditions. Rejmankova (2011) studied the role of macrophytes in wetland ecosystem. Wetland macrophytes comprise taxonomically highly diverse group of plants. Their functions in wetland ecosystems impact many processes such as nutrient availability often result in replacement of low productivity high species diversity systems with highly productive species monoculture.

Solak *et al*. (2012) studied aquatic macrophytes reflect anthropogenic influence and are very useful to detect and assess human impacts. Vyas *et al*. (2012) studied distribution of macrophytes in River Narmada near water intake point. Aquatic macrophytes are group of large macroscopic photosynthetic organisms usually growing with their roots in soil or water. Macrophytes provide habitat to aquatic organisms also help in maintaining water quality, nutrient cycling and stabilizing river banks.

Kshirasagar and Gunale (2013) recorded 74 species of macrophytes from Mula River flowing through the Pune city. They also studied that, aquatic macrophytes species are specific to environmental quality and therefore can be used as agent in bio remediation. Dhore and Lachure (2014) studied the macrophyte, the aquatic plants grows in or near the water bodies, plays an important role for maintaining the ecological balance and resilience and also are key factors for primary production of an aquatic ecosystem. Macrophytes serve as indicator species responding to changes in water quality and contaminants to cause pollution in several ecosystems.

Ghosh and Biswas (2015) studied bio monitoring macrophytes diversity and abundance for rating aquatic health of an Oxbow Lake Ecosystem in Ganga River Basin. They recorded altogether 45 genera of macrophytes. It was found altogether 13 genera of aquatic macrophytes belonging to 10 families and 24 plant species (bank flora) belonging to 16 families. In terms of genus number of plant, emergent showed the largest number in study followed by free floating, submerged and rooted floating leaf genus.

Reddy and Chaturvedi (2016) deals with the diversity of hydrophytes and other macrophytes generally found in and along the Rivers of the Chandrapur district. 16 hydrophytes and 56 other macrophytes were recorded. Among the enlisted macrophytes two are Algae, two are Pteridophytes and twelve are Angiosperms.

Among the Angiosperms taxa all are monocots and belongs to 9 families. Among the available taxa 7 are submerged, 6 are floating and 3 are marshy plants.

Sharma and Singh (2017) studied macrophytes of sacred Himalayan Lake Dudital, India: quantitative and diversity analysis. A total of 45 macrophytes species belonging to 29 families and 34 genera were reported. Maximum number of species were represented by emergents (30), followed by submerged (10), rooted-floating leaf type (3) and free floating (3) macrophytes. Joshi (2018) studied floristic diversity in the wetlands of Kota district, Rajasthan. The study revealed that the occurrence of 51 aquatic and semi aquatic families with 90 genera and 113 species of Angiosperm and two species of Pteridophytes were identified. The most dominant vascular family with respect to number of species is Poaceae with 11 plants, 34 families were dicot, remaining 16 were monocot and rest of two families were Pteridophytes.

Tenna Riis *et al*. (2019) studied riverine macrophytes control seasonal nutrient uptake via both physical and biological pathways. Metabolic activities of macrophytic communities accelerate the metabolic and the physico-chemical condition of stream water. Sethu *et al*. (2019) studied the physico-chemical parameters and distribution of aquatic macrophytes of seasonal wetlands flowing into the coast of Palk Bay, South-East coast of India. A total of 7 submerged macrophytes, 6 rooted floating weeds, 1 floating and rooted macrophyte were recorded in Tharavai Wetland. Submerged aquatic vegetation is used as the water quality key indicator and it exists where there is a better quality condition.

Rawlekar and Sawane (2020) studied macrophytes diversity of Kolar River in Nagpur region of Maharashtra state, India. They investigated 25 species from three groups. Which was categorized by free floating, submerged and marginal aquatic weeds. The enrichment of the shallow water with high bottom sediments provides on ideal habitat for luxuriant growth of macrophytes. Sarkar *et al*. (2020) studied that macrophytes are important structural components and bio indicators of freshwater lakes and its occurrence and species composition are dependent on the nutrient conditions, water level, water temperature and transparency. Variations in macrophytes species is affected by changing environmental conditions. Comparatively highest level of pollution status was observed in pond B then in pond A due to the presence of some macrophytes (*Eichhornia* and *Lemna*).

Kamble *et al.* (2021) studied wetland flora of Gorewada International Biopark, Nagpur. A total of 114 species from 33 families were identified from the Gorewada wetland area. 67 species belong to Dicot and 47 are Monocots. Some of major dominant wetland macrophytes are *Hydrilla, Azolla, Utricularia, Ipomea, Lemna, Nymphoides indica, Ceratophyllum,* etc. Submerged species are represented by *Naias, Nechmandra, Vallisneria, Hydrilla* and *Ceratophyllum*, while *Aponogeton, Limnophyllum* and *Ottelia* forms the floating leaves category. *Typha* and *Ipomea fistulosa* are the most frequent taxa of category. Besides these, Algae, Aquatic Fungi, Bryophytes and Pteridophytes are also measure parts of the wetland ecosystem.

This review addresses the **limnological studies of River Chandloi with special reference to ichthyofaunal diversity**. Specifically, we examine the role that river fishes have played or could play in informing water quality, conservation of fish diversity and management of river. These decisions give the current policy framework, using this framework as the organizational structure for the review.

Material and Methods

CHAPTER-III

MATERIAL AND METHOD

Present study was conducted between October18 to September 20. The work entitled **"Limnological studies of River Chandloi (district Kota, Rajasthan) with special reference to ichthyofaunal diversity"** were planed on seasonally basis at selected four study sites. The samples were taken between 7 a.m. to 12 noon throughout the study duration from all study sites. The physico-chemical analysis of water and sampling of fishes and other fauna was performed as per methods given in Needham and Needham (1969), Pennak (1989), Tonapi (1980), Welch (1998), APHA (2005), Day (1889), Srivastava (1968). Water samples were collected in plastic container for physico-chemical analysis and some parameters (such as temperature, depth, etc.) have done analyzed on the spot. Net of different mesh sizes were used for collecting other invertebrate fauna (zooplankton, phytoplankton, benthic invertebrates). The organisms were preserved immediately in 80% ethanol or 5% formalin. These samples were returned to the laboratory for processing. The collected fauna were sorted and identified to the best standard taxonomic keys.

About Kota District

Geography

Kota District is a district of the state of Rajasthan in Western India. The city of Kota is the administrative headquarters of the district. It's coordinates are $23^0$53' to North and $75^0$9' to $77^0$27' to East. Total area is 5,217 Km. square and total population are 1,951,014 (according 2011) and density are 370 people per square Km. Among total population 60.31% are urban.

The District is bounded on the North by Bundi district, on the East by Baran district, on the South by Jhalawar district and on the West by Chittorgarh district. It is renowned for its IIT JEE preparation as well as medical exams preparation. It is now the hub of educational institution and is home to Asia's biggest manufacturer of fertilizer. Further Kota is surrounded by four power stations within it's 50 Km. radius as: Rajasthan Atomic Power Plant, Rawatbhata, Kota, Thermal Power Plant, Kota, Anta Gas Power Plant, Anta, Jawahar Sagar power plant, Kota.

Climate

The climate of the area is dry. The coldest months last for about three and a half months from November to the mid of February. The period from April to the end of June constitutes the hottest months. The monsoon season starts in the middle of July. The hottest wind blows in the months of May and June. Mild wind blows in the months of February, March, September and October. December and January are the months in which the coldest wind blows. The study area gets maximum rainfall in the months of July and August and minimum in the months of September and October. The weather becomes moisturized and slightly cold during the rainy season.

The study area has a semi arid climate with temperature overall the year. The average rainfall of the area is about 660.6 mm.

Soil

The rocks of Vindhyan system, Satpura range, Narmada valley, Western Malwa plateau and Madhya Bharat plateau cover the major part of district. However, the small areas lying to the Eastern sides of Kota are an exception in as much as their geological antiquity belongs to decean traps of upper cretaceous to lower loceneage.

The major soils found in the district and their percentage

Deep black clay soils- 42%

Deep brown clay soils- 15%

Deep brown loamy soils- 11%

The soil in the plateau is rich alluvial of the medium to heavy clay loam type. The cultivated area in the district is confined into plateau and the grounds where the soil is rich and fertile. The Eastern and Western part slopes gradually to Chambal River are very fertile. It tends to be gravel and shallow and of rich nutritive quality.

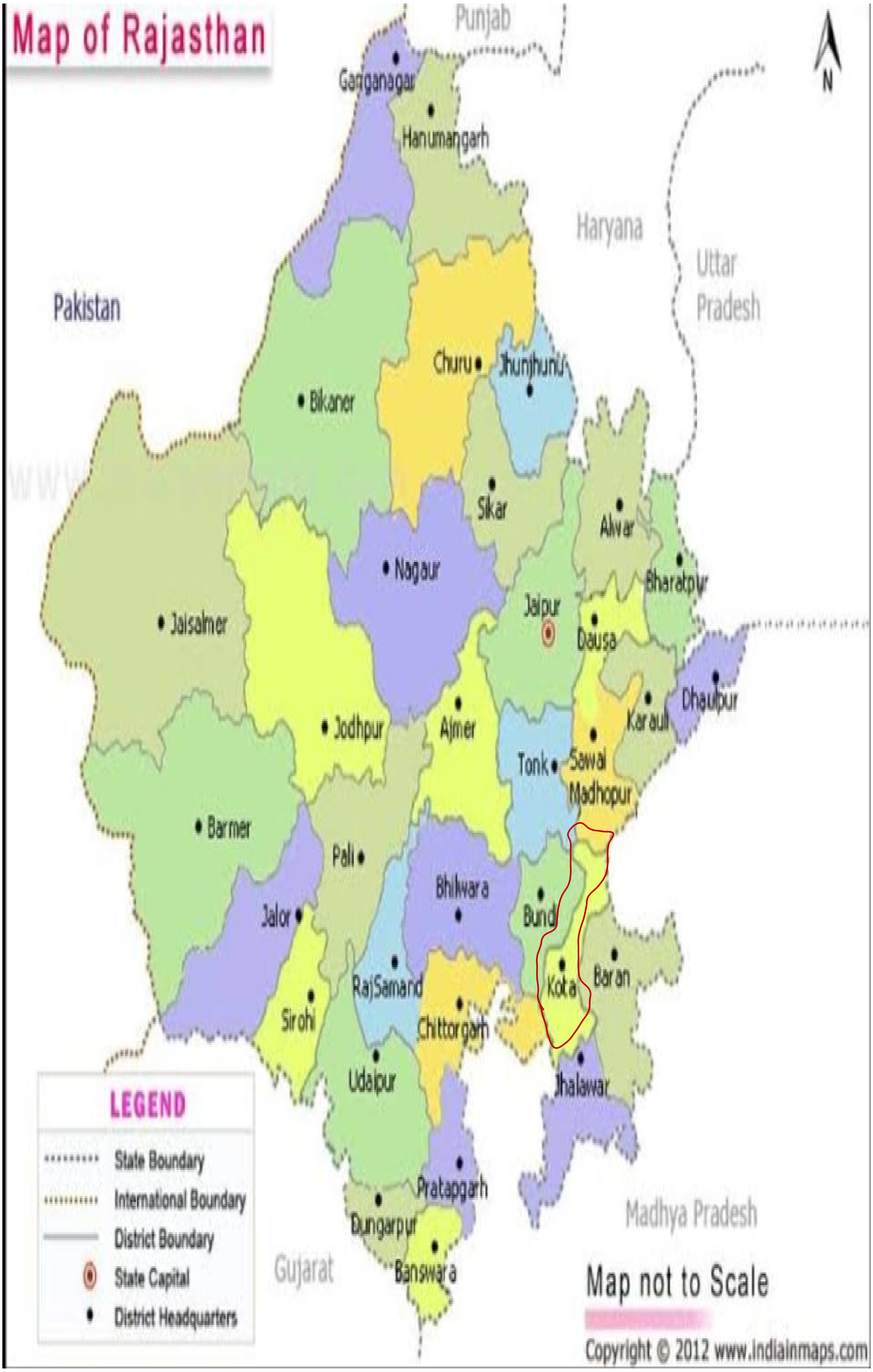
Description of Chambal River

Chambal River is one of the cleanest perennial river of India. It originates at Janapav, South of Mhow town on the South slope of the Vindhyachal range in M.P. The Chambal River is a chief tributary of the Yamuna River in Central India and thus forms the greater gangetic drainage system. The river flows North-Northeast through Madhya Pradesh, running for a time through Rajasthan then forming the boundary between Rajasthan and Madhya Pradesh before turning Southeast to join the Yamuna in Uttar Pradesh state. It's coordinates are $22^{0}27'$ North and $75^{0}31'$ East and length is 960 Km., out of which 370 Km. flows through Rajasthan. Chambal River's left bank tributaries are Banas, Mej and **Chandloi** and right bank tributaries are Parbati, Kalisindh and Shipra.

Description of Chandloi River

Chandloi River is a small, semi perineal left bank tributary of Chambal River. It originates from Aalania Dam near Aalania village and meets the River Chambal near village Kashoroipatan. It's location is 25.23 Latitudnal and 75.99 Longitudnal in Kota city. The river flows nearly 100 Km. before entering River Chambal and it's average width is 50 to 80 m. The River Chandloi recharge due to regeneration or surplus water from Chambal Command area. Water discharge from river 150 cusec (in June, July) to 20,000 cusec (in August, September) in monsoon season. Major historical locations of this river are Aalania mata temple at it's origin, famous and India's one Bibhishan temple in Kaithoon, and Chandresal temple of Naga Sadhu's. It's end point Kashoroipatan is also a famous pilgrimage spot dedicated to Lord Vishnu on bank of Chambal. Kesar, Dhani, Mawasa, Kaithoon, Borkhandi, Raipura, Mandaniya, Hathikheda and Chandresal villages are situated on the bank along this river path.

Map-1: Map of India showing the location of Rajasthan state.



Map-2: Map of Rajasthan showing the location of Kota district.

Map-3: Map of Kota district showing the location of Ladpura Tahsil.

Map-4: Location map showing the Chandloi River with two sampling points, Kota, Rajasthan.

Description of Sampling sites

Before finally fixing the sampling stations a general survey of River was made, samples were collected seasonally (pre monsoon, monsoon and post monsoon) and estimated from selected sites of Chandloi River.

Study Site

The water samples were collected from the various selected sampling sites in the Chandloi River which are as under:

Site- 1:- Two ghats are located in towards East. Each have five broad stairs to reach the river water. In rainy season these stairs are covered from river water. These ghats are used for human activities such as bathing, washing clothes, etc.

Site- 2:- Another site is situated in the Western side of the river, which is rather undisturbed site, because it is more deeper than site 1 and it has not stairs.

Site- 3:- Near origin of river. This place is situated near Aalania village. River Chandloi origin is Aalania Dam. Which is a beautiful nice place with lot of birds for picnic and outing. Here is a rest room of irrigation department.

Site- 4:- Near the entering into Chambal River near Kashoroipatan.

Sampling site 1: Situated in the East side of the river.

Sampling site 2: Situated in the West side of the river.

Sampling site 3: Origin of river near Aalania village.

Sampling site 4: Near the entering into Chambal River near Kashoroipatan.

PHYSICO-CHEMICAL ANALYSIS OF WATER

The water samples were collected from the four selected sampling sites- site 1, site 2, site 3 and site 4 in the Chandloi River for the period of 2 years from October 2018 to September 2020. In the analysis of the physico-chemical properties of water, standard method prescribed in limnological literature were used. Temperature, pH, Transparency, Depth and Dissolved oxygen (DO) were determined at the site, while other parameters like Biochemical Oxygen Demand (BOD), Total Hardness, Electrical conductivity (EC), Free Carbon dioxide, Alkalinity, Chloride, Nitrate and Phosphate were determined in the laboratory. The physico-chemical parameters were determined by standard methods (Golterman 1978, Welch 1998, APHA 2005).

Temperature

Water temperature is a physical property expressing how hot and cold water is. In limnological studies, water temperature is often required. Temperature was measured with mercury filled Celsius- thermometer with least count of 0.1 degree centigrade.

Depth

Water depth is important as a determinant of volume and therefore flushing rate. Depth was measured by standard graduated tape. A weight was tied on the lower end of tape. The graduated tape was dipped into the full depth of river and depth was measured by the wet length in Cm.

Turbidity

Turbidity is the cloudiness or haziness of a fluid. Turbidity in natural waters is caused by suspended matter like clay, organic matter, phytoplankton and other microscopic organisms.

Turbidity in terms of transparency was determined by sacchi disc method at sample sites. A circular metal disc of 20 Cm. and diameter was prepared with two white and two black equal quadrants alternatively, on the upper surface. To eliminate the possibility of reflection of light from the other side. It was painted black on the middle of the upper surface. A hook was soldered to tie a long wide plastic string and an opposite surface a heavy iron rod was fixed. This extra weight helped in the immersion of disc in water. The disc was dipped into water with the help of tagged thread and the point of its disappearance was noted. It was then gradually lifted till also disappeared. The point of its reappearance was recorded. The turbidity was calculated by these two readings.

Transparency (Cm.) = d_1+d_2/ 2

Where

d_1 = depth when sacchi disc disappeared.

d_2 = depth when sacchi disc reappeared.

In the laboratory turbidity was measured by the digital turbidity meter (Nephelometer). In this method the intensity of light scattered by a sample and standard reference under same conditions is compared. For this 5 ml. of hexa methylene tetramine solution (10%) was diluted to 1000 ml. 10 ml. of this solution is diluted to 400 ml. forming turbidity standard. Result is expressed in NTU.

Hydrogen ion concentration (pH)

The pH of the solution refers to its Hydrogen ion activity and is expressed as logarithm of reciprocal of hydrogen ion concentration in mole per litre at given temperature. pH is the “intensity” factor of acidity, pH scale ranges from 0-14 with midpoint 7 as a neutral point, below and above is acidic or alkaline respectively. The pH is an important factor in water chemistry since it enters into the calculation of acidity and alkalinity and process such as coagulation, disinfection, softening and corrosion control.

The pH value was measured by digital pH meter. The pH metre is an electrical device that determines the acidity or basicity of aqueous solutions, one of the most commonly monitored parameters. The pH electrode was first calibrated with standard buffer solutions with known pH values (4, 7 and 8.8) that span the range being measured.

To make a pH measurement, the electrode was immersed into the sample solution until a steady reading is reached. The electrode was then rinsed after each sample measurement.

Alkalinity

Alkalinity is a measure of water's buffering capacity or its ability to resist changes in pH upon the addition of acids or bases. Alkalinity of natural waters is due primarily to the presence of weak acid salts although strong bases may also contribute in extreme environment.

The estimation of based on simple acidimetric titration using different indicators which work in alkaline pH range (above 8.2) or in acidic range (below 6.0). The alkalinity of water is due to presence of carbonate, bicarbonate and hydroxide compounds of calcium, magnesium, sodium and potassium, etc. Phenolphthalein and methyl orange indicators were used for alkalinity titrations.

To determine the carbonate alkalinity or hydroxide alkalinity, 100 ml. of water after adding 2-3 drops of phenolphthalein indicator was titrated against N/ 50 till the pink colour was disappeared. The amount of acid used gave the value of carbonate or hydroxide alkalinity.

For bicarbonate determination, methyl orange indicator (2-3 drop) was added to the same beaker and the titrate (N/ 50 H_2SO_4) was mixed from the same pipette till the end point reached. Showing bicarbonate present in the sample.

Calculation

Mg $CaCO_3$ (mg/ L.) = Total standard acid × 100/ ml. of sample

Hardness

Hardness is a measurement of the mineral content in a water sample. Total hardness is determined by the multivalent cations concentration present in water specially Ca^{++}, Mg^{++}, etc.

Erichrome black 'T' forms wine red complex compound with metal ion. Thedi-sodium salt EDTA (ethylene diamine tetra acetic acid) extracts the metal ions from the dye metal ion complex as colourless chelate complexes leaving a blue coloured aqueous solution of the dye.

50 ml. of sample was taken and into it 2 ml. ammonia buffer solution and a pinch of erichrome black "T" was added as an indicator. Titrated it with EDTA solution until blue colour appeared.

Calculation

Total Hardness (mg/ L.) = ml. of titrate ×1000/ Volume of sample

Free Carbon Dioxide

Free carbon dioxide is the most dynamic of the constituents of dissolved inorganic carbon and is the dominant acid in most natural waters. The ratio of CO_2 to $HCO3^-$ and CO_3^{-2} is the major control of pH in most natural waters.

Free carbon dioxide was measured by titration method (APHA 2005) in the laboratory. 50 ml. of sample water was taken and few drops of phenolphthalein indicator were used and titrated with sodium hydroxide until pink colour appeared.

Calculation

Free CO_2 (mg/ L.) = (V_t× 1000) / Vs

Where

V_t = Volume of titrant

V_s = Volume of sample (ml.)

Dissolved oxygen (DO)

Dissolved oxygen is the amount of oxygen that is present in water. It is of prime importance to all living organisms and is considered to be the lone factor, which a greater extent can reveal the nature of whole aquatic system.

The mangnous sulphate reacts with the alkaline potassium hydroxide, which in the presence of oxygen gets oxidized to brown colour compound. In the strong acid medium mangnaic ions were reduced by iodine ions, which get converted to iodine equivalent to the original concentration of oxygen in the sample. The liberated iodine can be titrated against sodium thiosulphate using starch as an indicator.

$MnSo_4 + 2KOH \longrightarrow Mn(OH)_2 + K_2SO_4$

$2\ Mn(OH)_2 + O_2 \longrightarrow 2Mn(OH)_3$

$Mn(SO_4)_2 + 2KI \longrightarrow MnSO_4 + K_2SO_4$

$2\ NaS_2O_3 + I_2 \longrightarrow Na_2S_4O_6 + 2NaI$

The sample have collected in 300 ml. BOD bottle. 2 ml. mangnous sulphate (36%) and 2 ml. alkaline potassium iodine solution (100 gm. KOH and 50 gm KI in 200 ml. distilled water) was added to the sample and was shacked. The precipitate was allowed to settle, then 2 ml. concentrate H_2SO_4 is added, was shacked well till the precipitate dissolved. Titrated the liberated I_2 with 0.025 $Na_2S_2O_3$ (sodium thiosulphate) using starch as an indicator.

Calculation

Dissolved oxygen (mg/ L.) = $V_1 \times N \times 8 \times 1000 / V_2$

Where

V_1 = Volume of $Na_2S_2O_3$

N = Normality of $Na_2S_2O_3$

V2 = Volume of sample used

Chloride

Chloride is usually present in low concentration in natural waters and play metabolically active role in photolysis of water. Their high concentrations are considered as the indicators on pollution from animal origin as animal excretion contains with lots of chloride salts. Free chloride, which is commonly used as a disinfectant for drinking and waste water, soon gets either converted into chlorides or combines with matter to form toxic compounds.

In portable water the salty test was produced by chloride ion concentration. The chloride ions are determined by the titration with standard silver nitrate solution in which silver chloride precipitates out. The end point of the titration was indicated by the formation of red silver chromate from excess silver nitrate. The potassium chromate was used as an indicator in neutral to slightly alkaline solution.

50 ml. of sample was taken and 1 to 2 drops of potassium chromate solution was added as an indicator and titrated with silver nitrate solution until pinkish yellow colour appears. Standardize silver nitrate titrant and establish reagent blank value by the titration method outline above. A blank of 0.2 to 0.3 ml. was usual.

Calculation

Chloride (mg/ L.) = Reading of titrate× 500/ Volume of sample

Total Dissolved Solids (TDS)

Total dissolved solids represents the total concentration of dissolved substances in water. Common inorganic salts that can be found in water include calcium, magnesium, potassium and sodium (which are all cations) and carbonates, nitrates, bicarbonates, chlorides and sulfates (which are all anions).

Total dissolved solid was determined as the residue left after evaporation of filtered sample. For determination of total dissolved solid and evaporating dish of suitable size was taken and weighed. The unfiltered 50 ml. of the sample was taken in evaporating dish. This was evaporated on a water bath and the final weigh taken, it was the value of TDS in mg/ L.

Calculation

TDS (mg/ L.) = (A- B × 1,000) / V

Where

A = final weight of evaporating dish in mg.

B = Initial weight of evaporating dish in mg.

V = Volume of sample taken in ml.

S = Volume of sample in ml.

Biological Oxygen Demand (BOD)

Biological oxygen demand is the amount of oxygen required by the micro-organism in stabilizing the biological degradable organic matter under aerobic conditions. Biological oxygen demand was measured of the degraded organic material present in water sample.

The principle of the method involves measuring the differences of the oxygen concentration between the sample before and after incubation for 3 days at 27^0C.

Two BOD bottles were taken and filled fully with sample up to the neck. One of the bottle was placed in incubator for 3 days at 27^0C and in the second BOD bottle, initial BOD was determined by fixing it with 1 ml. of alkali azide and 1 ml. of magnous sulphate. Then 2 ml. of concentrate H_2SO_4 was added so that the precipitate gets settle down. Now 200 ml. of this sample was taken and titrated with sodium thiosulphate by adding starch as an indicator, till the sample becomes colourless. BOD bottle have taken out after 3 days from the incubator and the final BOD is determined using the same procedure.

Calculation

BOD (mg/ L.) = $(D_0 - D_3)$

Where

D_0 = Initial D_0 in the sample

D_3 = Final D_0 after 3 days at 27°C

Nitrate

Nitrate is the most oxidized form of nitrogen and is an important plant nutrient. In a system approaching higher trophic levels the organic material or metabolic waste descend to deeper waters where, nitrogen which does not get lost to the sediments is remineralized to nitrates via bacterial oxidative process by nitrifying bacteria.

The reaction between nitrate and phenol disulphonic acid results in formation of 6 nitro 1, 2, 4 phenol disulphonic acid which on conversion to the alkaline salt yield yellow colour.

100 ml. of sample was taken. It was heated to dryness in water bath, 2 ml. of phenol disulphonic acid, 100 ml. of distilled water was added. Now 6-7 ml. of ammonium solution was again added. Yellow colour appeared which can be measured spectrophotometrically at 410 nm and was compared against the calibration curve drawn for various known concentrations.

Phosphates

Phosphates, which are readily taken up by the phytoplankton, often deplete rapidly becoming the first limiting nutrient. It is essential compound for plant life, but when there is too much in water, it can speed up eutrophication (a reduction in dissolved oxygen in water bodies caused by an increase of mineral and organic nutrients) of rivers.

Phosphate in an acidified ammonium molybdate solution produced blue colour with stannous chloride was added. This colour was measured by spectrophotometer at 690 nm.

50 ml. of sample was taken and 2 ml. of ammonium molybdate solution and 1 ml. of stannous chloride solution were added to it. The blue colour appeared for some time and then the reading was taken on spectrophotometer at 690 nm and compared against the calibration curve drawn for various known concentration.

Calculation

Phosphate (mg/ L.) = Graph reading × 1000 × dilution factor /Volume of sample

Electrical conductivity (EC)

Electrical conductivity is a measure of water's capability to pass electrical flow. This ability is directly related to the concentration of ions in the water. These conductive ions come from dissolved salts and inorganic materials such as alkali, chlorides, sulfides, and carbonate compounds. Pure water is a bad conductor of electricity. Acids, bases and salts present in water make it comparatively good conductor of electricity.

An electrical conductivity meter measures the electrical conductivity. Conductivity could in principal be determined using the distance between the electrodes and their surface area using Ohm's law but generally, for accuracy, a calibration is employed using electrolytes of well-known conductivity.

The temperature of sample was noted and the temperature compensation knob of the conductivity meter was adjusted to the temperature of the sample. Keep the selector switch to ×1000 and calibrate to CAL mark. Dip the conductivity cell in the sample contained in a beaker and connect the cell terminals to the sockets provided in the instrument. If meter showed negligible deflection, disconnect the cell terminals. Move the selector switch to ×100 and calibrate to CAL mark. Reconnect the cell terminals and note the deflection. If it was still negligible, disconnect the cell and move the selector switch to ×10.

Calculation

EC (S) = DR × SS

Where

EC = Electrical conductivity

DR = Dial reading

SS = Value of selector switch.

In meters not provided with selector switch and temperature compensation knob, EC is computed as follows:

EC(S) = OEC× CC× TF at 25°C

Where

OEC = Observed conductance

CC = Cell constant (supplied by the manufacturer)

TF = Temperature factor

BIOLOGICAL ANALYSIS

Phytoplankton

Phytoplankton samples were collected during early morning on seasonally basis from each sampling site during the study period from October 2018 to September 2020 (pre monsoon, monsoon and post monsoon season). The phytoplankton samples were collected by filtering 100 L. of water through standard plankton net made up of bolting silk (No. 25; mesh size 70 µm). The concentrated plankton biomass of 100 L. sample water was transferred to a 30 ml. plastic bottle with labeled monitoring time and sampling site details. For further qualitative analysis in laboratory preserved with 5% formalin. These samples were examined under high power microscope.

The collected phytoplankton species were identified with the help of standard keys of Edmondson (1992), Needham and Needham (1978) and APHA (2005) up to the generic and species level.

Zooplankton

Zooplankton samples were collected during early morning on seasonally basis from each sampling site during the study period from October 2018 to September 2020 (pre monsoon, monsoon and post monsoon season). 100 L. of water sampled from different areas and depths of the river was filtered through plankton net made up of bolting silk (No. 25; mesh size 150 µm) and the plankton biomass were transferred to the specimens bottles (pre filled with 5% formalin) and subjected to microscopic analysis. The zooplankton was segregated group wise like Rotifer, Cladocera, Copepod, Ostracoda, etc. They were separated under a binocular stereo zoom dissection microscope using a fine needle and brush.

The identification of zooplankton was made by using standard keys of Michael and Sharma (1998), Sharma and Sharma (2008) and Altaff (2004) up to the generic and species level.

Fishes

Specimens of fishes were procured from different selected localities during the study period of October 2018 to September 2020, once in a month of the entire fishing season. The help of local marketers and fishermen who were using different types of nets namely gillnets, castnets, encircling nets and dragnets were taken. Fish markets were also regularly visited and the common species noted.

Immediately after procurement of the specimens, photographs were taken prior to preservation since formalin decolorizeed the fish. Formalin solution was prepared by diluting one part of concentrated formalin (commercial formaldehyde) with four parts of water like 5% formalin. Fishes brought to the lab were fixed in this solution in separate jars according to the size of species. Smaller fishes were directly placed in the formalin solution while larger fishes were preserved with an injection of preservative into the visceral cavity slitting of the abdomen for about 25% of body length, before they were labeled giving serial number tag bearing certain information such as collection site, date, time, weight, length, etc.

Identification of collected specimens was done using keys Day (1889), Jayaram (1999), Srivastava (1980), Talwar and Jhingran (1991) for fishes of the Indian subcontinent. The identification of the species was done mainly on the basis of the colour pattern, specific spots or marks on the surface of the body, shape of the body, structure of various fins, etc. and also with the help of taxonomic expertise.

Banthic Fauna

Banthic communities along the river were sampled seasonally from October 2018 to September 2020 at each of the four sites using D- net. The samples were collected by a bottom kick net (500 µm mesh). The samples were taken from an area of nearly 100 square meter in order to include all possible micro habitats at each site. In some areas with the presence of large stones, these were first picked out and washed into the kick net to remove pupae and other attached macro invertebrates. In addition, macro invertebrate samples were separated from the macrophytes and the sediment using sieves (250 µm).

All the animals collected were immediately fixed in formaldehyde (5%) in the field and then transferred to 70% ethyl alcohol. The macro invertebrates were preserved in 80% ethanol before laboratory identification. In the laboratory, the sample rinsed with the tap water to remove the preservative and then sorted, identified to the lowest possible taxon (species, genus or families) with the help of stereomicroscope.

Identification of benthic macro invertebrates with the help of standard books Needham and Needham (1969), Pennak (1989), Tonapi (1980), Welch (1998) and APHA (2005).

Macrophytes

Macrophytes samples were collected during early morning on seasonally basis from each sampling site during the study period from October 2018 to September 2020 (pre monsoon, monsoon and post monsoon season).

Macrophytes were collected by hand picking from the littoral one and exposed marginal areas of the river. For the deeper side a boat was hired in order to collect the macrophytes further than iron hook. The samples collected were immediately washed out to get rid from all adhering materials and were stored properly in polythene bags. Soon after collection all macrophytes species brought to laboratory.

The identification of macrophytes was done with the help of standard books, monographs and identification keys given by Adoni (1985), Cook (1996), Fasett (2000).

Observation and Results

CHAPTER- IV

OBSERVATION AND RESULTS

The present study was conducted in the two years from October 2018 to September 2020. Four study sites of Chandloi River were selected for the present research work.

Site1- Two ghats are located in towards East. These ghats are used for human activity such as bathing, washing cloths, etc.

Site 2- Another site is situated in the western side of the river, which is rather undisturbed site.

Site 3- Near origin of river.

Site 4- Near the entering into Chambal River.

Details of observations of physico-chemical parameters are as follows:

WATER TEMPERATURE

SITE 1

From October 2018 to September 2019, the water temperature was recorded from 16.9^{0}C to 25.2^{0}C. The minimum water temperature recorded was 16.9^{0}C in Post Monsoon and maximum was 25.2^{0}C in Pre Monsoon season. The average water temperature through the year was 22.1^{0}C with a Standard Deviation of 4.51. During October 2019 to September 2020 this fluctuation was between 16.4^{0}C and 23.6^{0}C. The minimum water temperature was 16.4^{0}C in Post Monsoon and maximum was 23.6^{0}C in monsoon. The average water temperature throughout the year was 21.2^{0}C with a Standard Deviation of 4.13 (Table 01, 02).

SITE 2

From October 2018 to September 2019, the water temperature was recorded from 16.5^{0}C to 24.9^{0}C. The minimum water temperature recorded was 16.5^{0}C in Post

Monsoon and maximum was 24.9^{0}C in Pre Monsoon season. The average water temperature through the year was 21.8^{0}C with a Standard Deviation of 4.64. During October 2019 to September 2020 this fluctuation was between 15.8^{0}C and 23.5^{0}C. The minimum water temperature was 15.8^{0}C in Post Monsoon and maximum was 23.5^{0}C in monsoon. The average water temperature throughout the year was 20.8^{0}C with a Standard Deviation of 4.36 (Table 01, 02).

SITE 3

From October 2018 to September 2019, the water temperature was recorded from 15.9^{0}C to 24.3^{0}C. The minimum water temperature recorded was 15.9^{0}C in Post Monsoon and maximum was 24.3^{0}C in Pre Monsoon season. The average water temperature through the year was 21.2^{0}C with a Standard Deviation of 4.66. During October 2019 to September 2020 this fluctuation was between 15.5^{0}C and 22.8^{0}C. The minimum water temperature was 15.5^{0}C in Post Monsoon and maximum was 22.8^{0}C in Monsoon. The average water temperature throughout the year was 20.2^{0}C with a Standard Deviation of 4.05 (Table 01, 02).

SITE 4

From October 2018 to September 2019, the water temperature was recorded from 17.5^{0}C to 25.6^{0}C. The minimum water temperature recorded was 17.5^{0}C in Post Monsoon and maximum was 25.6^{0}C in Pre Monsoon season. The average water temperature through the year was 22.5^{0}C with a Standard Deviation of 4.39. During October 2019 to September 2020 this fluctuation was between 16.6^{0}C and 24.2^{0}C. The minimum water temperature was 16.6^{0}C in Post Monsoon and maximum was 24.2^{0}C in monsoon. The average water temperature throughout the year was 21.6^{0}C with a Standard Deviation of 4.30 (Table 01, 02).

DEPTH

SITE 1

In the study period from October 2018 to September 2019, the depth of River was fluctuated between 136 Cm. to 308.75 Cm., minimum in Pre Monsoon and maximum in Monsoon season with an average depth of 208.67 Cm. and Standard

Deviation of 89.58. During October 2019 to September 2020 this fluctuation was 136 Cm. to 310.25 Cm., minimum in Pre Monsoon and maximum in Monsoon with an average depth of 209.17 Cm. and Standard Deviation of 90.42 (Table 03, 04).

SITE 2

In the study period from October 2018 to September 2019, the depth of River was fluctuated between 112 Cm. to 298 Cm., minimum in Pre Monsoon and maximum in Monsoon season with an average depth of 181.5 Cm. and Standard Deviation of 101.52. During October 2019 to September 2020 this fluctuation was 112 Cm. to 300.5 Cm., minimum in Pre Monsoon and maximum in Monsoon with an average depth of 182.33 Cm. and Standard Deviation of 102.95 (Table 03, 04).

SITE 3

In the study period from October 2018 to September 2019, the depth of River was fluctuated between 92.25 Cm. to 277.25 Cm., minimum in Post Monsoon and maximum in Monsoon season with an average depth of 157.25 Cm. and Standard Deviation of 104.04. During October 2019 to September 2020 this fluctuation was 94.75 Cm. to 277.25 Cm., minimum in Post Monsoon and maximum in Monsoon with an average depth of 158.08 Cm. and Standard Deviation of 102.36 (Table 03, 04).

SITE 4

In the study period from October 2018 to September 2019, the depth of River was fluctuated between 133.75 Cm. to 302.25 Cm., minimum in Pre Monsoon and maximum in Monsoon season with an average depth of 206.33 Cm. and Standard Deviation of 86.64. During October 2019 to September 2020 this fluctuation was 133.75 Cm. to 304.75 Cm., minimum in Pre Monsoon and maximum in Monsoon with an average depth of 205.33 Cm. and Standard Deviation of 88.83 (Table 03, 04).

TURBIDITY

SITE 1

In the study period from October 2018 to September 2019, the turbidity between 11.8 to 25.3 NTU, minimum in Pre Monsoon and maximum in Monsoon season with an average turbidity of 16.7 NTU and Standard Deviation of 7.47. During October 2019 to September 2020 this fluctuation was 11.3 to 25.5 NTU, minimum in Pre Monsoon and maximum in Monsoon with an average turbidity of 16.3 NTU and Standard Deviation of 8.00 (Table 05, 06).

SITE 2

In the study period from October 2018 to September 2019, the turbidity between 10.0 to 24.0 NTU, minimum in Pre Monsoon and maximum in Monsoon season with an average turbidity of 15.6 NTU and Standard Deviation of 7.41. During October 2019 to September 2020 this fluctuation was 10.5 to 23.5 NTU, minimum in Pre Monsoon and maximum in Monsoon with an average turbidity of 15.1 NTU and Standard Deviation of 7.29 (Table 05, 06).

SITE 3

In the study period from October 2018 to September 2019, the turbidity between 8.5 to 23.5 NTU, minimum in Pre Monsoon and maximum in Monsoon season with an average turbidity of 14.0 NTU and Standard Deviation of 8.26. During October 2019 to September 2020 this fluctuation was 9.3 to 22.5 NTU, minimum in Pre Monsoon and maximum in Monsoon with an average turbidity of 14.1 NTU and Standard Deviation of 7.30 (Table 05, 06).

SITE 4

In the study period from October 2018 to September 2019, the turbidity between 13.0 to 26.8 NTU, minimum in Pre Monsoon and maximum in Monsoon season with an average turbidity of 18.1 NTU and Standard Deviation of 7.57. During October 2019 to September 2020 this fluctuation was 12.8 to 25.3 NTU, minimum in Pre Monsoon and maximum in Monsoon with an average turbidity of 17.2 NTU and Standard Deviation of 7.02 (Table 05, 06).

pH (HYDROGEN ION CONCENTERATION)

SITE 1

During October 2018 to September 2019, the Hydrogen ion concentration (pH) was fluctuated between 8.3 to 8.6, minimum in Monsoon and maximum in Post Monsoon season with an average pH of 8.5 and Standard Deviation of 0.15. During October 2019 to September 2020 this fluctuation was 8.4 to 8.6, minimum in Monsoon and maximum in Pre Monsoon with an average pH of 8.5 and Standard Deviation of 0.10 (Table 07, 08).

SITE 2

In the study period from October 2018 to September 2019, the Hydrogen ion concentration (pH) was fluctuated between 8.1 to 8.6, minimum in Monsoon and maximum in Post Monsoon season with an average pH of 8.3 and Standard Deviation of 0.25. During October 2019 to September 2020 this fluctuation was 8.2 to 8.4, minimum in Monsoon and maximum in Post Monsoon with an average pH of 8.3 and Standard Deviation of 0.10 (Table 07, 08).

SITE 3

In the study period from October 2018 to September 2019, the Hydrogen ion concentration (pH) was fluctuated between 8.2 to 8.4, minimum in Monsoon and maximum in Pre Monsoon season with an average pH of 8.3 and Standard Deviation of 0.10. During October 2019 to September 2020 this fluctuation was 8.0 to 8.6, minimum in Monsoon and maximum in Pre Monsoon with an average pH of 8.2 and Standard Deviation of 0.32 (Table 07, 08).

SITE 4

During October 2018 to September 2019, the Hydrogen ion concentration (pH) was fluctuated between 9.0 to 9.2, minimum in Post Monsoon and maximum in Pre Monsoon season with an average pH of 9.1 and Standard Deviation of 0.10. During October 2019 to September 2020 this fluctuation was 9.0 to 9.1, minimum in both Pre Monsoon and Monsoon season and maximum in Post Monsoon with an average pH of 9.0 and Standard Deviation of 0.00 (Table 07, 08).

ALKALINITY

SITE 1

In the study period from October 2018 to September 2019, the alkalinity value between 125.53 mg/ L. to 135.48 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon season with an average alkalinity value of 128.90 mg/ L. and Standard Deviation of 5.70. During October 2019 to September 2020 this fluctuation was 203.85 mg/ L. to 384.5 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average alkalinity value of 285.62 and Standard Deviation of 91.53 (Table 09, Table 10).

SITE 2

In the study period from October 2018 to September 2019, the alkalinity value between 122.9 mg/ L. to 131.8 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average alkalinity value of 126.14 mg/ L. and Standard Deviation of 4.92. During October 2019 to September 2020 this fluctuation was 197.98 mg/ L. to 381.73 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average alkalinity value of 281.07 and Standard Deviation of 93.13 (Table 09, Table 10).

SITE 3

In the study period from October 2018 to September 2019, the alkalinity value between 119.9 mg/ L. to 127.5 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average alkalinity value of 123.31 mg/ L. and Standard Deviation of 3.86. During October 2019 to September 2020 this fluctuation was 196.1 mg/ L. to 375.25 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average alkalinity value of 275.46 and Standard Deviation of 91.31 (Table 09, Table 10).

SITE 4

In the study period from October 2018 to September 2019, the alkalinity value between 127.4 mg/ L. to 140.05 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon season with an average alkalinity value of 132.14 mg/ L. and Standard Deviation of 6.89. During October 2019 to September 2020 this fluctuation was 208.53 mg/ L. to 396.3 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average alkalinity value of 296.11 and Standard Deviation of 93.52 (Table 09, Table 10).

HARDNESS

SITE 1

In the study period from October 2018 to September 2019, the hardness value between 125.78 mg/ L. to 136.73 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average hardness value of 129.47 mg/ L. and Standard Deviation of 6.29. During October 2019 to September 2020 this fluctuation was 126.2 mg/ L. to 136.5 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average hardness value of 129.84 mg/ L. and Standard Deviation of 5.77 (Table 11, Table 12).

SITE 2

In the study period from October 2018 to September 2019, the hardness value between 124.87 mg/ L. to 134 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average hardness value of 128.02 mg/ L. and Standard Deviation of 5.18. During October 2019 to September 2020 this fluctuation was 124.85 mg/ L. to 134.55 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average hardness value of 128.39 mg/ L. and Standard Deviation of 5.35 (Table 11, Table 12).

SITE 3

In the study period from October 2018 to September 2019, the hardness value between 123.4 mg/ L. to 133.65 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average hardness value of 127 mg/ L. and Standard Deviation of 5.77. During October 2019 to September 2020 this fluctuation was

123.83 mg/ L. to 133.33 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average hardness value of 127.10 mg/ L. and Standard Deviation of 5.39 (Table 11, Table 12).

SITE 4

In the study period from October 2018 to September 2019, the hardness value between 126.88 mg/ L. to 139.5 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average hardness value of 131.11 mg/ L. and Standard Deviation of 7.27. During October 2019 to September 2020 this fluctuation was 127.85 mg/ L. to 139.33 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average hardness value of 131.76 mg/ L. and Standard Deviation of 6.56 (Table 11, Table 12).

FREE CARBON DIOXIDE (CO_2)

SITE 1

In the study period from October 2018 to September 2019, the free CO_2 value between 0.53 mg/ L. to 1.2 mg/ L., minimum in Post Monsoon and maximum in Monsoon season with an average CO_2 value of 0.97 mg/ L. and Standard Deviation of 0.38. During October 2019 to September 2020 this fluctuation was 0.53 mg/ L. to 1.2 mg/ L., minimum in Post Monsoon and maximum in Monsoon with an average CO_2 value of 0.94 and Standard Deviation of 0.36 (Table 13, Table 14).

SITE 2

In the study period from October 2018 to September 2019, the free CO_2 value between 0.55 mg/ L. to 2.28 mg/ L., minimum in Post Monsoon and maximum in Monsoon season with an average CO_2 value of 1.51 mg/ L. and Standard Deviation of 0.88. During October 2019 to September 2020 this fluctuation was 0.6 mg/ L. to 2.35 mg/ L., minimum in Post Monsoon and maximum in Monsoon with an average CO_2 value of 1.52 and Standard Deviation of 0.88 (Table 13, Table 14).

SITE 3

In the study period from October 2018 to September 2019, the free CO_2 value between 0.68 mg/ L. to 2.33 mg/ L., minimum in Post Monsoon and maximum in Monsoon season with an average CO_2 value of 1.40 mg/ L. and Standard Deviation of 0.84. During October 2019 to September 2020 this fluctuation was 0.68 mg/ L. to 2.35 mg/ L., minimum in Post Monsoon and maximum in Monsoon with an average CO_2 value of 1.37 and Standard Deviation of 0.87 (Table 13, Table 14).

SITE 4

In the study period from October 2018 to September 2019, the free CO_2 value between 0.45 mg/ L. to 1.25 mg/ L., minimum in Post Monsoon and maximum in Monsoon season with an average CO_2 value of 0.90 mg/ L. and Standard Deviation of 0.41. During October 2019 to September 2020 this fluctuation was 0.5 mg/ L. to 1.35 mg/ L., minimum in Post Monsoon and maximum in Monsoon with an average CO_2 value of 0.97 and Standard Deviation of 0.43 (Table 13, Table 14).

DISSOLVED OXYGEN (DO)

SITE 1

In the study period from October 2018 to September 2019, the DO value between 4.96 mg/ L. to 5.9 mg/ L., minimum in both Pre and Post monsoon, maximum in Monsoon season with an average DO value of 5.27 mg/ L. and Standard Deviation of 0.54. During October 2019 to September 2020 this fluctuation was 4.88 mg/ L. to 5.98 mg/ L., minimum in Pre Monsoon and maximum in Monsoon with an average DO value of 5.29 and Standard Deviation of 0.60 (Table 15, Table 16).

SITE 2

In the study period from October 2018 to September 2019, the DO value between 5.73 mg/ L. to 7.03 mg/ L., minimum in Pre Monsoon and maximum in Monsoon season with an average DO value of 6.35 mg/ L. and Standard Deviation of 0.65. During October 2019 to September 2020 this fluctuation was 5.68 mg/ L. to 7.1 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon with an average DO value of 6.60 and Standard Deviation of 0.80 (Table 15, Table 16).

SITE 3

In the study period from October 2018 to September 2019, the DO value between 6.43 mg/ L. to 7.33 mg/ L., minimum in Pre Monsoon and maximum in Monsoon season with an average DO value of 6.95 mg/ L. and Standard Deviation of 0.46. During October 2019 to September 2020 this fluctuation was 6.56 mg/ L. to 7.1 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon with an average DO value of 6.86 and Standard Deviation of 0.28 (Table 15, Table 16).

SITE 4

In the study period from October 2018 to September 2019, the DO value between 4.13 mg/ L. to 5.3 mg/ L., minimum in Pre Monsoon and maximum in Monsoon season with an average DO value of 4.70 mg/ L. and Standard Deviation of 0.59. During October 2019 to September 2020 this fluctuation was 3.98 mg/ L. to 5.18 mg/ L., minimum in Pre Monsoon and maximum in Monsoon with an average DO value of 4.55 and Standard Deviation of 0.60 (Table 15, Table 16).

CHLORIDE

SITE 1

In the study period from October 2018 to September 2019, the Chloride value between 83.05 mg/ L. to 137.1 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average Chloride value of 108.51 mg/ L. and Standard Deviation of 26.95. During October 2019 to September 2020 this fluctuation was 83.63 mg/ L. to 136.6 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average Chloride value of 108.54 mg/ L. and Standard Deviation of 26.63 (Table17, Table 18).

SITE 2

In the study period from October 2018 to September 2019, the Chloride value between 58.18 mg/ L. to 78.8 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average Chloride value of 65.83 mg/ L. and Standard Deviation of 11.29. During October 2019 to September 2020 this fluctuation was 58.5 mg/ L. to 79.05 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average Chloride value of 65.98 mg/ L. and Standard Deviation of 11.36 (Table17, Table 18).

SITE 3

In the study period from October 2018 to September 2019, the Chloride value between 35.4 mg/ L. to 59.1 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average Chloride value of 46.04 mg/ L. and Standard Deviation of 12.03. During October 2019 to September 2020 this fluctuation was 38.38 mg/ L. to 59.13 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average Chloride value of 47.05 mg/ L. and Standard Deviation of 10.79 (Table17, Table 18).

SITE 4

In the study period from October 2018 to September 2019, the Chloride value between 107.45 mg/ L. to 150 mg/ L., minimum in Monsoon and maximum in Pre Monsoon season with an average Chloride value of 133.56 mg/ L. and Standard Deviation of 22.86. During October 2019 to September 2020 this fluctuation was 107.58 mg/ L. to 150.13 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average Chloride value of 133.65 mg/ L. and Standard Deviation of 22.84 (Table17, Table 18).

TOTAL DISSOLVED SOLIDS (TDS)

SITE 1

In the study period from October 2018 to September 2019, the TDS value between 526.38 mg/ L. to 536.2 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon season with an average TDS value of 530.32 mg/ L. and Standard Deviation of 5.19. During October 2019 to September 2020 this fluctuation was 525.43 mg/ L. to 537 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon with an average TDS value of 531.26 mg/ L. and Standard Deviation of 5.79 (Table 19, Table 20).

SITE 2

In the study period from October 2018 to September 2019, the TDS value between 281.7 mg/ L. to 423.63 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average TDS value of 361.18 mg/ L. and Standard Deviation of 72.48. During October 2019 to September 2020 this fluctuation was 301.85 mg/ L. to 425.23 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average TDS value of 352.86 mg/ L. and Standard Deviation of 64.40 (Table 19, Table 20).

SITE 3

In the study period from October 2018 to September 2019, the TDS value between 124.13 mg/ L. to 132.25 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon season with an average TDS value of 128.39 mg/ L. and Standard Deviation of 4.08. During October 2019 to September 2020 this fluctuation was 125.15 mg/ L. to 134.25 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon with an average TDS value of 128.43 mg/ L. and Standard Deviation of 5.05 (Table 19, Table 20).

SITE 4

In the study period from October 2018 to September 2019, the TDS value between 808 mg/ L. to 927.6 mg/ L., minimum in Pre Monsoon and maximum in Monsoon season with an average TDS value of 887.58 mg/ L. and Standard Deviation of 68.92. During October 2019 to September 2020 this fluctuation was 915.75 mg/ L. to 938.4 mg/ L., minimum in Pre Monsoon and maximum in Monsoon with an average TDS value of 925.91 mg/ L. and Standard Deviation of 11.50 (Table 19, Table 20).

BIOLOGICAL OXYGEN DEMAND (BOD)

SITE 1

In the study period from October 2018 to September 2019, the BOD value between 41.03 mg/ L. to 79.05 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average BOD value of 58.23 mg/ L. and Standard Deviation of 19.27. During October 2019 to September 2020 this fluctuation was 46.48 mg/ L. to 86.38 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon with an average BOD value of 61.63 mg/ L. and Standard Deviation of 21.61 (Table 21, Table 22).

SITE 2

In the study period from October 2018 to September 2019, the BOD value between 26.43 mg/ L. to 41.1 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average BOD value of 36.02 mg/ L. and Standard Deviation of 8.31. During October 2019 to September 2020 this fluctuation was 28.85 mg/ L. to 46.13 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average BOD value of 37.25 mg/ L. and Standard Deviation of 8.65 (Table 21, Table 22).

SITE 3

In the study period from October 2018 to September 2019, the BOD value between 7.58 mg/ L. to 20.65 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average BOD value of 13.49 mg/ L. and Standard Deviation of 6.63. During October 2019 to September 2020 this fluctuation was 7.07 mg/ L. to 24.13 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average BOD value of 14.45 mg/ L. and Standard Deviation of 8.76 (Table 21, Table 22).

SITE 4

In the study period from October 2018 to September 2019, the BOD value between 23.9 mg/ L. to 106 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon season with an average BOD value of 78.56 mg/ L. and Standard Deviation of 47.34. During October 2019 to September 2020 this fluctuation was

98.57 mg/ L. to 119.63 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon with an average BOD value of 110.63 mg/ L. and Standard Deviation of 10.86 (Table 21, Table 22).

NITRATE

SITE 1

In the study period from October 2018 to September 2019, the Nitrate value between 60.6 mg/ L. to 83.15 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average Nitrate value of 69.32 mg/ L. and Standard Deviation of 12.11. During October 2019 to September 2020 this fluctuation was 65.05 mg/ L. to 80.65 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average Nitrate value of 71.05 mg/ L. and Standard Deviation of 8.40 (Table 23, Table 24).

SITE 2

In the study period from October 2018 to September 2019, the Nitrate value between 56.95 mg/ L. to 84.4 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average Nitrate value of 70.00 mg/ L. and Standard Deviation of 13.77. During October 2019 to September 2020 this fluctuation was 65.1 mg/ L. to 76.33 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon with an average Nitrate value of 70.25 mg/ L. and Standard Deviation of 5.67 (Table 23, Table 24).

SITE 3

In the study period from October 2018 to September 2019, the Nitrate value between 47.43 mg/ L. to 76.15 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average Nitrate value of 61.10 mg/ L. and Standard Deviation of 14.41. During October 2019 to September 2020 this fluctuation was 54.65 mg/ L. to 71.5 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon with an average Nitrate value of 62.22 mg/ L. and Standard Deviation of 8.56 (Table 23, Table 24).

SITE 4

In the study period from October 2018 to September 2019, the Nitrate value between 74.85 mg/ L. to 100.00 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average Nitrate value of 84.87 mg/ L. and Standard Deviation of 13.33. During October 2019 to September 2020 this fluctuation was 80.93 mg/ L. to 91.68 mg/ L., minimum in Monsoon and maximum in Post Monsoon with an average Nitrate value of 85.48 mg/ L. and Standard Deviation of 5.56 (Table 23, Table 24).

PHOSPHATE

SITE 1

In the study period from October 2018 to September 2019, the Phosphate value between 64.05 mg/ L. to 89.5 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average Phosphate value of 75.58 mg/ L. and Standard Deviation of 12.89. During October 2019 to September 2020 this fluctuation was 64.15 mg/ L. to 74.78 mg/ L., minimum in Post Monsoon and maximum in Pre Monsoon with an average Phosphate value of 68.04 mg/ L. and Standard Deviation of 5.86 (Table 25, Table 26).

SITE 2

In the study period from October 2018 to September 2019, the Phosphate value between 43.93 mg/ L. to 68.13 mg/ L., minimum in Pre Monsoon and maximum in Monsoon season with an average Phosphate value of 58.48 mg/ L. and Standard Deviation of 12.82. During October 2019 to September 2020 this fluctuation was 48.65 mg/ L. to 59.73 mg/ L., minimum in Pre Monsoon and maximum in Monsoon with an average Phosphate value of 55.58 mg/ L. and Standard Deviation of 6.04 (Table 25, Table 26).

SITE 3

In the study period from October 2018 to September 2019, the Phosphate value between 41.45 mg/ L. to 63.38 mg/ L., minimum in Pre Monsoon and maximum in Post Monsoon season with an average Phosphate value of 54.13 mg/ L. and Standard Deviation of 11.36. During October 2019 to September 2020 this fluctuation was 31.68 mg/ L. to 46.6 mg/ L., minimum in Pre Monsoon and maximum in Monsoon with an average Phosphate value of 41.49 mg/ L. and Standard Deviation of 8.50 (Table 25, Table 26).

SITE 4

In the study period from October 2018 to September 2019, the Phosphate value between 84.93 mg/ L. to 87.3 mg/ L., minimum in Monsoon and maximum in Post Monsoon season with an average Phosphate value of 85.79 mg/ L. and Standard Deviation of 1.31. During October 2019 to September 2020 this fluctuation was 79.15 mg/ L. to 89.68 mg/ L., minimum in Monsoon and maximum in Pre Monsoon with an average Phosphate value of 82.72 mg/ L. and Standard Deviation of 6.03 (Table 25, Table 26).

ELECTRIC CONDUCTIVITY (EC)

SITE 1

In the study period from October 2018 to September 2019, the EC value between 199.85 µmhos/ Cm. to 385.35 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon season with an average EC value of 284.71 µmhos/ Cm. and Standard Deviation of 93.75. During October 2019 to September 2020 this fluctuation was 203.85 µmhos/ Cm. to 384.5 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon with an average EC value of 285.62 µmhos/ Cm. and Standard Deviation of 91.53 (Table 27, Table 28).

SITE 2

In the study period from October 2018 to September 2019, the EC value between 197.68 µmhos/ Cm. to 383.25 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon season with an average EC value of 281.39 µmhos/ Cm. and Standard Deviation of 94.11. During October 2019 to September 2020 this fluctuation was 197.98 µmhos/ Cm. to 381.73 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon with an average EC value of 281.07 µmhos/ Cm. and Standard Deviation of 93.13 (Table 27, Table 28).

SITE 3

In the study period from October 2018 to September 2019, the EC value between 195.6 µmhos/ Cm. to 377 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon season with an average EC value of 276.46 µmhos/ Cm. and Standard Deviation of 92.29. During October 2019 to September 2020 this fluctuation was 196.1 µmhos/ Cm. to 375.25 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon with an average EC value of 275.46 µmhos/ Cm. and Standard Deviation of 91.31 (Table 27, Table 28).

SITE 4

In the study period from October 2018 to September 2019, the EC value between 208.2 µmhos/ Cm. to 393.7 µmhos/ Cm., minimum in mansoon and maximum in Pre Monsoon season with an average EC value of 294.81 µmhos/ Cm. and Standard Deviation of 93.36. During October 2019 to September 2020 this fluctuation was 208.53 µmhos/ Cm. to 396.3 µmhos/ Cm., minimum in Monsoon and maximum in Pre Monsoon with an average EC value of 296.11 µmhos/ Cm. and Standard Deviation of 94.52 (Table 27, Table 28).

Table 01: Seasonal fluctuation in water Temperature (^{0}C) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	25.2	24.1	16.9	22.1	16.9	25.2	4.51
Site2	24.9	24.1	16.5	21.8	16.5	24.9	4.64
Site3	24.3	23.6	15.9	21.2	15.9	24.3	4.66
Site4	25.6	24.5	17.5	22.5	17.5	25.6	4.39

Table 02: Seasonal fluctuation in water Temperature (^{0}C) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	23.5	23.6	16.4	21.2	16.4	23.6	4.13
Site2	23.2	23.5	15.8	20.8	15.8	23.5	4.36
Site3	22.2	22.8	15.5	20.2	15.5	22.8	4.05
Site4	23.9	24.2	16.6	21.6	16.6	24.2	4.30

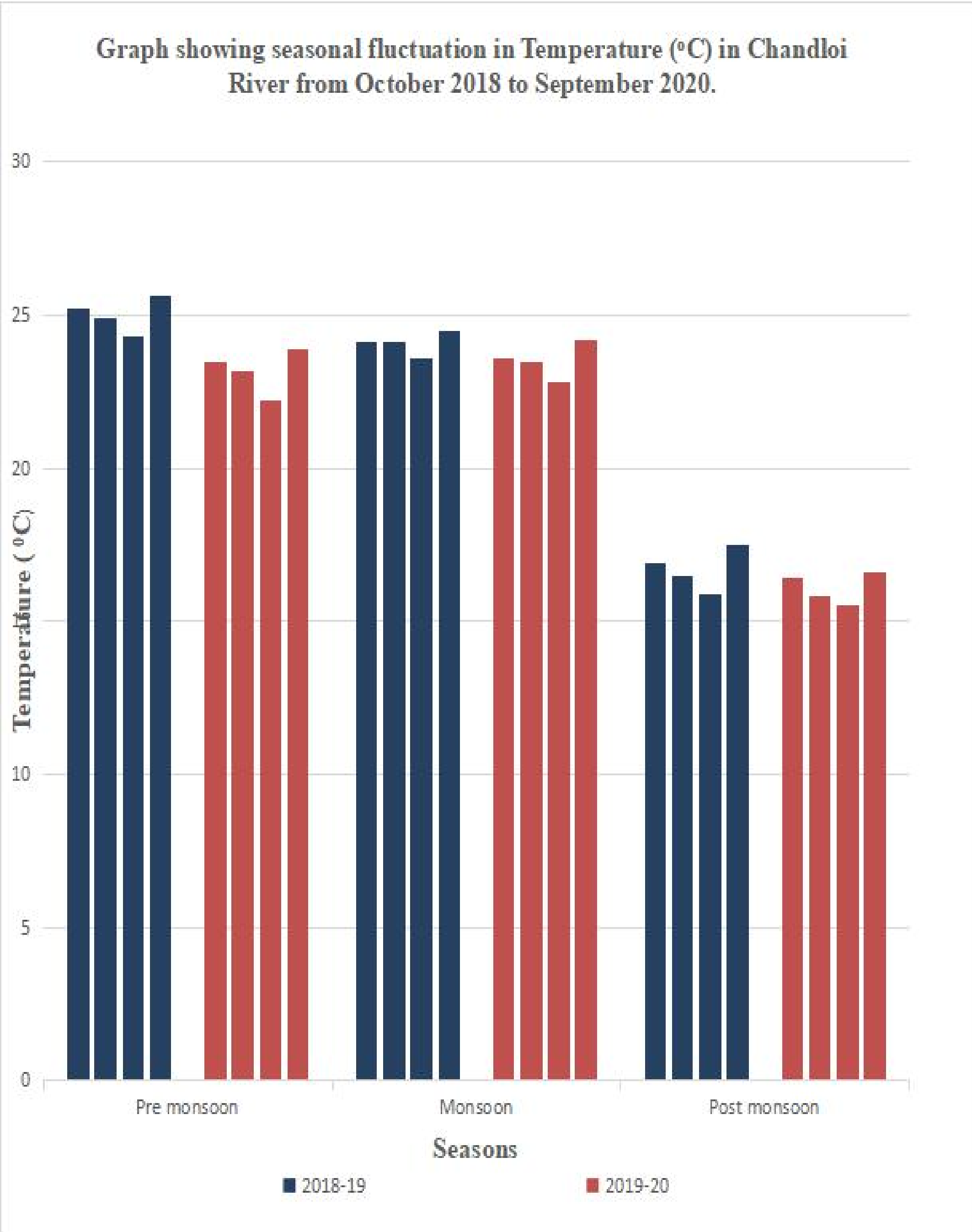

Graph showing seasonal fluctuation in Temperature (°C) in Chandloi River from October 2018 to September 2020.
30
25
20
15
10
5
0
Temperature (°C)
Pre monsoon
Monsoon
Post monsoon
Seasons
2018-19
2019-20

Table 03: Seasonal fluctuation in Depth (Cm.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	136	308.75	181.25	208.67	136	308.75	89.58
Site2	112	298	134.5	181.5	112	298	101.52
Site3	102.25	277.25	92.25	157.25	92.25	277.25	104.04
Site4	133.75	302.25	183	206.33	133.75	302.25	86.64

Table 04: Seasonal fluctuation in Depth (Cm.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	136	310.25	181.25	209.17	136	310.25	90.42
Site2	112	300.5	134.5	182.33	112	300.5	102.95
Site3	102.25	277.25	94.75	158.08	94.75	277.25	102.36
Site4	133.75	304.75	177.5	205.33	133.75	304.75	88.83

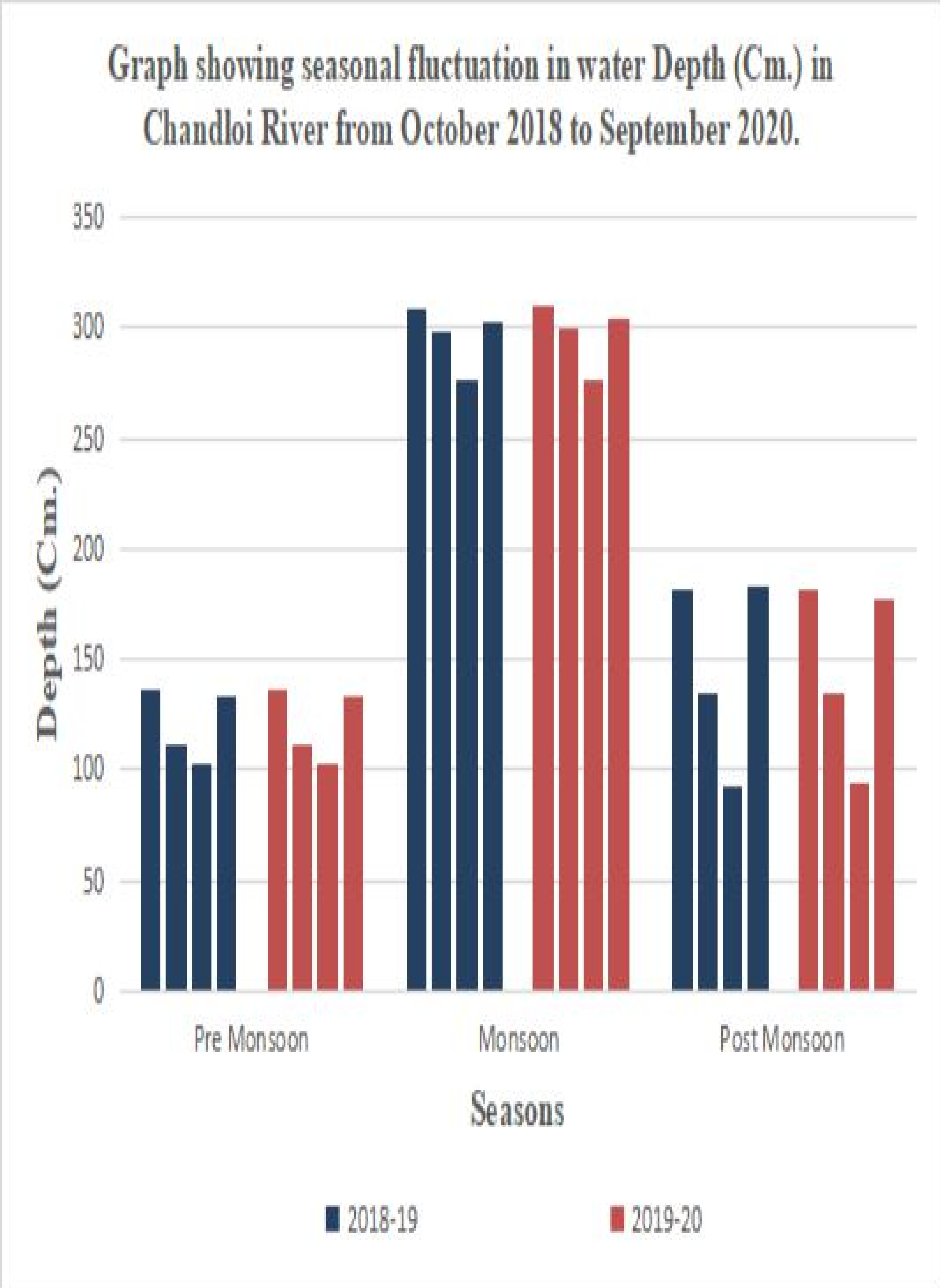

Graph showing seasonal fluctuation in water Depth (Cm.) in Chandloi River from October 2018 to September 2020.
350
300
250
200
150
100
50
0
Depth (Cm.)
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 05: Seasonal fluctuation in Turbidity (NTU) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	11.8	25.3	13	16.7	11.8	25.3	7.47
Site2	10	24	12.8	15.6	10	24	7.41
Site3	8.5	23.5	10	14	8.5	23.5	8.26
Site4	13	26.8	14.5	18.1	13	26.8	7.57

Table 06: Seasonal fluctuation in Turbidity (NTU) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	11.3	25.5	12	16.3	11.3	25.5	8.0
Site2	10.5	23.5	11.3	15.1	10.5	23.5	7.29
Site3	9.3	22.5	10.5	14.1	9.3	22.5	7.30
Site4	12.8	25.3	13.5	17.2	12.8	25.3	7.02

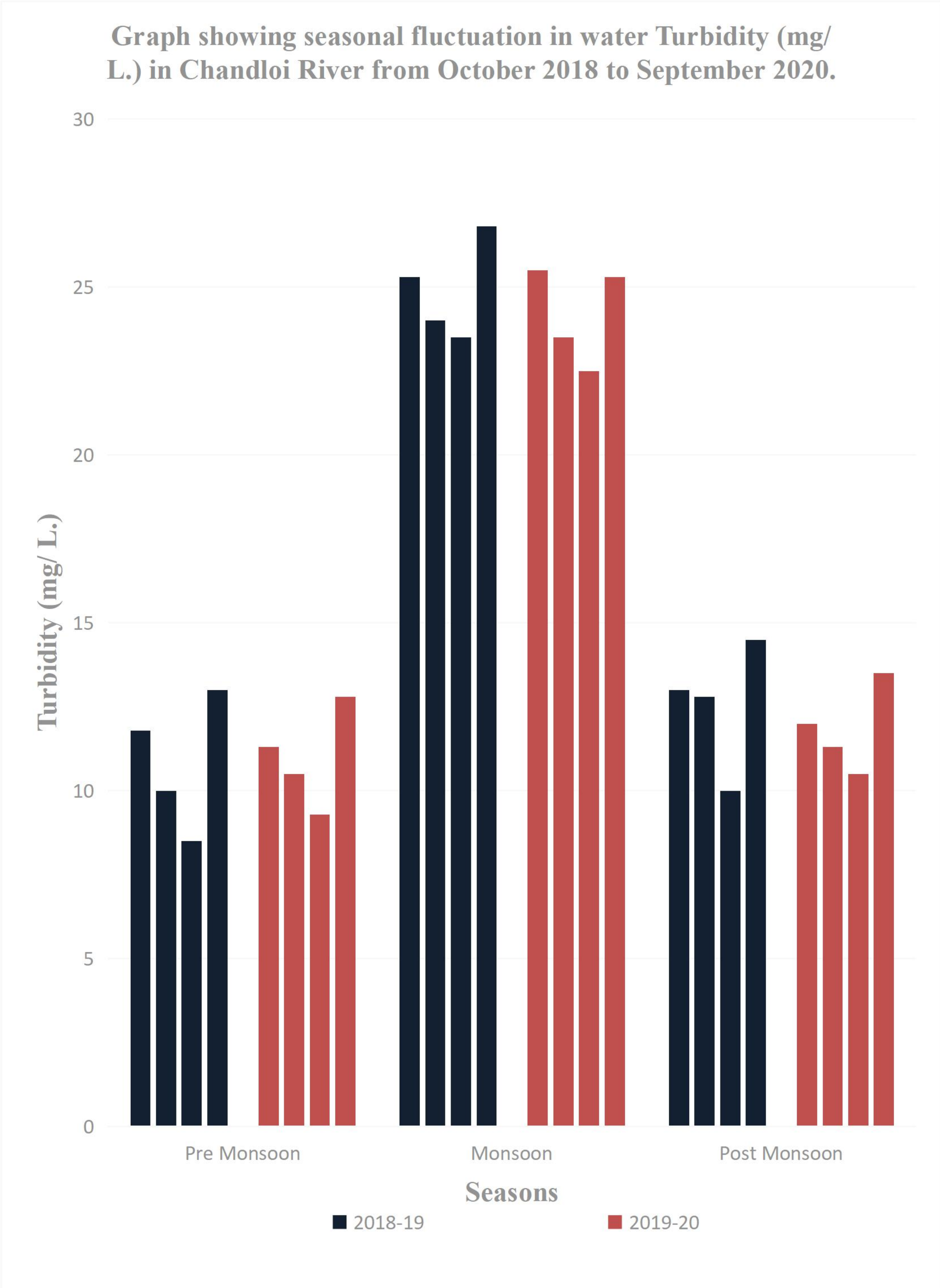
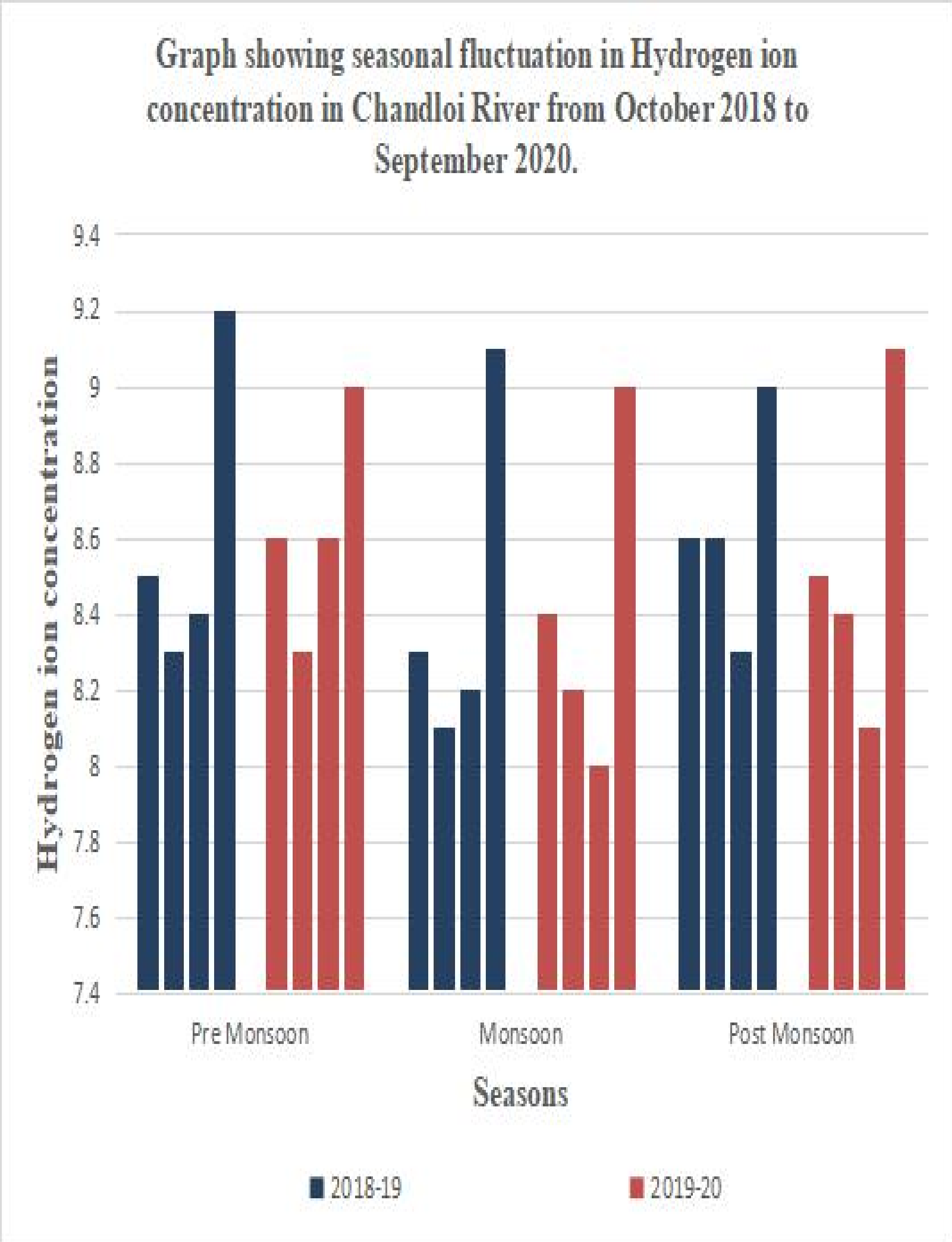

Graph showing seasonal fluctuation in water Turbidity (mg/ L.) in Chandloi River from October 2018 to September 2020.
30
25
20
15
10
5
0
Turbidity (mg/ L.)
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 07: Seasonal fluctuation in Hydrogen ion concentration (pH) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	8.5	8.3	8.6	8.5	8.3	8.6	0.15
Site2	8.3	8.1	8.6	8.3	8.1	8.6	0.25
Site3	8.4	8.2	8.3	8.3	8.2	8.4	0.10
Site4	9.2	9.1	9.0	9.1	9.0	9.2	0.10

Table 08: Seasonal fluctuation in Hydrogen ion concentration (pH) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	8.6	8.4	8.5	8.5	8.4	8.6	0.10
Site2	8.3	8.2	8.4	8.3	8.2	8.4	0.10
Site3	8.6	8	8.1	8.2	8	8.6	0.32
Site4	9	9	9.1	9	9	9.1	0.00



Graph showing seasonal fluctuation in Hydrogen ion concentration in Chandloi River from October 2018 to September 2020.
Hydrogen ion concentration
9.4
9.2
9
8.8
8.6
8.4
8.2
8
7.8
7.6
7.4
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 09: Seasonal fluctuation in Alkalinity (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	135.48	125.68	125.53	128.90	125.53	135.48	5.70
Site2	131.8	122.9	123.73	126.14	122.9	131.8	4.92
Site3	127.5	119.9	122.53	123.31	119.9	127.5	3.86
Site4	140.05	128.98	127.4	132.14	127.4	140.05	6.89

Table 10: Seasonal fluctuation in Alkalinity (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	384.5	203.85	268.5	285.62	203.85	384.5	91.53
Site2	381.73	197.98	263.5	281.07	197.98	381.73	93.13
Site3	375.25	196.1	255.03	275.46	196.1	375.25	91.31
Site4	396.3	208.53	283.5	296.11	208.53	396.3	93.52

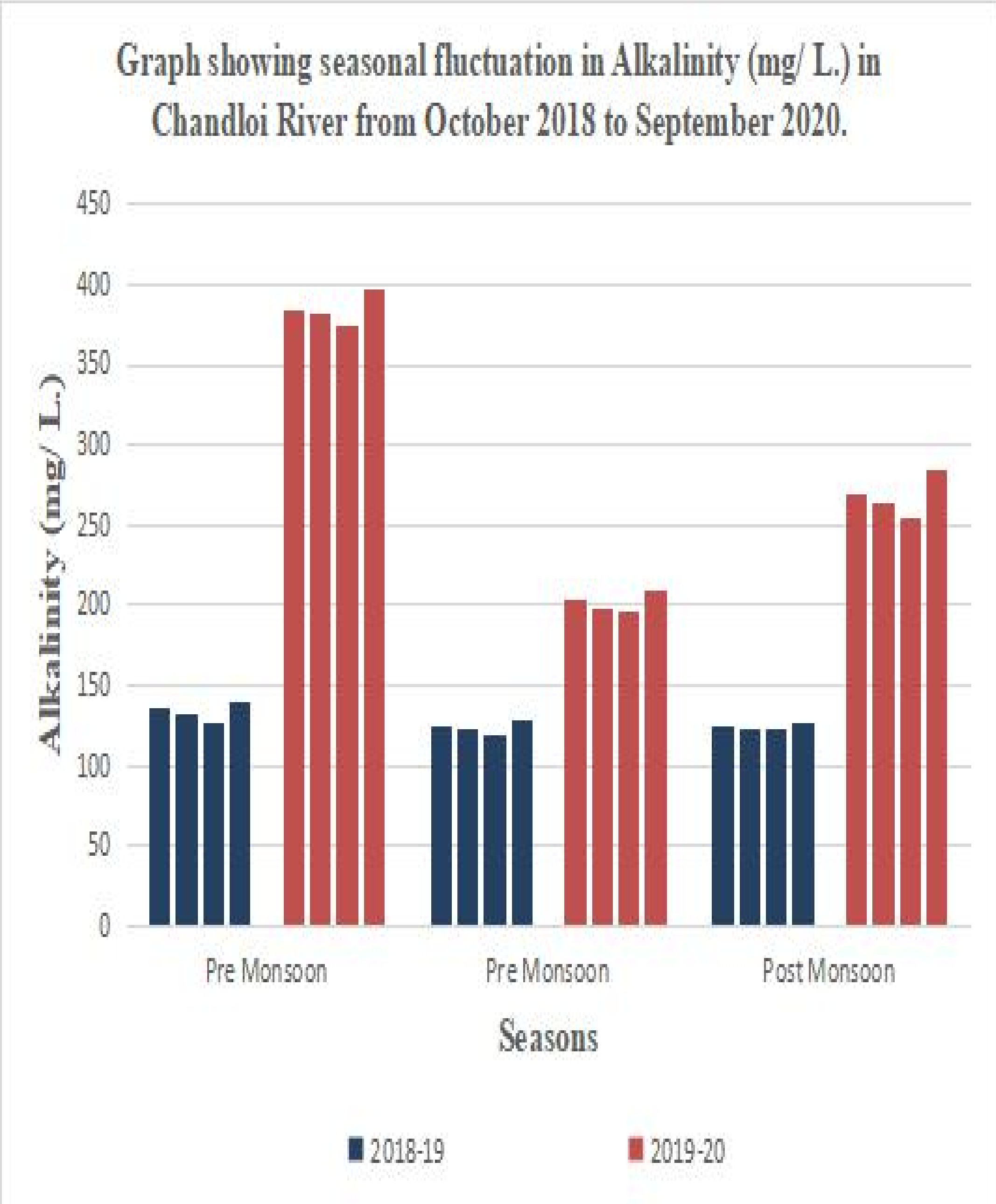

Graph showing seasonal fluctuation in Alkalinity (mg/ L.) in Chandloi River from October 2018 to September 2020.
Alkalinity (mg/ L.)
450
400
350
300
250
200
150
100
50
0
Pre Monsoon
Pre Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 11: Seasonal fluctuation in Hardness (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	136.73	125.78	125.9	129.47	125.78	136.73	6.29
Site2	134	124.87	125.2	128.02	124.87	134	5.18
Site3	133.65	123.4	123.95	127	123.4	133.65	5.77
Site4	139.5	126.88	126.93	131.11	126.88	139.5	7.27

Table 12: Seasonal fluctuation in Hardness (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	136.5	126.2	126.83	129.84	126.2	136.5	5.77
Site2	134.55	124.85	125.78	128.39	124.85	134.55	5.35
Site3	133.33	123.83	124.15	127.10	123.83	133.33	5.39
Site4	139.33	127.85	128.1	131.76	127.85	139.33	6.56

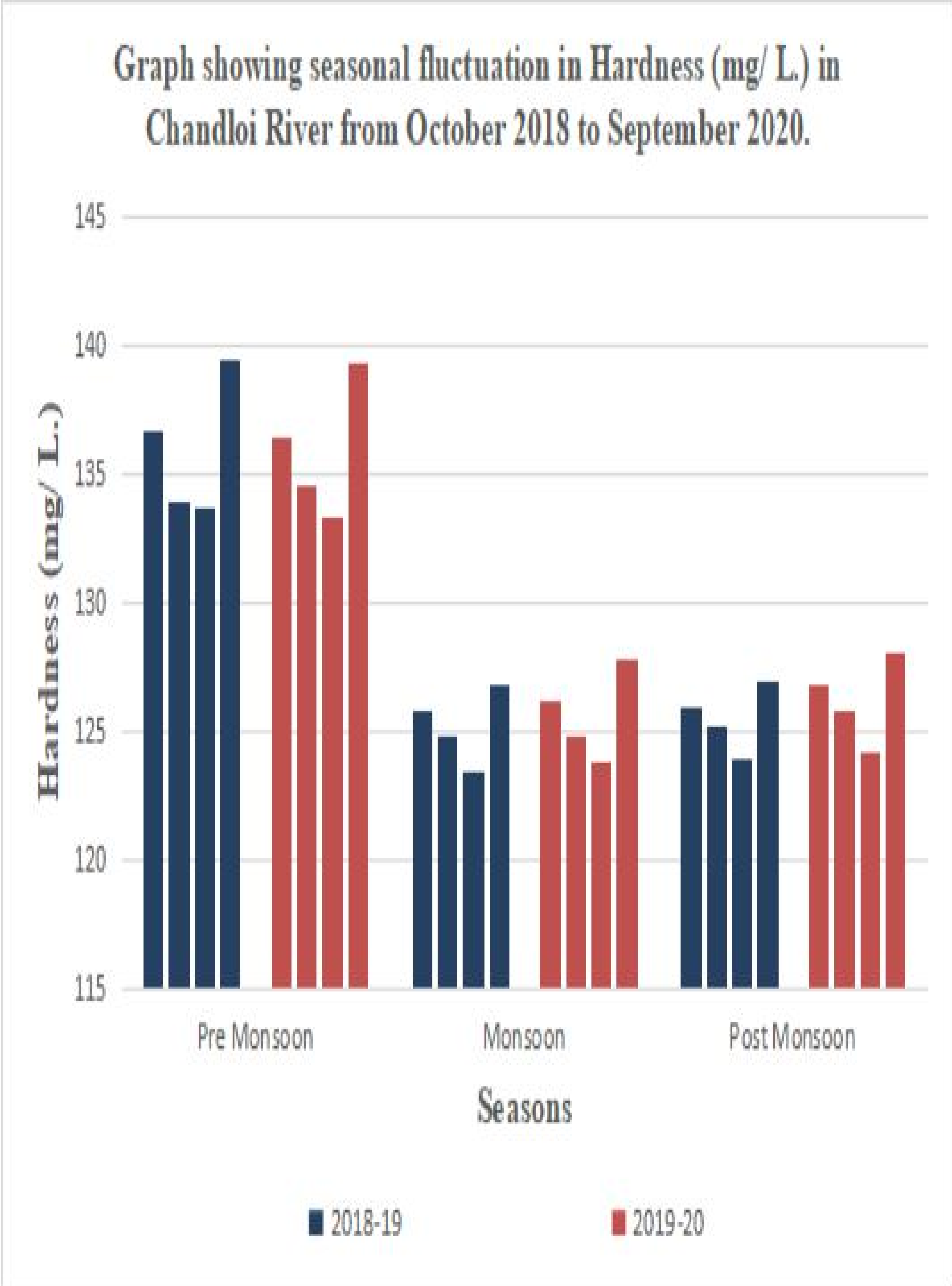
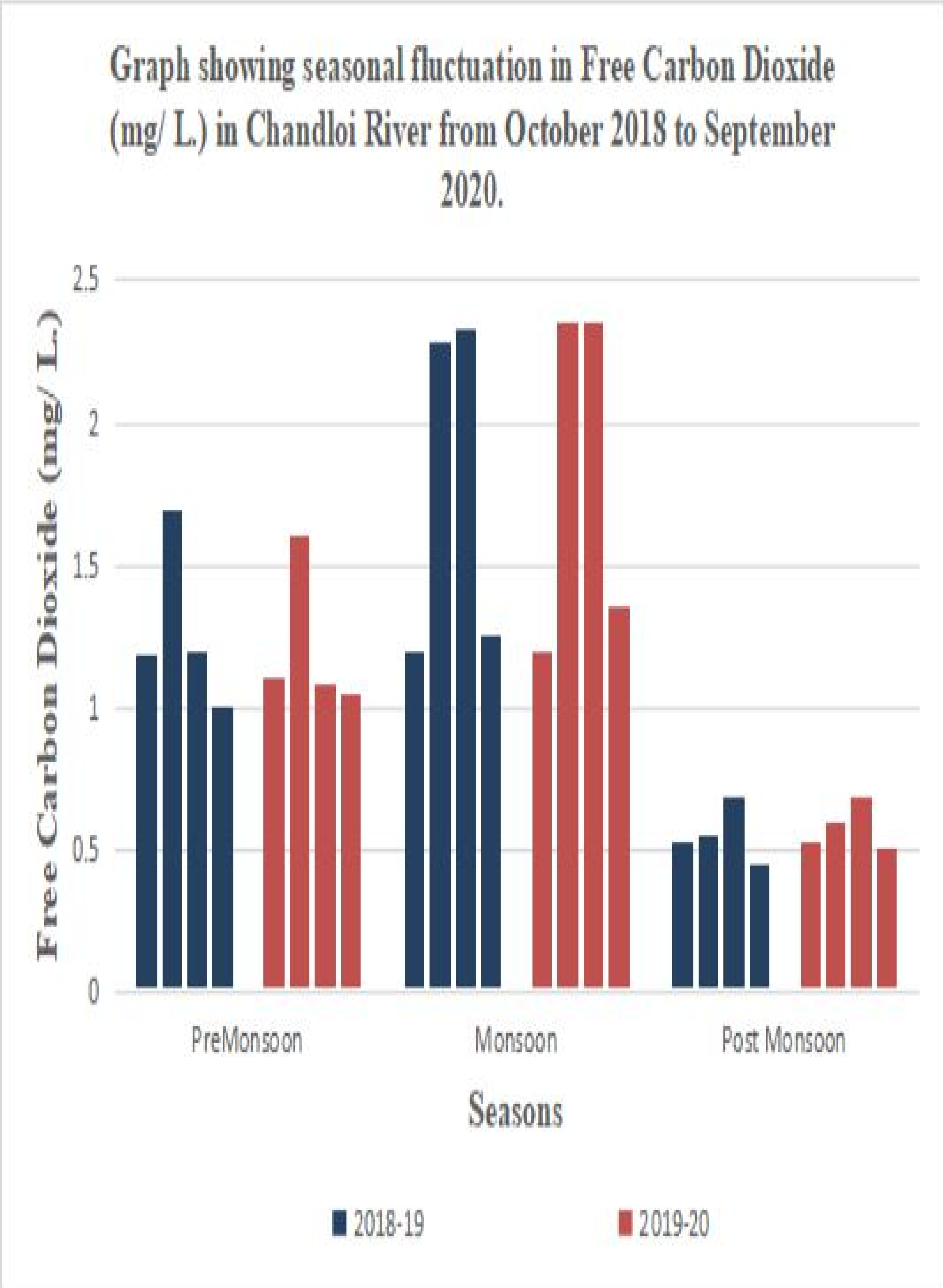

Graph showing seasonal fluctuation in Hardness (mg/ L.) in Chandloi River from October 2018 to September 2020.
Hardness (mg/ L.)
145
140
135
130
125
120
115
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 13: Seasonal fluctuation in Free Carbon dioxide (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	1.18	1.2	0.53	0.97	0.53	1.2	0.38
Site2	1.7	2.28	0.55	1.51	0.55	2.28	0.88
Site3	1.2	2.33	0.68	1.40	0.68	2.33	0.84
Site4	1.00	1.25	0.45	0.90	0.45	1.25	0.41

Table 14: Seasonal fluctuation in Free Carbon dioxide (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	1.1	1.2	0.53	0.94	0.53	1.2	0.36
Site2	1.6	2.35	0.6	1.52	0.6	2.35	0.88
Site3	1.08	2.35	0.68	1.37	0.68	2.35	0.87
Site4	1.05	1.35	0.5	0.97	0.5	1.35	0.43



Graph showing seasonal fluctuation in Free Carbon Dioxide (mg/ L.) in Chandloi River from October 2018 to September 2020.
Free Carbon Dioxide (mg/ L.)
2.5
2
1.5
1
0.5
0
PreMonsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 15: Seasonal fluctuation in Dissolved Oxygen (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	4.96	5.9	4.96	5.27	4.96	5.9	0.54
Site2	5.73	7.03	6.3	6.35	5.73	7.03	0.65
Site3	6.43	7.33	7.08	6.95	6.43	7.33	0.46
Site4	4.13	5.3	4.68	4.70	4.13	5.3	0.59

Table 16: Seasonal fluctuation in Dissolved Oxygen (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	4.88	5.98	5.03	5.29	4.88	5.98	0.60
Site2	5.68	7.03	7.1	6.60	5.68	7.1	0.80
Site3	6.56	6.93	7.1	6.86	6.56	7.1	0.28
Site4	3.98	5.18	4.5	4.55	3.98	5.18	0.60

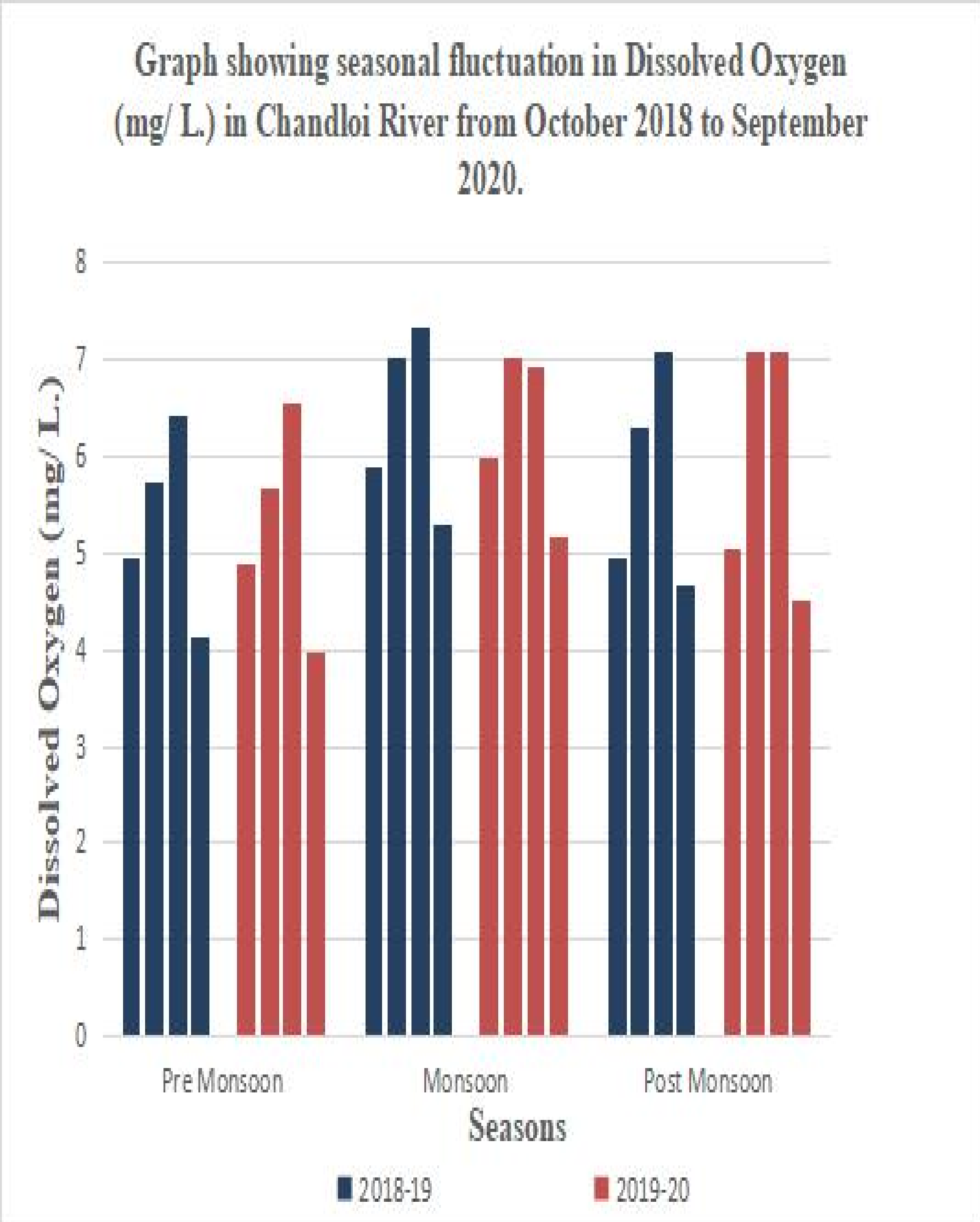
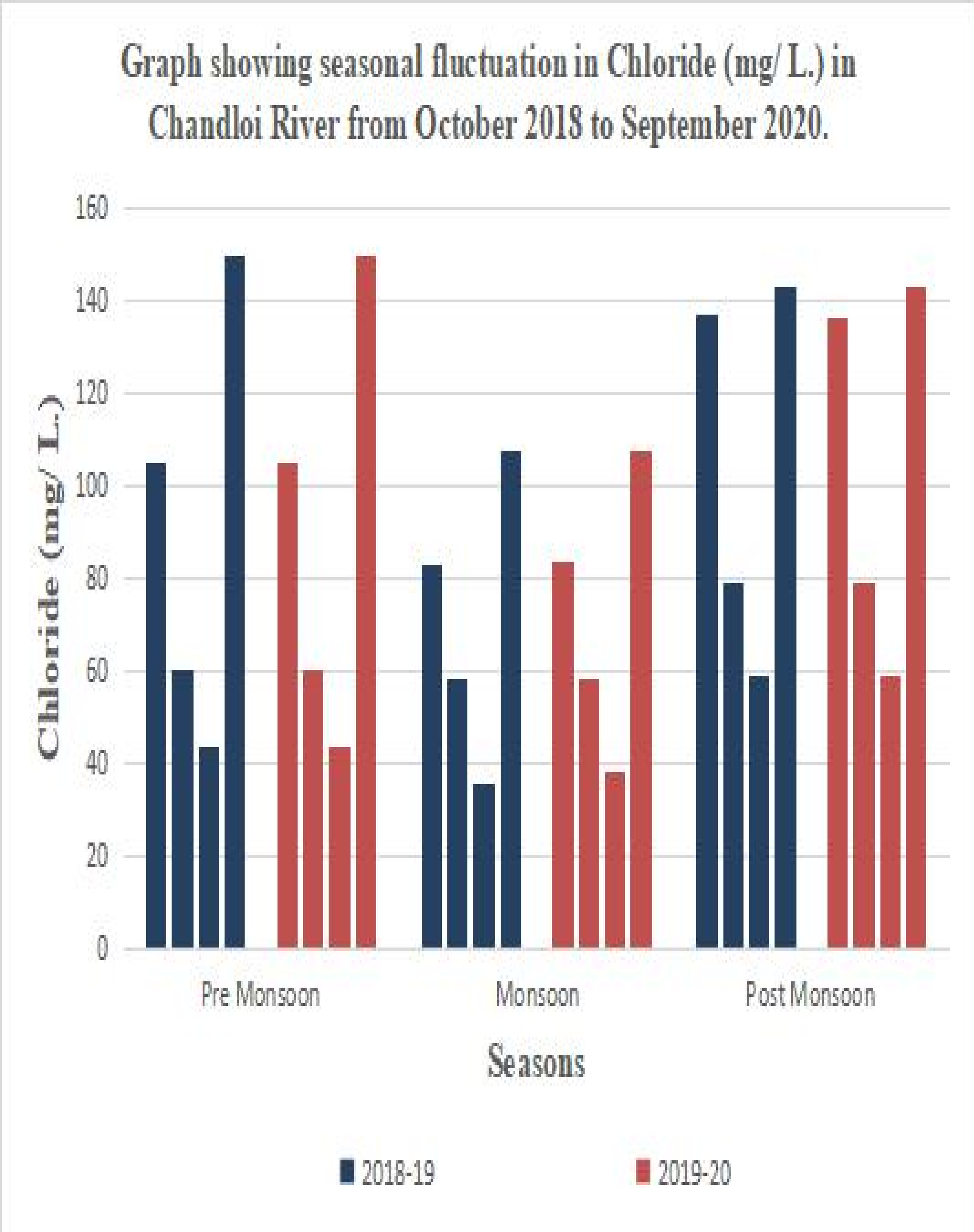

Graph showing seasonal fluctuation in Dissolved Oxygen (mg/ L.) in Chandloi River from October 2018 to September 2020.
Dissolved Oxygen (mg/ L.)
8
7
6
5
4
3
2
1
0
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 17: Seasonal fluctuation in Chloride (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	105.38	83.05	137.1	108.51	83.05	137.1	26.95
Site2	60.5	58.18	78.8	65.83	58.18	78.8	11.29
Site3	43.63	35.4	59.1	46.04	35.4	59.1	12.03
Site4	150	107.45	143.23	133.56	107.45	150.00	22.86

Table 18: Seasonal fluctuation in Chloride (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	105.38	83.63	136.6	108.54	83.63	136.6	26.63
Site2	60.38	58.5	79.05	65.98	58.5	79.05	11.36
Site3	43.63	38.38	59.13	47.05	38.38	59.13	10.79
Site4	150.13	107.58	143.23	133.65	107.58	150.13	22.84



Graph showing seasonal fluctuation in Chloride (mg/ L.) in Chandloi River from October 2018 to September 2020.
160
140
120
100
80
60
40
20
0
Chloride (mg/ L.)
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 19: Seasonal fluctuation in Total Dissolved Solids (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	536.2	528.38	526.38	530.32	526.38	536.2	5.19
Site2	281.7	378.2	423.63	361.18	281.7	423.63	72.48
Site3	132.25	128.8	124.13	128.39	124.13	132.25	4.08
Site4	808	927.6	927.13	887.58	808	927.6	68.92

Table 20: Seasonal fluctuation in Total Dissolved Solids (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	537	531.35	525.43	531.26	525.43	537	5.79
Site2	331.5	301.85	425.23	352.86	301.85	425.23	64.40
Site3	134.25	125.9	125.15	128.43	125.15	134.25	5.05
Site4	915.75	938.4	923.58	925.91	915.75	938.4	11.50

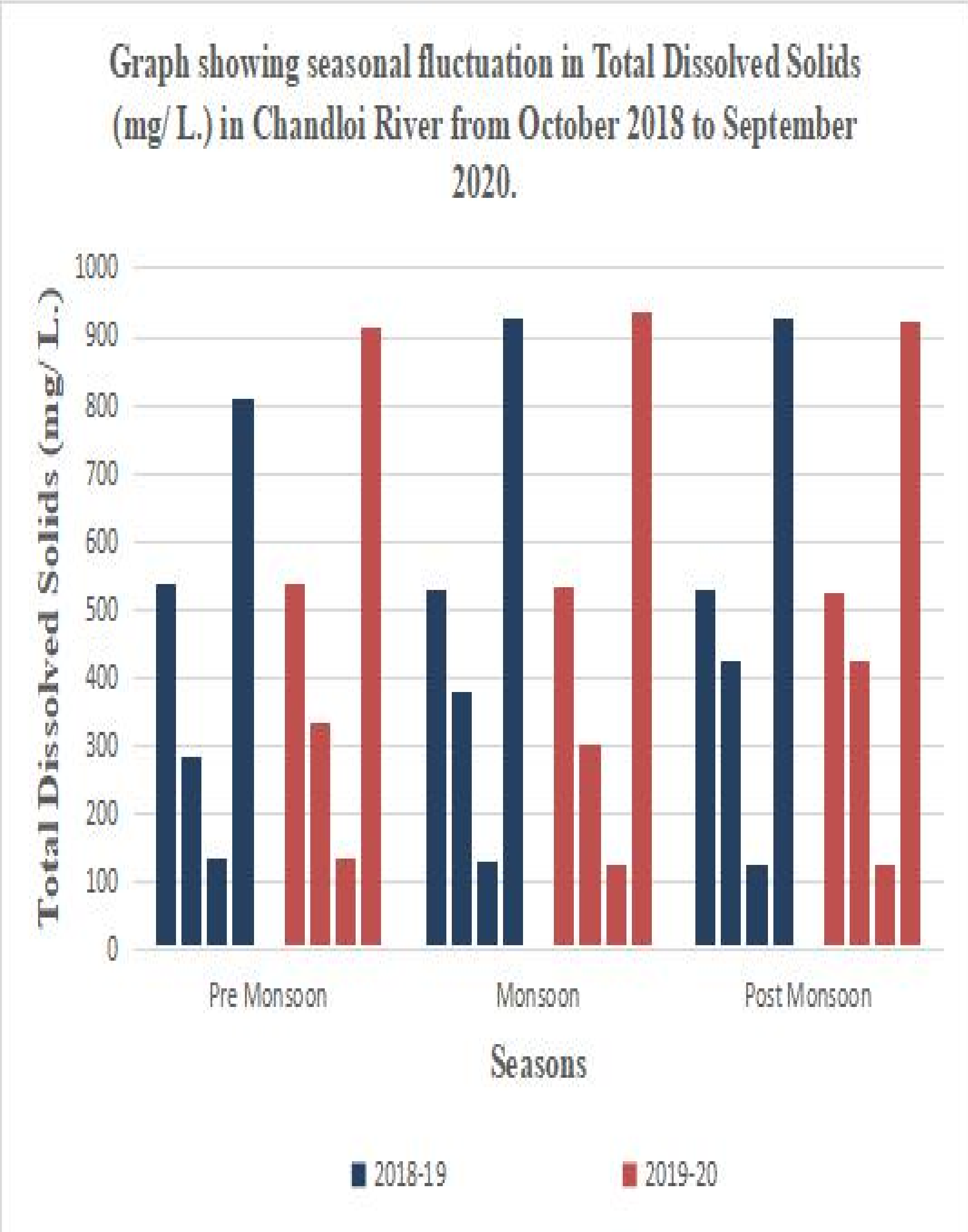

Graph showing seasonal fluctuation in Total Dissolved Solids (mg/ L.) in Chandloi River from October 2018 to September 2020.
Total Dissolved Solids (mg/ L.)
1000
900
800
700
600
500
400
300
200
100
0
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 21: Seasonal fluctuation in Biological Oxygen Demand (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	54.6	41.03	79.05	58.23	41.03	79.05	19.27
Site2	40.52	26.43	41.1	36.02	26.43	41.1	8.31
Site3	12.23	7.58	20.65	13.49	7.58	20.65	6.63
Site4	106.00	105.78	23.9	78.56	23.9	106.00	47.34

Table 22: Seasonal fluctuation in Biological Oxygen Demand (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	46.48	52.03	86.38	61.63	46.48	86.38	21.61
Site2	36.78	28.85	46.13	37.25	28.85	46.13	8.65
Site3	12.15	7.07	24.13	14.45	7.07	24.13	8.76
Site4	98.57	113.68	119.63	110.63	98.57	119.63	10.86

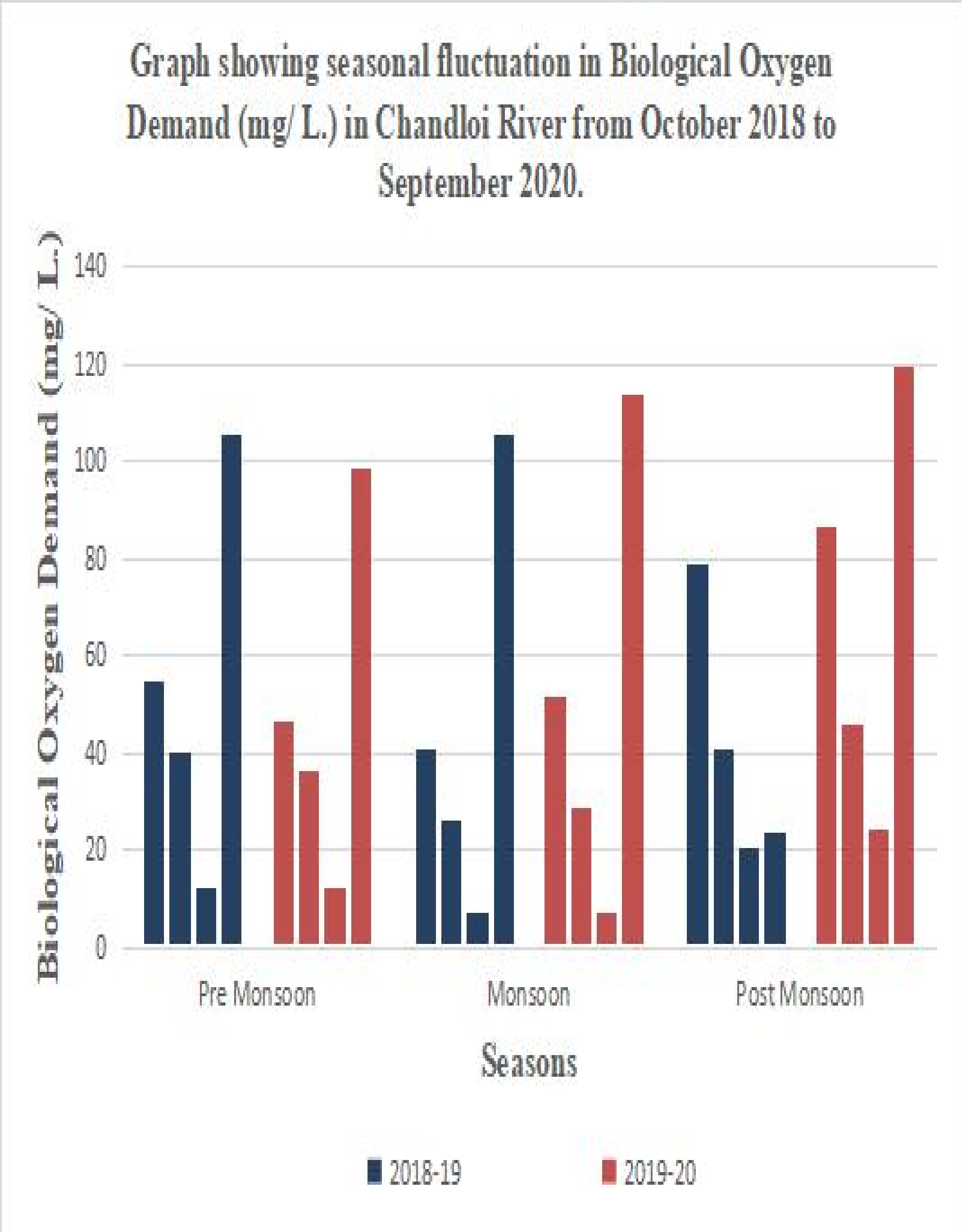

Graph showing seasonal fluctuation in Biological Oxygen Demand (mg/ L.) in Chandloi River from October 2018 to September 2020.
Biological Oxygen Demand (mg/ L.)
0
20
40
60
80
100
120
140
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 23: Seasonal fluctuation in Nitrate (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	60.6	64.2	83.15	69.32	60.6	83.15	12.11
Site2	56.95	68.65	84.4	70.00	56.95	84.4	13.77
Site3	47.43	59.72	76.15	61.10	47.43	76.15	14.41
Site4	74.85	79.75	100.00	84.87	74.85	100.00	13.33

Table 24: Seasonal fluctuation in Nitrate (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	67.45	65.05	80.65	71.05	65.05	80.65	8.40
Site2	65.1	69.33	76.33	70.25	65.1	76.33	5.67
Site3	54.65	60.5	71.5	62.22	54.65	71.5	8.56
Site4	83.85	80.93	91.68	85.48	80.93	91.68	5.56

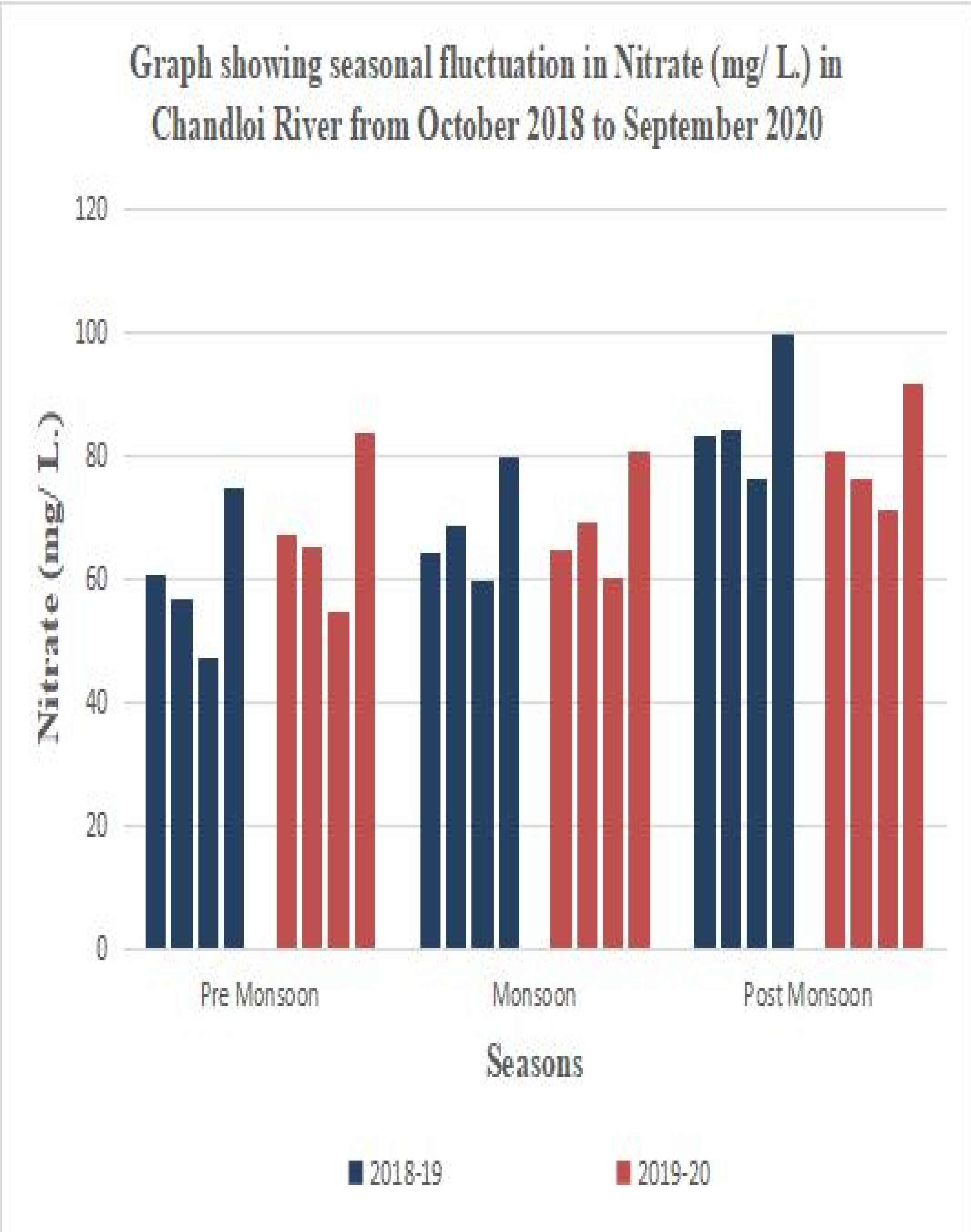

Graph showing seasonal fluctuation in Nitrate (mg/ L.) in Chandloi River from October 2018 to September 2020
120
100
80
60
40
20
0
Nitrate (mg/ L.)
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 25: Seasonal fluctuation in Phosphate (mg/ L.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	64.05	73.2	89.5	75.58	64.05	89.5	12.89
Site2	43.93	68.13	63.38	58.48	43.93	68.13	12.82
Site3	41.45	57.55	63.38	54.13	41.45	63.38	11.36
Site4	85.15	84.93	87.3	85.79	84.93	87.3	1.31

Table 26: Seasonal fluctuation in Phosphate (mg/ L.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	74.78	65.18	64.15	68.04	64.15	74.78	5.86
Site2	48.65	59.73	58.35	55.58	48.65	59.73	6.04
Site3	31.68	46.6	46.18	41.49	31.68	46.6	8.50
Site4	89.68	79.15	79.32	82.72	79.15	89.68	6.03

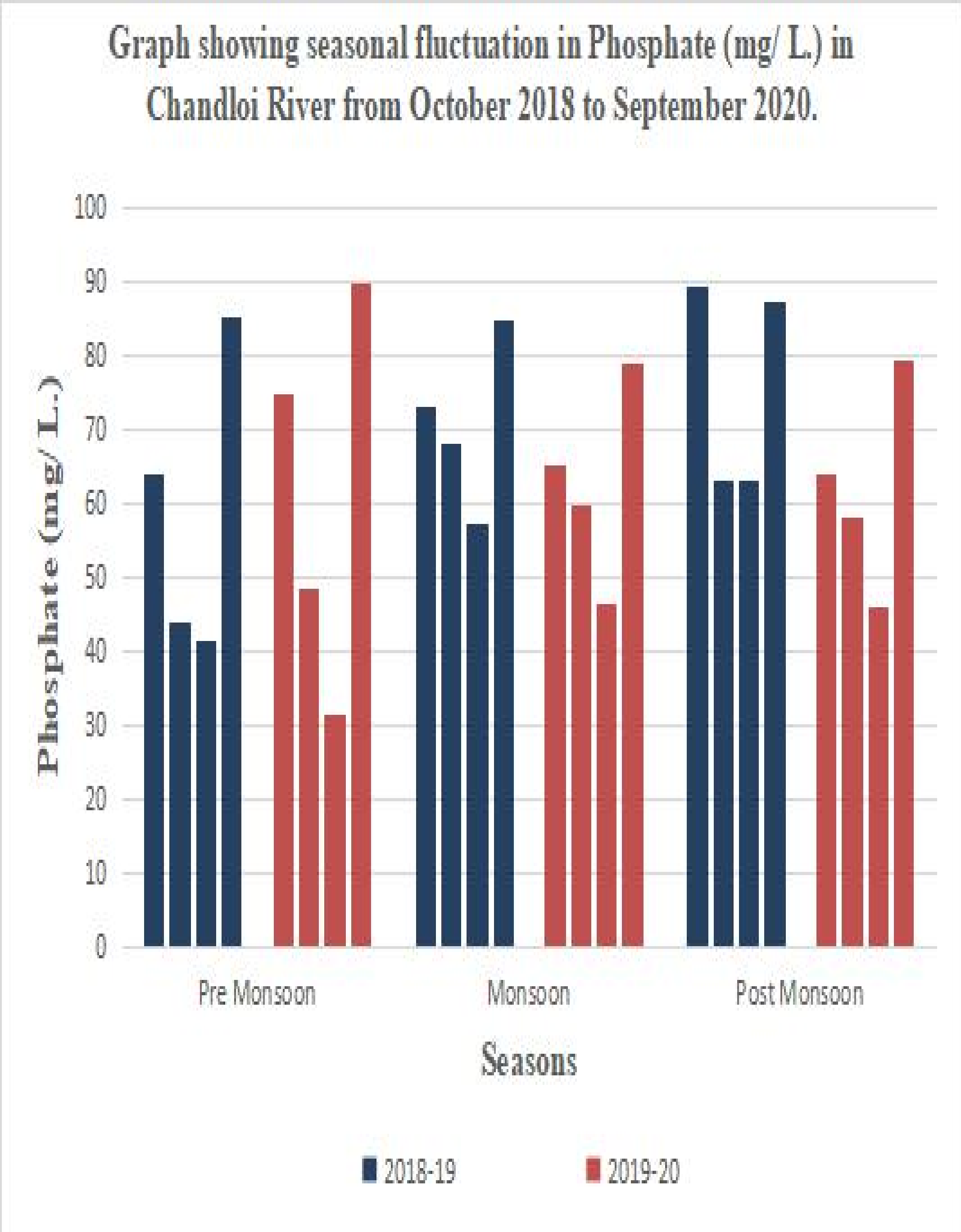
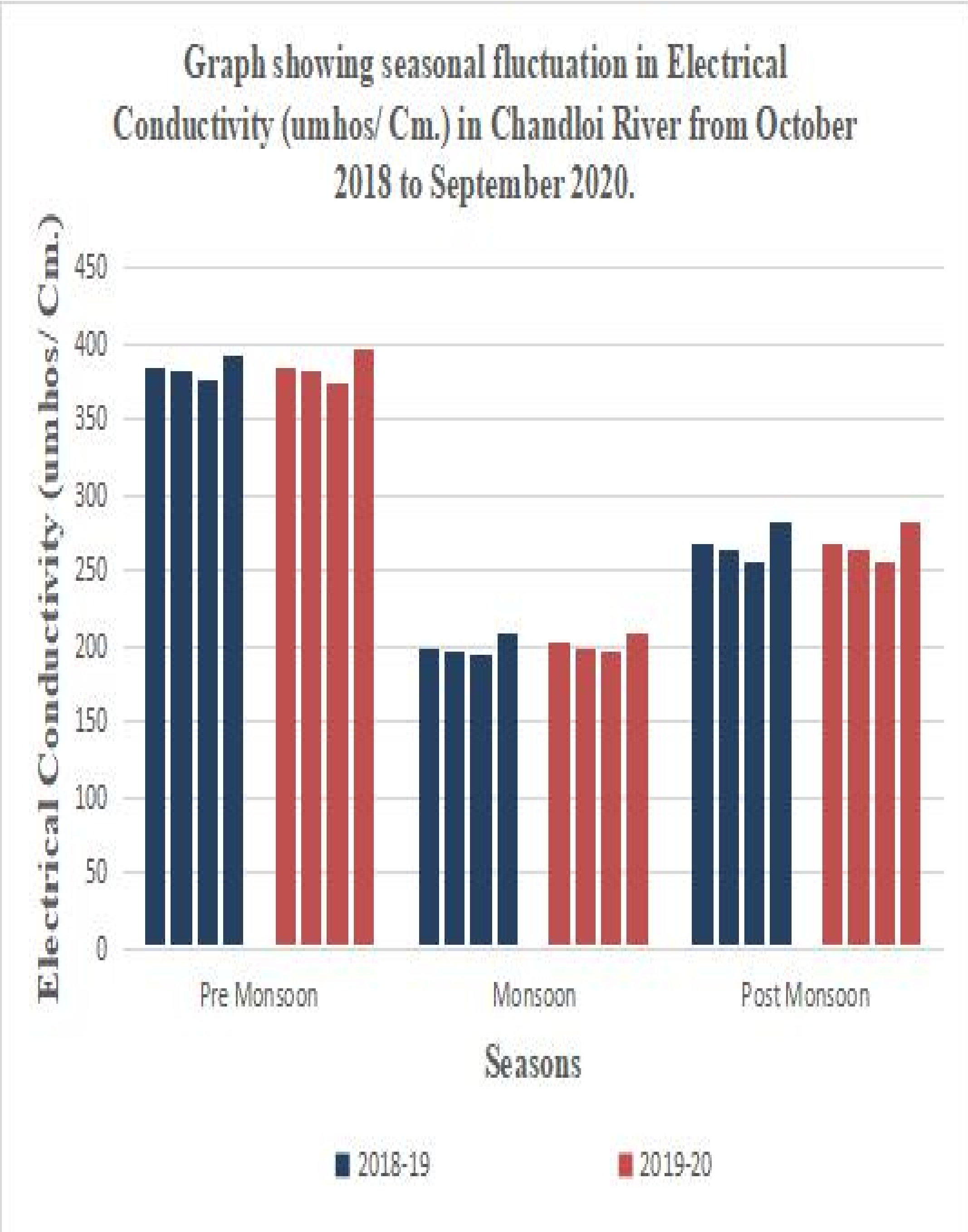

Graph showing seasonal fluctuation in Phosphate (mg/ L.) in
Chandloi River from October 2018 to September 2020.
Phosphate (mg/ L.)
100
90
80
70
60
50
40
30
20
10
0
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

Table 27: Seasonal fluctuation in Electrical Conductivity (µmhos/ Cm.) in Chandloi River (Kota) during October 2018 to September 2019.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	385.35	199.85	268.93	284.71	199.85	385.35	93.75
Site2	383.25	197.68	263.25	281.39	197.68	383.25	94.11
Site3	377.00	195.6	256.78	276.46	195.6	377.00	92.29
Site4	393.7	208.2	282.53	294.81	208.2	393.7	93.36

Table 28: Seasonal fluctuation in Electrical Conductivity (µmhos/ Cm.) in Chandloi River (Kota) during October 2019 to September 2020.

Sites & Season	Pre Monsoon	Monsoon	Post Monsoon	Average	Minimum	Maximum	Standard Deviation
Site1	384.5	203.85	268.5	285.62	203.85	384.5	91.53
Site2	381.73	197.98	263.5	281.07	197.98	381.73	93.13
Site3	375.25	196.1	255.03	275.46	196.1	375.25	91.31
Site4	396.3	208.53	283.5	296.11	208.53	396.3	94.52


Graph showing seasonal fluctuation in Electrical Conductivity (umhos/ Cm.) in Chandloi River from October 2018 to September 2020.
Electrical Conductivity (umhos/ Cm.)
450
400
350
300
250
200
150
100
50
0
Pre Monsoon
Monsoon
Post Monsoon
Seasons
2018-19
2019-20

DIVERSITY OF PHYTOPLANKTON

The present study underlines good phytoplankton diversity in the Chandloi River (Kota, Rajasthan). Total 37 species phytoplankton belonged to 6 phylum, 7 classes and 25 families were recorded. 37 species were identified of phytoplankton representing 6 groups namely Chlorophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Cyanophyta and Dinoflagellata. Chlorophyta includes 14 species, Bacillariophyta 6 species, Xanthophyta 4 species, Euglenophyta 3 species, Cyanophyta 8 species and Dinoflagellata 2 species. Group Chlorophyta (38%) was dominated over Cyanophyta (22%), Bacillariophyta (16%), Xanthophyta (11%), Euglenophyta (8%) and Dinoflagellata (5%), respectively (Table 29).

In Chlorophyta class Chlorophyceae has 8 families (Hydrodictyaceae, Chlamydomonadaceae, Volvocaceae, Oedogoniaceae, Desmediaceae, Chaetophoraceae, Chlorellaceae, Zygnemaceae). Family Hydrodictyaceae has 2 species *Hydrodictyon* and *Pediastrum duplex*, Chlamydomonadaceae has 2 species *Chlamydomonas eugametos*, *Chlamydomonas caudata*, Volvocaceae has 2 species *Volvox aureus*, *Volvox globater*, Oedogoniaceae has 1 species *Oedogonium nodulosum*, Desmediaceae has one species *Closterium*, Chaetophoraceae has one species *Draparnaldiopsis*, Chlorellaceae has one species *Chlorella vulgaris* and Family Zygnemaceae has 4 species *Zygnema, Spirogyra karnalae, Spirogyra varians, Spirogyra jogensis*. In Bacillariophyta class Bacillariophyceae has 5 families (Melosiraceae, Pinnulariaceae, Stephanodiscaceae, Tabellariaceae and Fragilariaceae). Melosiraceae and Pinnulariaceae, each family has 1 species *Melosira varians* and *Pinnularia viridis* respectively. Stephanodiscaceae has one species *Cyclotella,* Tabellariaceae has one species *Tabellaria*, and class Fragilariaceae has 2 species *Fragilaria crotonensis* and *Asterionella formosa.* In Xanthophyta class Xanthophyceae has 3 families (Botrydiaceae, Vaucheriaceae and Tribonemataceae). Tribonemataceae and Vaucheriaceae, each family has one species *Tribonema bombycina* and *Vaucheria geminata* respectively, Family Botrydiaceae has 2 species *Botrydium granulatum and Botrydium tuberosum.* In Euglenophyta class Euglenophyceae has one family (Euglenoidae), Euglenoidae has 3 species *Euglena viridis, Euglena sanguinea* and *Euglena gracillis*. In Cyanophyta class Cyanophyceae has 6 families (Chroococcaceae, Oscillatoriaceae, Nostocaceae, Scytonemataceae, Rivulariaceae and Microcystaceae). Family Chroococcaceae has one species *Chroococcus turgidis*, Oscillatoriaceae has one species *Oscillatoria princeps*, Nostocaceae has 2 species *Nostoc muscoru* and *Anabaena spp.* Scytonemataceae has one species *Scytonema simplex*, Rivulariaceae has one species *Gloeotrichia indica* and Microcystaceae has 2 species *Microcystis aeruginosa* and *microcystis flosaquae.* In Dinoflagellata class Dinophyceae has 2 families (Peridiniaceae and Ceratiaceae). Peridiniaceae and Ceratiaceae each family has one species *Peridinium spp.* and *Ceratium spp*. respectively.

SITE 1

Two ghats are located in towards East. These ghats are used for human activity such as bathing, washing cloths, etc. Cyanophyta were the most rich species group in this site followed by group Bacillariophyta, Euglenophyta, Chlorophyta and Dinoflagellata respectively. Cyanophyta were dominating the phytoplankton with 6 species *Nostoc muscoru, Anabaena spp., Scytonema simplex*, *Gloeotrichia indica, Microcystis aeruginosa* and *microcystis flosaquae.* Bacillariophyta recorded 5 species *Melosira granulata, Melosira varians, Pinnularia viridis, Fragilaria crotonensis* and *Asterionella formosa.* Euglenophyta represented 3 species *Euglena viridis, Euglena sanguinea* and *Euglena gracillis.* Chlorophyta represented own only 3 species *Volvox globater*, *Oedogonium nodulosum* and *Chlorella vulgaris.* Dinoflagellata represented one species *Peridinium spp.*

SITE 2

This site is situated in the western side of the river, which is rather undisturbed site. Chlorophyta were the most rich species group in this site with 10 species followed by Xanthophyta with 2 species, Cyanophyta one species and Dinoflagellata with one species. 2 species of Euglenophyta has also seen which are indicative of very low pollution in this site. From Chlorophyta *Chlamydomonas eugametos*, *Chlamydomonas caudata*, *Volvox aureus*, *Volvox* *globater*, *Oedogonium nodulosum*, *Closterium*, *Draparnaldiopsis*, *Chlorella vulgaris, Spirogyra karnalae, Spirogyra varians* species were dominent. Xanthophyta represented 2 species *Vaucheria geminata* and *Tribonema bombycina*. *Oscillatoria princeps* represented Phylum Cyanophyta and *Ceratium spp*. represented Phylum Dinoflagellata. Euglenophyta species has also seen in this site *Euglena viridis* and *Euglena gracillis.*

SITE 3

This site is near origin of river and no anthropogenic activities are here. Chlorophyta were the most rich species group in this site at Chandloi River followed by Xanthophyta, Cyanophyta, Dinoflagellata and Bacillariophyta. Chlorophyta were the most important phytoplankton in eutrophic waters. In the present study, Chlorophyta is dominating in the phytoplankton with 14 species, *Hydrodictyon, Pediastrum duplex*, *Chlamydomonas eugametos*, *Chlamydomonas caudata*, *Volvox aureus*, *Volvox globater*, *Oedogonium nodulosum*, *Closterium*, *Draparnaldiopsis*, *Chlorella vulgaris, Zygnema, Spirogyra karnalae, Spirogyra varians* and *Spirogyra jogensis*. Followed by Xanthophyta with 4 species, *Tribonema bombycina, Vaucheria geminata, Botrydium granulatum* and *Botrydium tuberosum.* Followed by Cyanophyta and Dinoflagellata with 2-2 species, *Chroococcus turgidis*, *Oscillatoria princeps, Peridinium spp.* and *Ceratium spp*. respectively. Followed by Bacillariophyta with 2 species *Cyclotella* and *Tabellaria*.

SITE 4

This site is near the entering into River Chambal at Village Kashoroipatan. Cyanophyta were the most rich species group in this site followed by group Bacillariophyta and Euglenophyta. Cyanophyta were dominating the phytoplankton with 6 species *Nostoc muscoru, Anabaena spp., Scytonema simplex*, *Gloeotrichia indica, Microcystis aeruginosa* and *microcystis flosaquae.* Bacillariophyta recorded 5 species *Melosira granulata, Melosira varians, Pinnularia viridis, Fragilaria crotonensis* and *Asterionella formosa.*

Euglenophyta represented 3 species *Euglena viridis, Euglena sanguinea* and *Euglena gracillis.*

In the present study of Chandloi River (October 2018 to September 2020), Cyanophyta, Bacillariophyta and Euglenophyta species getting more in site 1 is an indication that this site is heavily polluted. Human activities are the main causes of water pollution. Some species of Chlorophyta and Dinoflagellata also indicate that the water is not completely polluted here. In site 2 finding of Euglenophyta species are the sign that some pollution of site 1 is reaching here but it is not much polluted yet. In site 3, the maximum species found of Chlorophyta and Xanthophyta is an indicator that the water is unpolluted here because it is the origin of river. Thus the site 3 is completely unpolluted. Site 4 has not found a single species of Chlorophyta and Xanthophyta. The finding of such species of phytoplankton suggests that this site is completely polluted. This is the result of industrialization and anthropogenic activities.

DIVERSITY OF ZOOPLANKTON

The present study underlines good zooplankton diversity in the Chandloi River (Kota, Rajasthan). Total 29 species of zooplankton belonged to 3 phylum, 6 classes and 16 families were recorded. 29 species were identified of zooplankton representing 3 groups namely Rotifera, Protozoa and Arthropoda. Rotifera has 8 species, Protozoa has 7 species and Arthropoda has 14 species. Group Arthropoda (48%) was dominated over Rotifera (28%) and Protozoa (24%), respectively (Table 30).

Phylum Rotifera and Protozoa has only one class Monogonata and Ciliata respectively. Group Arthropoda has 4 classes Branchiopoda, Cladocera, Ostracoda and Copepoda. In Rotifera class Monogonata has 3 families (Lacanidae, Notommatidae and Brachionidae). Family Lacanidae has 2 species *Lecane spp.* and *Monostyla bulla*. Notommatidae has one species *Scaridium longicaudum*. Brachionidae has 5 species *Brachionus calcyflorus, Brachionus forficula, Kertella tropica, Kertella procurva* and *Notholca spp.* Group Protozoa class Ciliata has 6 families (Parameciidae, Vorlicelldae, Oxytrichidae, Tracheliudae, Enchelyidae and Ophryoglenidae). Family Parameciidae has one species *Paramecium caudatum*, Vorlicelldae one species *Vorticella campanula*, Oxytrichidae 2 species *Oxytricha ovalis* and *Eeuplotes spp.*, Tracheliudae one species *Trachelius ovum*, Enchelyidae one species *Lacrymaria olor* and Ophryoglenidae has one species *Ophryoglena flava*. In Arthropoda class Branchiopoda has 2 familes (Streptocephali and Triopsidae), class Cladocera has one family (Daphinidae), class Ostracoda has one family (Cypridinidae) and class Copepoda has 3 families (Diatomidae, Canthocomptidae and Cyclopidae). Family Streptocephali has one species *Streptocephalus dichotomus*, Triopsidae has one species *Triops longicaudatus*, family Daphinidae has 4 species *Daphnia carinata, Moina dubia, Simocephalus spp.* and *Ceriodaphnia spp.*, Family Cypridinidae has 2 species *Ostracode* and *Heterocypris*, Family Diatomidae has 3 species *Heliodiaptomus viduus, Phyllodiaptomus annae* and *Spicodiaptomus chelospinus*, Family Canthocamptidae has one species *Cletocamptus albuquerquensis*, Family Cyclopidae has 2 species *Mesocyclops leuckart* and *Mesocyclops hyalinus*.

SITE 1

Two ghats are located in towards East. These ghats are used for human activity such as bathing, washing cloths, etc. Protozoa were the most rich species group in this site followed by group Arthropoda and Rotifera respectively. Protozoa were dominating zooplankton with 5 species *Paramecium caudatum*, *Vorticella campanula*, *Oxytricha ovalis, Lacrymaria olor* and *Ophryoglena flava*. In Arthropoda class Branchiopoda and Ostracoda shows 2 species each *Streptocephalus dichotomus*, *Triops longicaudatus*, *Ostracode* and *Heterocypris,* respectively. Rotifera represents 3 species *Notholca spp., Brachionus forficula* and *Monostyla bulla*.

SITE 2

This site is situated in the western side of the river, which is rather undisturbed site. Rotifers were the most rich species group in this site followed by Copepods and Cladocerans, 2 species of Ciliata and 2 species of Branchiopoda were also recorded. Rotifers were dominating zooplankton with 6 species *Monostyla bulla,* *Brachionus calcyflorus, Brachionus forficula, Kertella tropica, Kertella procurva* and *Notholca spp.* In Copepods species *Heliodiaptomus viduus, Phyllodiaptomus annae, Cletocamptus albuquerquensis*, *Mesocyclops leuckart* and *Mesocyclops hyalinus* were found whereas in Cladocerans species *Daphnia carinata, Moina dubia, Simocephalus spp.* were recorded. Ciliata reptresents 2 species *Vorticella campanula* and *Ophryoglena flava* and Branchiopoda represents by 2 species *Streptocephalus dichotomus*, *Triops longicaudatus.*

SITE 3

This site is near origin of river and here are no anthropogenic activities. Rotifers were the most rich species group in this site at Chandloi River followed by Copepods and Cladocerans. In the present study, Rotifers were dominating zooplankton with 8 species *Lecane spp.*, *Monostyla bulla, Scaridium longicaudum, Brachionus calcyflorus, Brachionus forficula, Kertella tropica, Kertella procurva* and *Notholca spp.* In Copepods species *Heliodiaptomus viduus, Phyllodiaptomus annae, Cletocamptus albuquerquensis*, *Mesocyclops leuckart, Spicodiaptomus chelospinus* and *Mesocyclops hyalinus* were found where as in Cladocerans species *Daphnia carinata, Moina dubia, Simocephalus spp.* and *Ceriodaphnia spp.* were recorded.

SITE 4

This site is near the entering into River Chambal at Village Kashoroipatan. Protozoa were the most rich species group in this site followed by group Arthropoda. Protozoa were dominating zooplankton with 7 species *Paramecium caudatum*, *Vorticella campanula*, *Oxytricha ovalis, Eeuplotes spp.*, *Trachelius ovum*, *Lacrymaria olor* and *Ophryoglena flava.* In Arthropoda class Branchiopoda and Ostracoda shows 2 species each *Streptocephalus dichotomus*, *Triops longicaudatus*, *Ostracode* and *Heterocypris* respectively.

In the present study of Chandloi River from October 2018 to September 2020, Protozoa and Arthropoda species getting more in site 1 is an indication that this site is heavily polluted. Human activities are the main causes of water pollution. In site 2 findings of some Rotifer species indicate that the water is not completely polluted here. Ciliata and Branchiopoda species are the sign that some pollution of site 1 is reaching here but it is not much polluted yet. In site 3 species *Brachionus calcyflorus, Kertella tropica, Monostyla bulla* and *Lecane spp.* are good indicators of eutrophic conditions. *Brachionus* can be considered a target taxon for more intensive monitoring of water quality and conservation planning on aquatic environment. *Brachionus and Kertella spp.* were most dominant Rotifers in the River. Thus site 3 is completely unpolluted site of the river. In site 4 finding of more Protozoans species of zooplankton suggests that this site is completely polluted. This site has not found a single species of Rotifers. This is the result of industrialization and anthropogenic activities.

DIVERSITY OF FISHES

The present study from October 2018 to September 2020, highlights good fishes diversity in the Chandloi River. Total 16 species of fishes belonged to phylum Chordata, class Actinopterygii, 5 orders and 7 families were recorded. 16 species identified of fishes representing 5 orders Cypriniformes, Anabantiformes, Siluriformes, Cichliformes and Synbranchiformes. Order Cypriniformes has 7 species, Anabantiformes has 2, Siluriformes has 5, Cichliformes has 1 and Synbranchiformes has 1 species. Order Cypriniformes (44%) has dominated over Siluriformes (31%), Anabantiformes (12.5), Cichliformes (6%) and Synbranchiformes (6%), respectively (Table 31)

Order Cypriniformes has single family (Cyprinidae), Anabantiformes has also single family (Channidae), Order Siluriformes has 3 families (Ariidae, Siluridae, Bagridae), Order Cichliformes has one family (Cichlidae), and Synbranchiformes has one family (Mastacembelidae). Family Cyprinidae has 7 species *Mylopharyngodon piceus* (Black carp), *Crucian carassius* (Crucian carps), *Cirrhinus cirrhosus* (Mrigal carp), *Labeo rohita* (Rohu), *Labeo catla* (Young catla), *Labeo calbasu* (Labeo), *Osteochilus vittatus* (Bonylip barb). Family Channidae has 2 species *Channa argus* (Northern snakehead), *Channa striata* (Striped snakehead). Family Ariidae has one species *Plicofollis dussumieri* (Catfish). Family Cichlidae has one species *Oreochromis niloticus* (Tilapia). Family Siluridae has 3 species *Ompok bimaculatus* (Butter catfish), *Wallago attu*

(Helicopter catfish), *Phalacronotus apogon* (Sheat fish). Family Mastacembelidae has one species *Mastacembelus moorii* (Eel fish) and family Bagridae has one species *Sperata aor* (Long whiskered catfish).

In the present study of Chandloi River (October 2018 to September 2020), percentwise composition of order Cypriniformes dominated with 44% over Siluriformes (31%), Anabantiformes (13%), Cichliformes (6%) and Synbranchiformes (6%), respectively. Order Cypriniformes and family Cyprinidae were dominent class with 7 species, followed by order Siluriformes with 3 families and 5 species. Order Anabantiformes and family Channidae has 2 species. Order Cichliformes, Synbranchiformes and family Cichlidae and Mastacembelidae have single single species.

Fish species diversity in rivers is dependent on the complex interaction of different ecological variables of the river as temperature (between 20^0C to 30^0C), pH (between 5 to 9), turbidity (below 25 NTU), DO (between 2 to 5 mg./ L.) and food availability.

Fishes are moving from one place to another, so it is difficult to find their diversity at one site. In the present study of Chandloi River it was found that the diversity of all 16 fish species at site 2 and site 3 was found very good. Because these sites temperature, pH, turbidity, DO and food availability factors are fish-friendly, as well as no anthropogenic activities here and due to very less. These sites were absolutely pollution free and all the species were seen in large number. Among all species *Labeo rohita, Labeo catla, Labeo calbasu, Mastacembelus moorii, Sperata aor, Channa argus, Channa striata, Wallago attu* seen more in all fishes. While not all 16 species appeared on site 1 and site 4. *Oreochromis niloticus, Crucian carassius, Cirrhinus cirrhosus, Ompok bimaculatus* seen more with other species in site 1 whereas only species *Oreochromis niloticus* and *Crucian carassius* were recorded in site 4. Because in these sites anthropogenic activities, sewerage of village, industrial water, etc. gets mixed in the river. So temperature, pH, turbidity of water increases and reduces the amount of DO and availability of food, which is not favourable for fishes. This shows these species tolerance quality, not only tolerance to chemical stress but also tolerance to high water temperature, pH, trophic status, prior invasion success may play more important role. Thus the diversity of fishes tells us site 1 is an indication that this site is heavily polluted. Human activities are the main cause of water pollution. Site 2 is not completely unpolluted but some pollution of site 1 is reaching here but it is not much polluted yet. Site 3 is near origin of river so anthropogenic activities are not here right now, this is completely unpolluted site. Site 4 suggests that this site is completely polluted. This is the result of industrialization and anthropogenic activities

Mylopharyngodon piceus

Crucian carassius

ICHTHYOFAUNA OF CHANDLOI RIVER

Channa argus

Channa striata

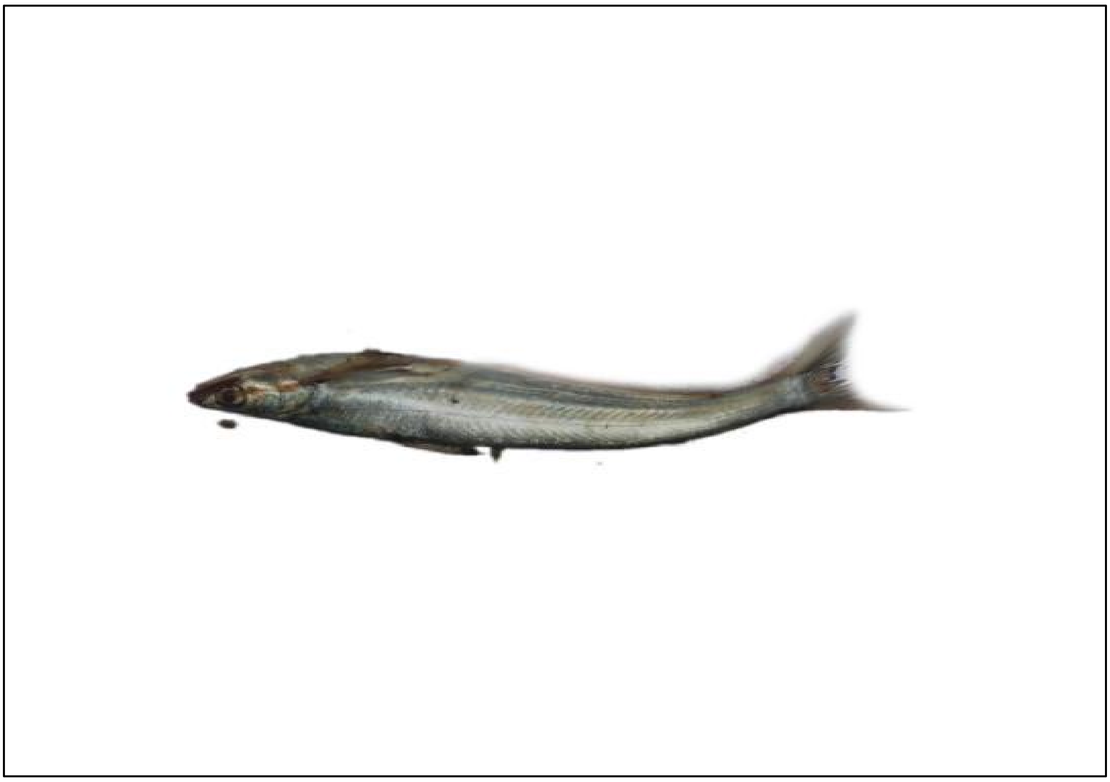
ICHTHYOFAUNA OF CHANDLOI RIVER

Plicofollis dussumieri

Oreochromis niloticus

ICHTHYOFAUNA OF CHANDLOI RIVER

Ompok bimaculatus



Cirrhinus cirrhosus

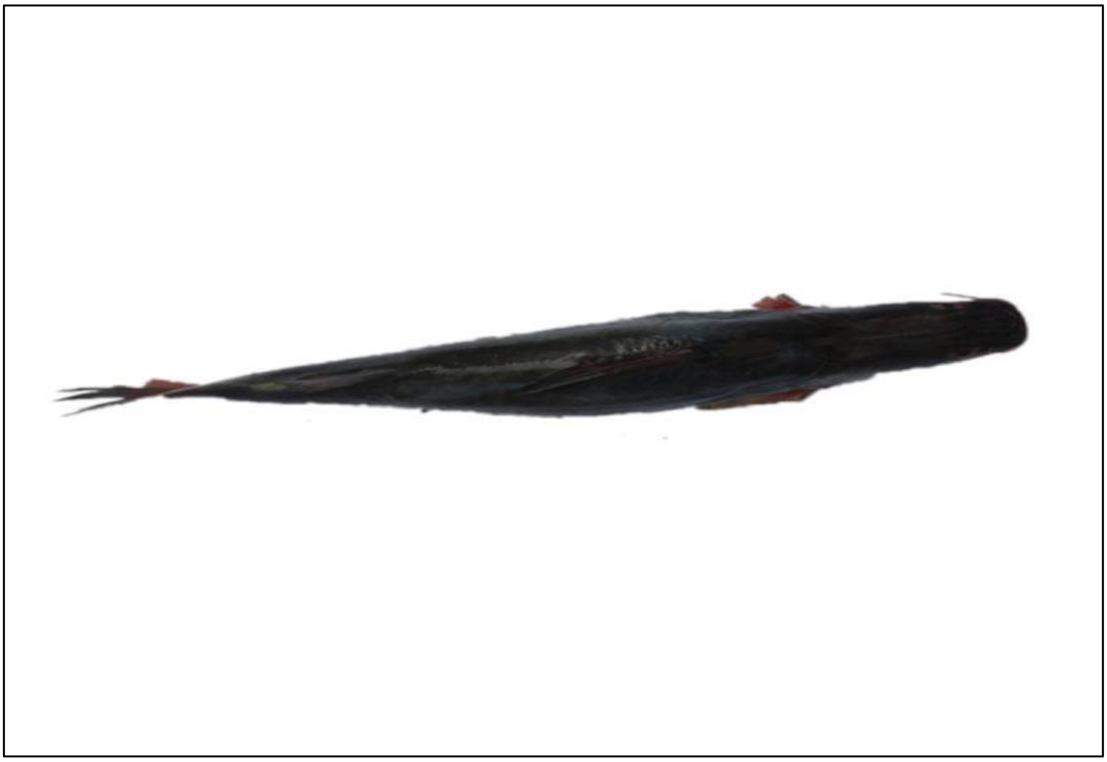
ICHTHYOFAUNA OF CHANDLOI RIVER

Mastacembelus morrii

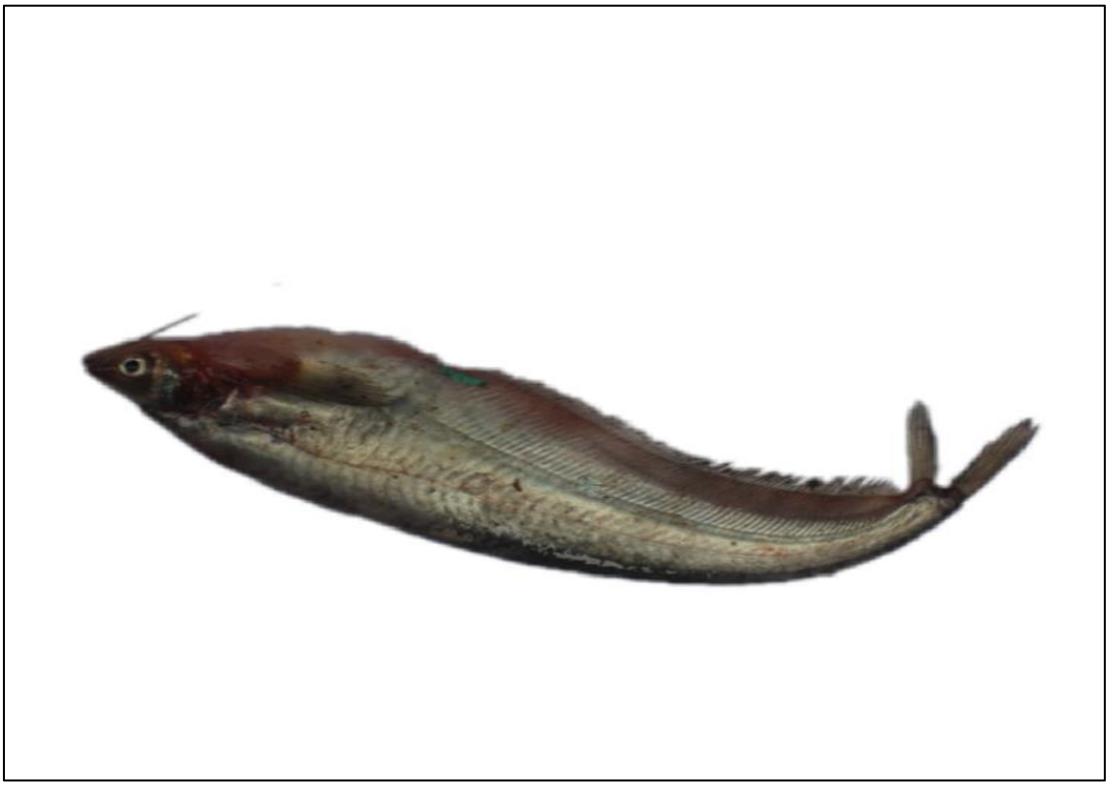
Wallago attu

Mastacembelus morrii

ICHTHYOFAUNA OF CHANDLOI RIVER

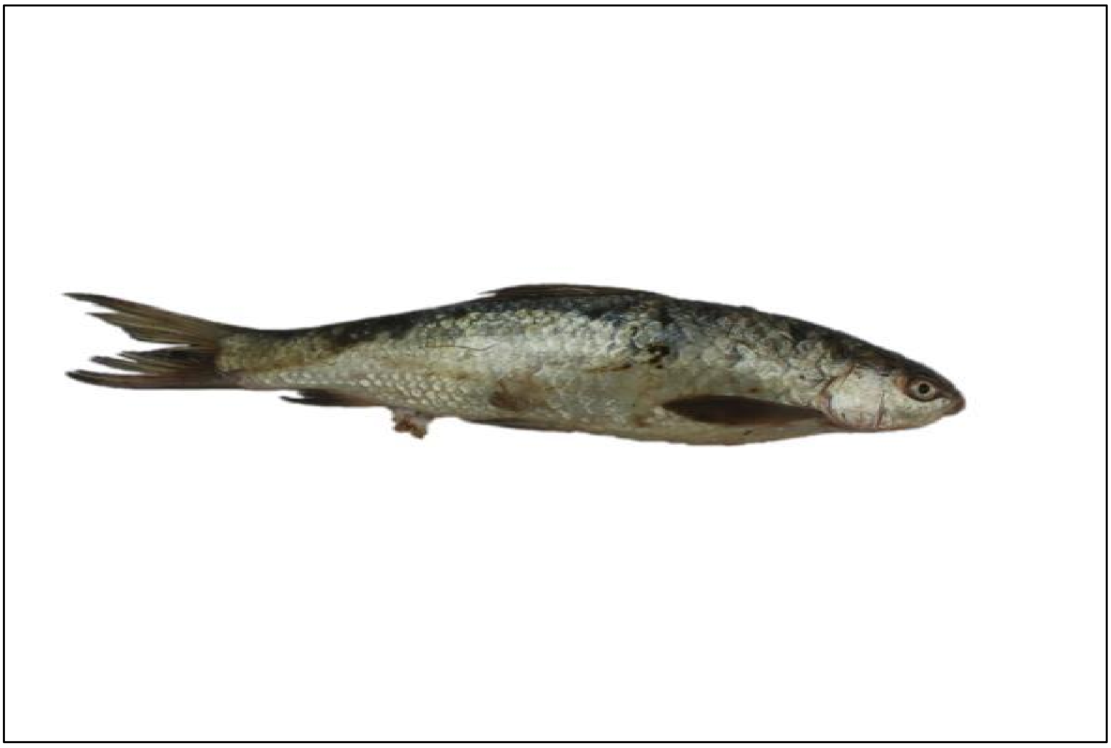


Sperata aor

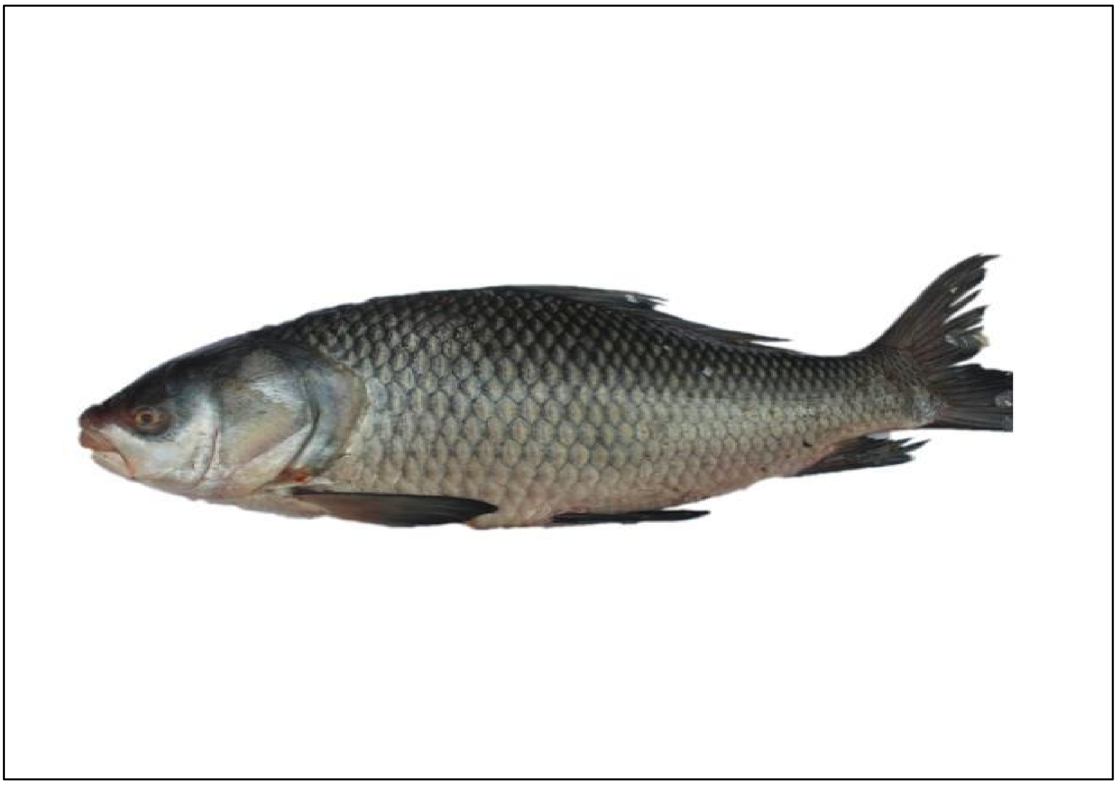


Phalacronotus apogon

ICHTHYOFAUNA OF CHANDLOI RIVER

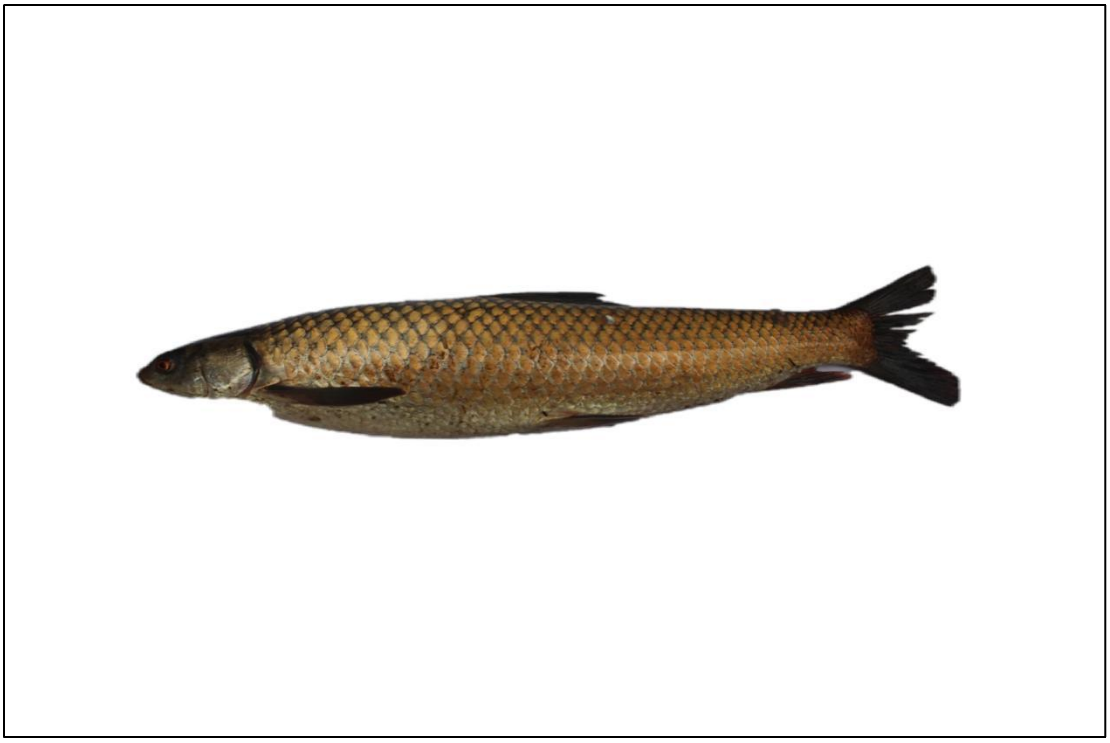


Labeo rohita

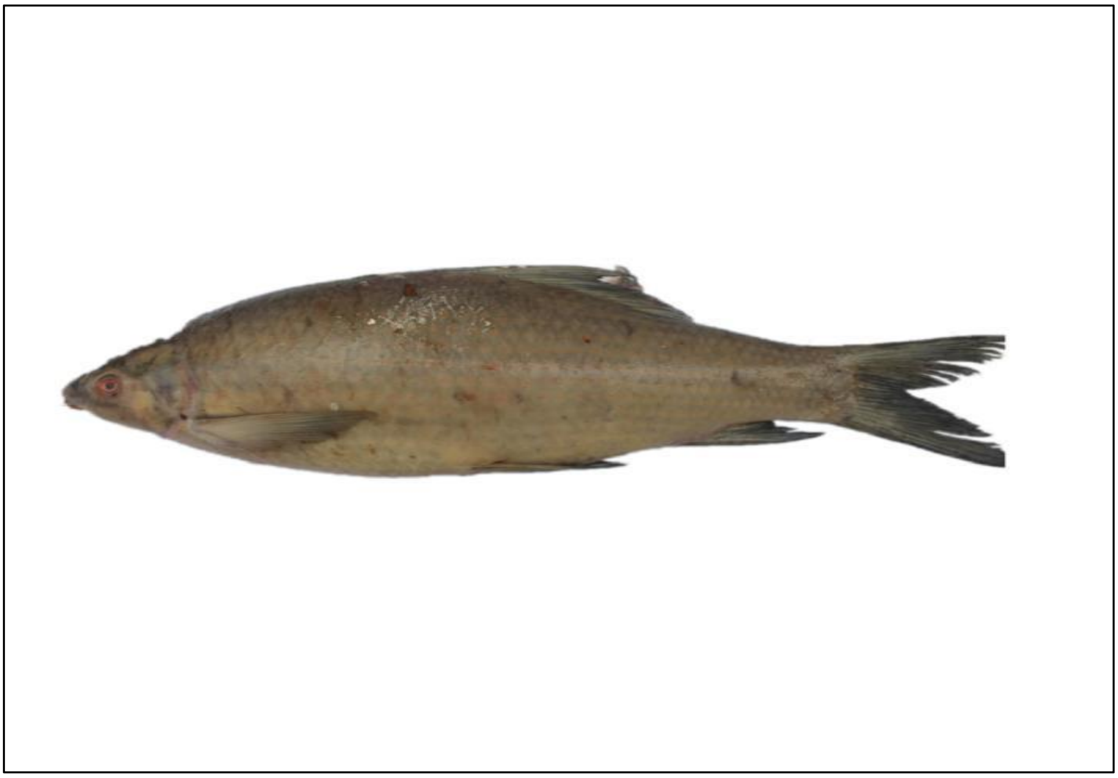


Labeo catla

ICHTHYOFAUNA OF CHANDLOI RIVER



Osteochilus vittatus



Labeo calbasu

ICHTHYOFAUNA OF CHANDLOI RIVER

DIVERSITY OF BENTHIC INVERTEBRATES

The present study highlights good benthic diversity in the Chandloi River (Kota, Rajasthan). Total 22 species benthos belonged to 4 phyla, 8 classes and 17 families were recorded. 22 species were identified of benthic invertebrates representing 4 groups, Mollusca, Annelida, Arthopoda and Nematoda. Mollusca 9 species, Annelida 6 species, Arthopoda 2 species and Nematoda includes 5 species. Mollusca (41%) dominated over Annelida (27%), Nematoda (23%) and Arthopoda (9%), respectively (Table 32).

Phylum Mollusca has two classes Gastropoda and Bivalvia. 4 families found in Gastropoda namely (Ampullariidae, Thiaridae, Bithyniidae and Lymnacidae). In family Ampullariidae found 2 species *Pila pesmet* and *Pila ampullaceal*, Thiaridae one species *Thiara tuberculata*, Bithyniidae one species *Bithynia spp.* and Lymnacidae 2 species *Lymnaea acuminate* and *Lymnaea glabra.* Class Bivalvia has 3 families (Solenidae, Arcidae and Pholadidae). Family Solenidae has one species *Solen spp.*, Arcidae has one species *Arca granulose* and Pholadidae has also one species *Pholas dactylus*. Phylum Annelida represented 3 classes Hirudinea, Polychaeta and Oligochaeta. Class Hirudinea has one family (Piscicolidae) and it represented only one species *Piscicola spp.* Polychaeta has 2 families (Nereidae and Nephtyidae). Nereidae has one species *Nereis spp.* and Nephtyidae has one species *Nephtys spp.*, unidentified *Polychaete* larve also found in class Polychaeta. Class Oligochaeta has one family (Tubificidae) and it represented 2 species *Tubifex spp.* and *Branchiura spp*. Phylum Arthopoda has one class Insecta and it represented 2 families (Chironomidae and Tabanidae). Each family has one species *Chironomus spp. and Tabanus spp*., respectively. Phylum Nematoda has 2 classes Phasmidia and Aphasmidia. Phasmidia has 2 families (Rhabaditidae and Diplogasleridae). Both families represented one species *Rhabaditis cranganorencis* and *Gobindonemafili caudatum,* respectively. Class Aphasmidia has 2 families (Hoplolamidae and Monhysteridae). Hoplolamidae has one species *Helicotylenchuscren acauda* and Monhysteridae has 2 species *Monohystera pseudomacrura* and *Albunema indicum.*

SITE 1

Two ghats are located in towards East. These ghats are used for human activity such as bathing, washing cloths, etc. Nematoda were the most rich species group in this site followed by group Annelida, Mollusca and Arthopoda respectively. Nematoda were dominated with 4 species *Rhabaditis cranganorencis, Gobindonemafili caudatum, Monohystera pseudomacrura* and *Albunema indicum.* Followed by Annelida with 3 species *Nereis spp.* and *Nephtys spp. Polychaete* larvae were also found. Followed by Mollusca with 3 species *Pila pasmet, Solen spp.* and *Lymnaea glabra.* Followed by Arthopoda with 2 species *Chironomus spp. and Tabanus spp*.

SITE 2

This site is situated in the western side of the river, which is rather undisturbed site. Mollusca were the most rich species group in this site at Chandloi River followed by Annelida and Arthopoda. Mollusca were dominated with 7 species *Pila pesmet, Pila ampullaceal*, *Thiara tuberculata*, *Bithynia spp., Lymnaea acuminate, Arca granulose* and *Pholas dactylus*. Followed by Annelida with 3 species *Piscicola spp., Branchiura spp*. and *Tubifex spp*. Followed by Arthopoda with single species *Tabanus spp.* One species of Nematoda *Monohystera pseudomacrura* were also found in this site.

SITE 3

This site is near origin of river and no anthropogenic activities are here. Mollusca were the most rich species group in this site at Chandloi River followed by Annelida and Arthopoda. Mollusca were dominated with 8 species *Pila pesmet, Pila ampullaceal*, *Thiara tuberculata*, *Bithynia spp., Lymnaea acuminate, Solen spp.*, *Arca granulose* and *Pholas dactylus*. Followed by Annelida with 4 species *Piscicola spp., Branchiura spp*., *Tubifex spp.* and *Nephtys spp*. Followed by Arthopoda with single species *Tabanus spp*.

SITE 4

This site is near the entering into River Chambal at Village Kashoroipatan. Nematoda were the most rich species group in this site followed by group Annelida and Arthopoda. Nematoda were dominated with 5 species *Rhabaditis cranganorencis, Gobindonemafili caudatum, Helicotylenchuscren acauda, Monohystera pseudomacrura* and *Albunema indicum.* Followed by Annelida with 3 species *Nereis* *spp.* and *Nephtys spp. Polychaete* larvae were also found. Followed by Arthopoda with 1 species *Chironomus spp.*

In the present study of Chandloi River (October 2018 to September 2020), Nematoda and Annelida species getting more in site 1 is an indication that this site is heavily polluted. Human activities are the main causes of water pollution. In site 2 findings of some species of Mollusca and Annelida indicate that the water is unpolluted here. Nematoda species are the sign that some pollution of site 1 is reaching here but it is not much polluted yet. In site 3 findings of more Molluscan species *Tubifex spp., Nephtys spp.* indicate that the site 3 is fully unpolluted because this is completely undisturbed site. In site 4 findings of rich species of Nematoda and has not found a single species of Mollusca suggests that this site is completely polluted. This is the result of industrialization and anthropogenic activities.

The species of Chironomidae were found maximum in polluted water sites during the investigation, because these species have a high tolerance and found in all water from clean to highly polluted. Among Oligochaeta *Tubifex* was most common observed in fresh water sites. This is a typical Indian freshwater species with wide distribution. The importance of Tubifex as pollution indicator.

DIVERSITY OF MACROPHYTES

The present study (October 2018 to September 2020) highlights good macrophytic diversity in the Chandloi River. In this study 22 species belonged to phylum Magnoliophyta and 2 classes Liliopsida and Magnoliopsida and 16 families and 18 genera. Class Liliopsida and Magnoliopsida each has 11 species. Class Liliopsida has 8 families (Alismataceae, Amaryllidaceae, Areceae, Cyperaceae, Hydrocharitaceae, Lemnaceae, Pontederiaceae and Typhaceae). Class Magnoliopsida has also 8 families (Amaranthaceae, Menyanthaceae, Nymphaeaceae, Ceratophyllaceae, Convolvulaceae, Scrophulariaceae, Aponogetonaceae, Lentibulariaceae). Both these Classes Liliopsida and Magnoliopsida have 50%-50% of total community (Table 33). Semi aquatic plants and aquatic wetland plants were included into general survey.

In class Liliopsida, Family Alismataceae has one species *Sagittaria guayanensis*, Family Amaryllidaceae has one species *Crinum asiaticum*, Family Areceae has two species *Colocasiae sculanta, Pistia stratiotes*, Family Cyperaceae has one species

Eleocharis atropurpurea, Family Hydrocharitaceae has 3 species *Hydrilla verticillata, Vallisneria natans, Vallisneria spiralis*, Family Lemnaceae has one species *Wolffia arriza*, Family Pontederiaceae has one species *Eichhornia crassipes*, Family Typhaceae has one species *Typha angustata*. Whereas in class Magnoliopsida, Family Amaranthaceae has one species *Alternanthera sessilis*, Family Menyanthaceae has 2 species *Nymphoides indica* and *Nymphoides hydrophilla*, Family Nymphaeaceae has 2 species *Nymphaea nouchali* and *Nymphaea pubescens*, Family Ceratophyllaceae has one species *Ceratophyllum demersum*, Family Convolvulaceae has two species *Ipomoea aquatic* and *Ipomoea carnea*, Family Scrophulariaceae has one species *Limnophila indica*, Family Aponogetonaceae has one species *Aponogeton natans*, Family Lentibulariaceae has one species *Utricularia aurea*.

In the present study of Chandoi River, all macrophytes species were found almost every site. But some species *Sagittaria guayanensis, Utricularia aurea, Wolffia arriza, Ceratophyllum demersum, Pistia stratiotes,* etc. were found more number in and around site 2 and site 3. These findings of macrophytes species tells that these both sites are a few polluted or completely unpolluted. Whereas *Hydrilla verticillata, Eichhornia crassipes*, *Typha angustata,* etc. were found more number in and around site 1 and site 4. These observation of macrophytes species tells that these both sites are more polluted because these species are used as pollution indicator.

Thus the diversity of macrophytes tells us site 1 is an indication that this site is heavily polluted. Human activities are the main cause of water pollution. Site 2 is not completely unpolluted but some pollution of site 1 is reaching here but it is not much polluted yet. Site 3 is near origin of river so this is completely unpolluted site. Site 4 suggests that this site is completely polluted. This is the result of industrialization and anthropogenic activities.

Table 29: Qualitative estimation of phytoplankton in Chandloi River (Kota) during October 2018 to September 2020.

Phylum	Class	Family	Genus & Species
Chlorophyta	Chlorophyceae	Hydrodictyaceae	*Hydrodictyon*
Chlorophyta	Chlorophyceae	Hydrodictyaceae	*Pediastrum duplex*
Chlorophyta	Chlorophyceae	Chlamydomonadaceae	*Chlamydomonas eugametos*
Chlorophyta	Chlorophyceae	Chlamydomonadaceae	*Chlamydomonas caudata*
Chlorophyta	Chlorophyceae	Volvocaceae	*Volvox aureus*
Chlorophyta	Chlorophyceae	Volvocaceae	*Volvox globater*
Chlorophyta	Chlorophyceae	Oedogoniaceae	*Oedogonium nodulosum*
Chlorophyta	Chlorophyceae	Desmediaceae	*Closterium*
Chlorophyta	Chlorophyceae	Chaetophoraceae	*Draparnaldiopsis*
Chlorophyta	Chlorophyceae	Chlorellaceae	*Chlorella vulgaris*
Chlorophyta	Chlorophyceae	Zygnemaceae	*Zygnema*
Chlorophyta	Chlorophyceae	Zygnemaceae	*Spirogyra karnalae*
Chlorophyta	Chlorophyceae	Zygnemaceae	*Spirogyra varians*
Chlorophyta	Chlorophyceae	Zygnemaceae	*Spirogyra jogensis*
Bacillariophyta	Bacillariophyceae	Melosiraceae	*Melosira varians*
Bacillariophyta	Bacillariophyceae	Pinnulariaceae	*Pinnularia viridis*
Bacillariophyta	Bacillariophyceae	Stephanodiscaceae	*Cyclotella*

Bacillariophyta	Fragilariophyceae	Tabellariaceae	*Tabellaria*
Bacillariophyta	Fragilariophyceae	Fragilariaceae	*Fragilaria crotonensis*
Bacillariophyta	Fragilariophyceae	Fragilariaceae	*Asterionella formosa*
Xanthophyta	Xanthophyceae	Botrydiaceae	*Botrydium tuberosum*
Xanthophyta	Xanthophyceae	Botrydiaceae	*Botrydium granulatum*
Xanthophyta	Xanthophyceae	Vaucheriaceae	*Vaucheria geminata*
Xanthophyta	Xanthophyceae	Tribonemataceae	*Tribonema bombycina*
Euglenophyta	Euglenophyceae	Euglenoidae	*Euglena viridis*
Euglenophyta	Euglenophyceae	Euglenoidae	*Euglena sanguinea*
Euglenophyta	Euglenophyceae	Euglenoidae	*Euglena gracillis*
Cyanophyta	Cyanophyceae	Chroococcaceae	*Chroococcus turgidis*
Cyanophyta	Cyanophyceae	Oscillatoriaceae	*Oscillatoria princeps*
Cyanophyta	Cyanophyceae	Nostocaceae	*Nostoc muscoru*
Cyanophyta	Cyanophyceae	Nostocaceae	*Anabaena spp.*
Cyanophyta	Cyanophyceae	Scytonemataceae	*Scytonema simplex*
Cyanophyta	Cyanophyceae	Rivulariaceae	*Gloeotrichia indica*
Cyanophyta	Cyanophyceae	Microcystaceae	*Microcystis aeruginosa*

Cyanophyta	Cyanophyceae	Microcystaceae	*Microcystis flosaquae*
Dinoflagellata	Dinophyceae	Peridiniaceae	*Peridinium spp.*
Dinoflagellata	Dinophyceae	Ceratiaceae	*Ceratium spp.*

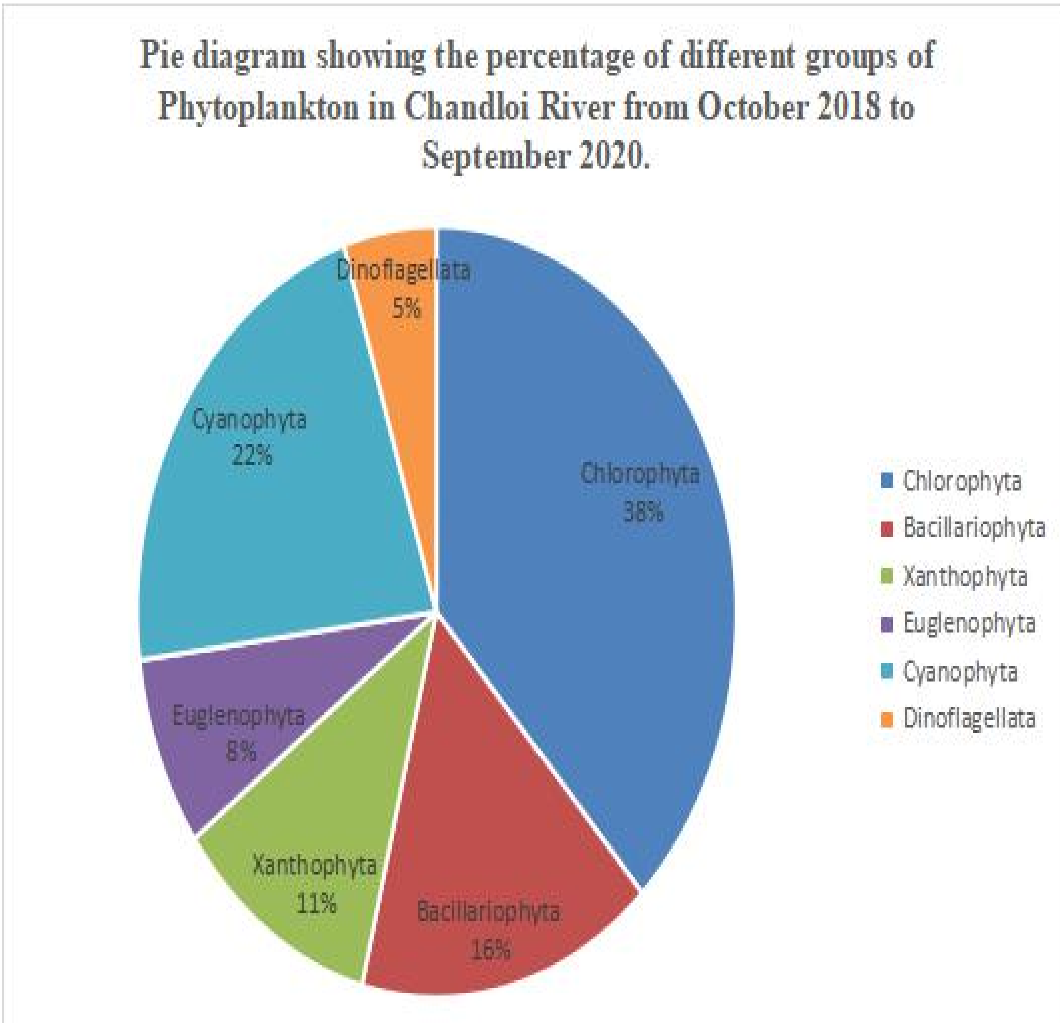

Pie diagram showing the percentage of different groups of Phytoplankton in Chandloi River from October 2018 to September 2020.
Dinoflagellata 5%
Cyanophyta 22%
Chlorophyta 38%
Euglenophyta 8%
Xanthophyta 11%
Bacillariophyta 16%
Chlorophyta
Bacillariophyta
Xanthophyta
Euglenophyta
Cyanophyta
Dinoflagellata

Table 30: Qualitative estimation of Zooplankton in Chandloi River (Kota) during October 2018 to September 2020.

Phylum	**Class**	**Family**	**Genus & Species**
Rotifera	Monogonata	Lacanidae	*Lecane spp.*
Rotifera	Monogonata	Lacanidae	*Monostyla bulla*
Rotifera	Monogonata	Notommatidae	*Scaridium longicaudum*
Rotifera	Monogonata	Brachionidae	*Brachionus calcyflorus*
Rotifera	Monogonata	Brachionidae	*Brachionus forficula*
Rotifera	Monogonata	Brachionidae	*Kertella tropica*
Rotifera	Monogonata	Brachionidae	*Kertella procurva*
Rotifera	Monogonata	Brachionidae	*Notholca spp.*
Protozoa	Ciliata	Parameciidae	*Paramecium caudatum*
Protozoa	Ciliata	Vorlicelldae	*Vorticella campanula*
Protozoa	Ciliata	Oxytrichidae	*Oxytricha ovalis*
Protozoa	Ciliata	Oxytrichidae	*Eeuplotes spp.*

Protozoa	Ciliata	Tracheliudae	*Trachelius ovum*
Protozoa	Ciliata	Enchelyidae	*Lacrymaria olor*
Protozoa	Ciliata	Ophryoglenidae	*Ophryoglena flava*
Arthropoda	Branchiopoda	Streptocephali	*Streptocephalus dichotomus*
Arthropoda	Branchiopoda	Triopsidae	*Triops longicaudatus*
Arthropoda	Cladocera	Daphinidae	*Daphnia carinata*
Arthropoda	Cladocera	Daphinidae	*Moina dubia*
Arthropoda	Cladocera	Daphinidae	*Simocephalus spp.*
Arthropoda	Cladocera	Daphinidae	*Ceriodaphnia spp.*
Arthropoda	Ostracoda	Cypridinidae	*Ostracode*
Arthropoda	Ostracoda	Cypridinidae	*Heterocypris*
Arthropoda	Copepoda	Diatomidae	*Heliodiaptomus viduus*
Arthropoda	Copepoda	Diatomidae	*Phyllodiaptomus annae*
Arthropoda	Copepoda	Diatomidae	*Spicodiaptomus chelospinus*
Arthropoda	Copepoda	Canthocamptidae	*Cletocamptus albuquerquensis*

Arthropoda	Copepoda	Cyclopidae	*Mesocyclops leuckart*
Arthropoda	Copepoda	Cyclopidae	*Mesocyclops hyalinus*

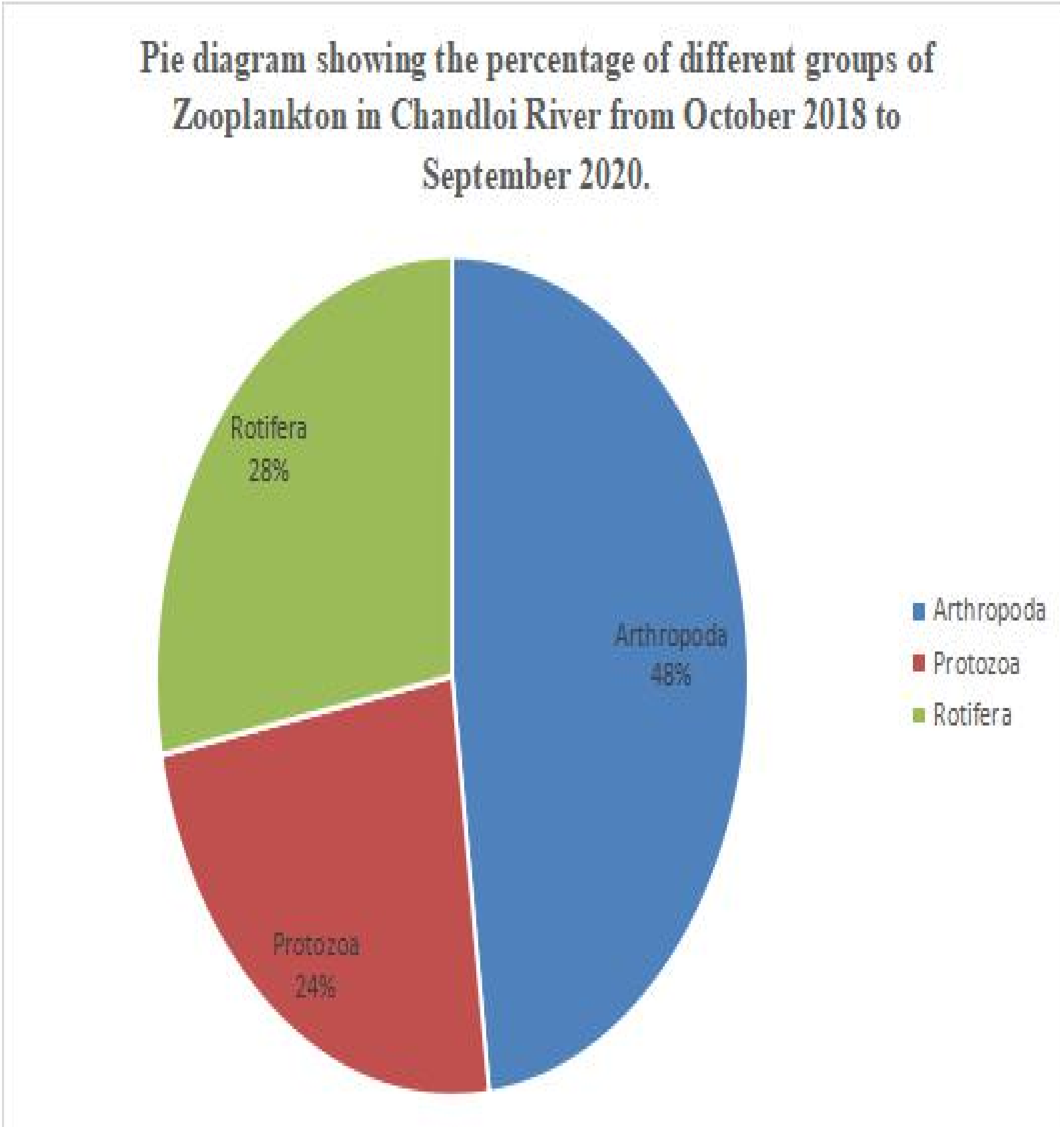

Pie diagram showing the percentage of different groups of Zooplankton in Chandloi River from October 2018 to September 2020.
Rotifera 28%
Arthropoda 48%
Protozoa 24%
Arthropoda
Protozoa
Rotifera

Table 31: Qualitative estimation of fishes in Chandloi River (Kota) during October 2018 to September 2020.

Phylum	Class	Order	Family	Genus & Species
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Mylopharyngodo n piceus*
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Crucian carassius*
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Cirrhinus cirrhosus*
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Labeo rohita*
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Labeo catla*
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Labeo calbasu*
Chordat a	Actinopterygi i	Cypriniformes	Cyprinidae	*Osteochilus vittatus*
Chordat a	Actinopterygi i	Anabantiformes	Channidae	*Channa argus*
Chordat a	Actinopterygi i	Anabantiformes	Channidae	*Channa striata*
Chordat	Actinopterygi	Siluriformes	Ariidae	*Plicofollis*

a	i			*dussumieri*
Chordata	Actinopterygii	Siluriformes	Siluridae	*Ompok bimaculatus*
Chordata	Actinopterygii	Siluriformes	Siluridae	*Wallago attu*
Chordata	Actinopterygii	Siluriformes	Siluridae	*Phalacronotus apogon*
Chordata	Actinopterygii	Siluriformes	Bagridae	*Sperata aor*
Chordata	Actinopterygii	Cichliformes	Cichlidae	*Oreochromis niloticus*
Chordata	Actinopterygii	Synbranchiformes	Mastacembelidae	*Mastacembelus moorii*

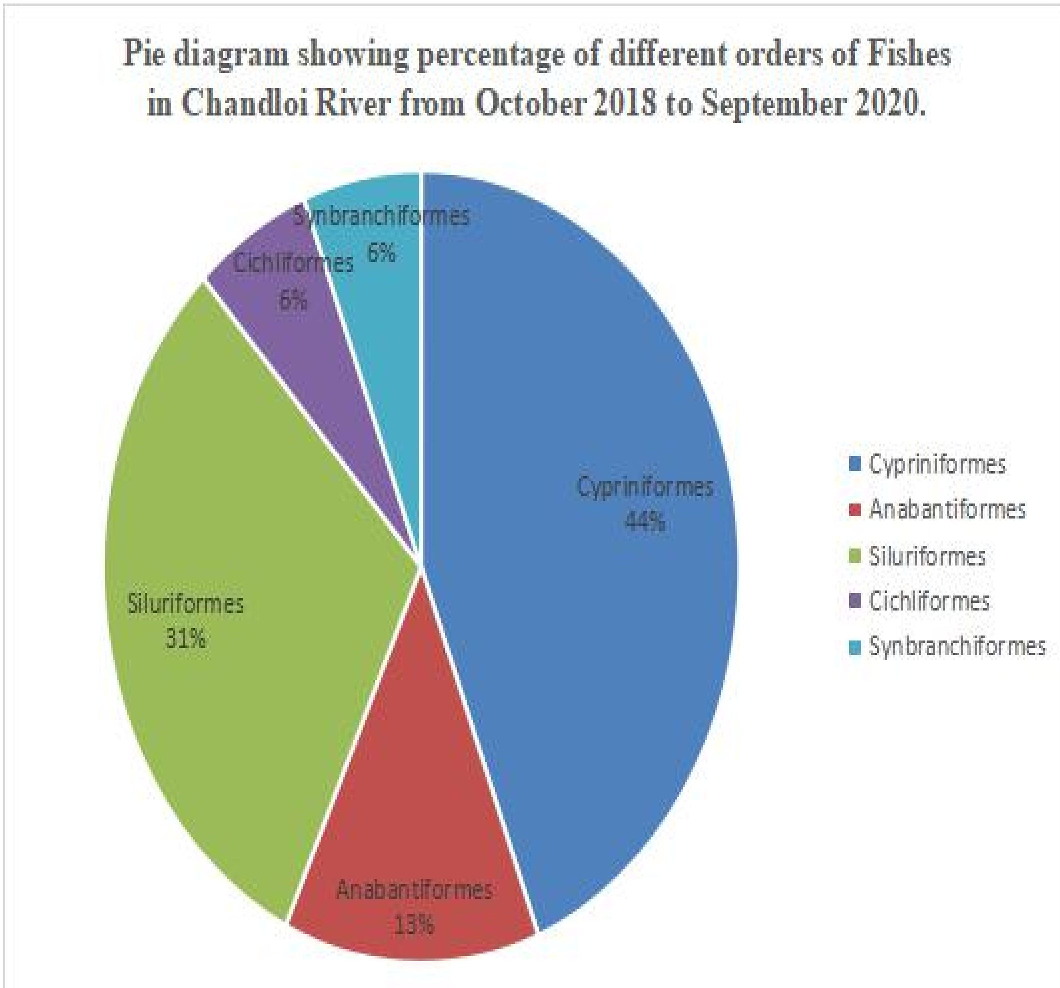

Pie diagram showing percentage of different orders of Fishes in Chandloi River from October 2018 to September 2020.
Synbranchiformes 6%
Cichliformes 6%
Cypriniformes 44%
Siluriformes 31%
Anabantiformes 13%
Cypriniformes
Anabantiformes
Siluriformes
Cichliformes
Synbranchiformes

Table (32): Qualitative estimation of benthic invertebrates in Chandloi River (Kota) during October 2018 to September 2020.

Phylum	**Class**	**Family**	**Genus & Species**
Mollusca	Gastropoda	Ampullariidae	*Pila pesmet*
Mollusca	Gastropoda	Ampullarriidae	*Pila ampullaceal*
Mollusca	Gastropoda	Bithyniidae	*Bithynia spp.*
Mollusca	Gastropoda	Lymnacidae	*Lymnaea acuminate*
Mollusca	Gastropoda	Lymnacidae	*Lymnaea glabra*
Mollusca	Gastropoda	Thiaridae	*Thiara tuberculata*
Mollusca	Bivalvia	Solenidae	*Solen spp.*
Mollusca	Bivalvia	Arcidae	*Arca granulose*
Mollusca	Bivalvia	Pholadidae	*Pholas dactylus*
Annelida	Hirudinea	Piscicolidae	*Piscicola spp.*
Annelida	Polychaeta	Nereidae	*Nereis spp.*
Annelida	Polychaeta		*Polychaete larve(unidentified)*
Annelida	Polychaeta	Nephtyidae	*Nephtys spp.*
Annelida	Oligochaeta	Tubificidae	*Branchiura spp.*
Annelida	Oligochaeta	Tubificidae	*Tubifex spp.*

Arthopoda	Insecta	Chironomidae	*Chironomus spp.*
Arthopoda	Insecta	Tabanidae	*Tabanus spp.*
Nematoda	Phasmidia	Rhabaditidae	*Rhabaditis cranganorencis*
Nematoda	Phasmidia	Diplogasleridae	*Gobindonemafili caudatum*
Nematoda	Aphasmidia	Hoplolamidae	*Helicotylenchuscren acauda*
Nematoda	Aphasmidia	Monhysteridae	*Monohystera pseudomacrura*
Nematoda	Aphasmidia	Monhysteridae	*Albunema indicum*

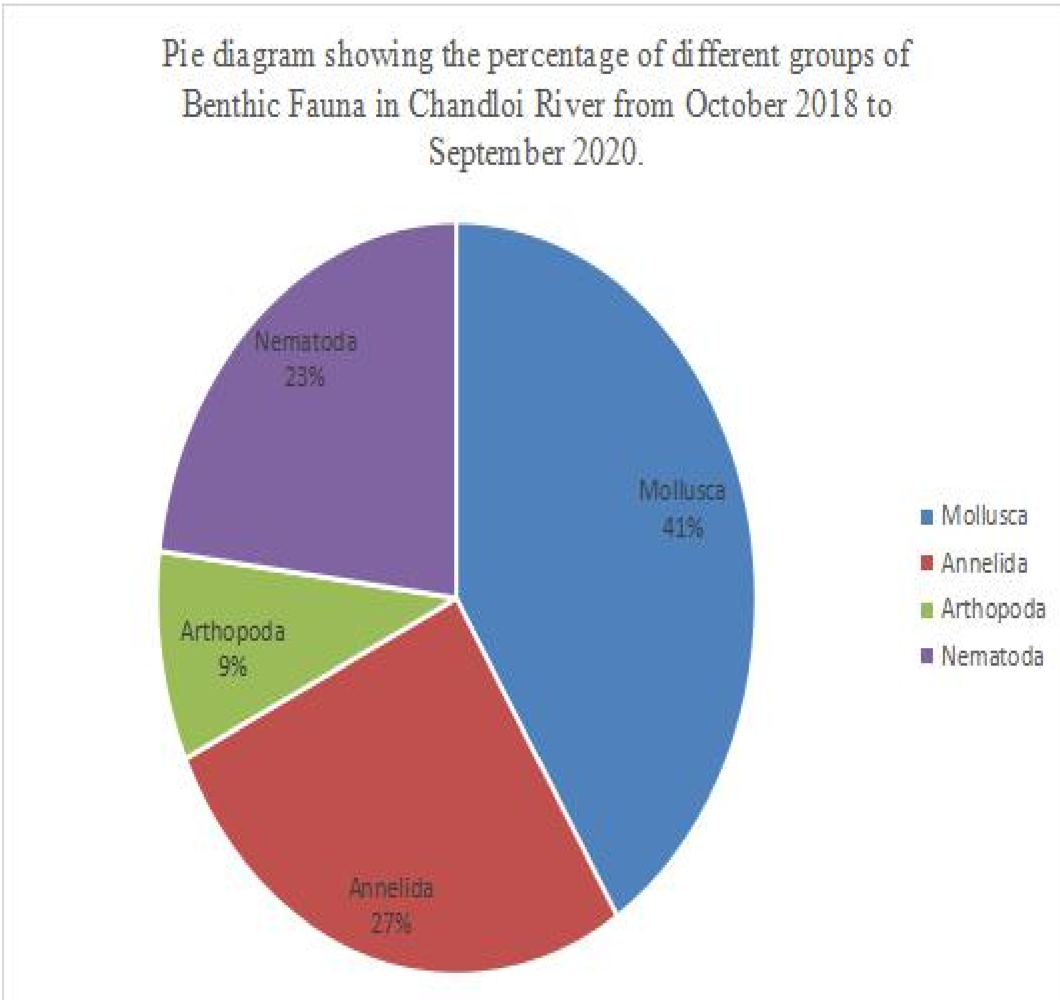
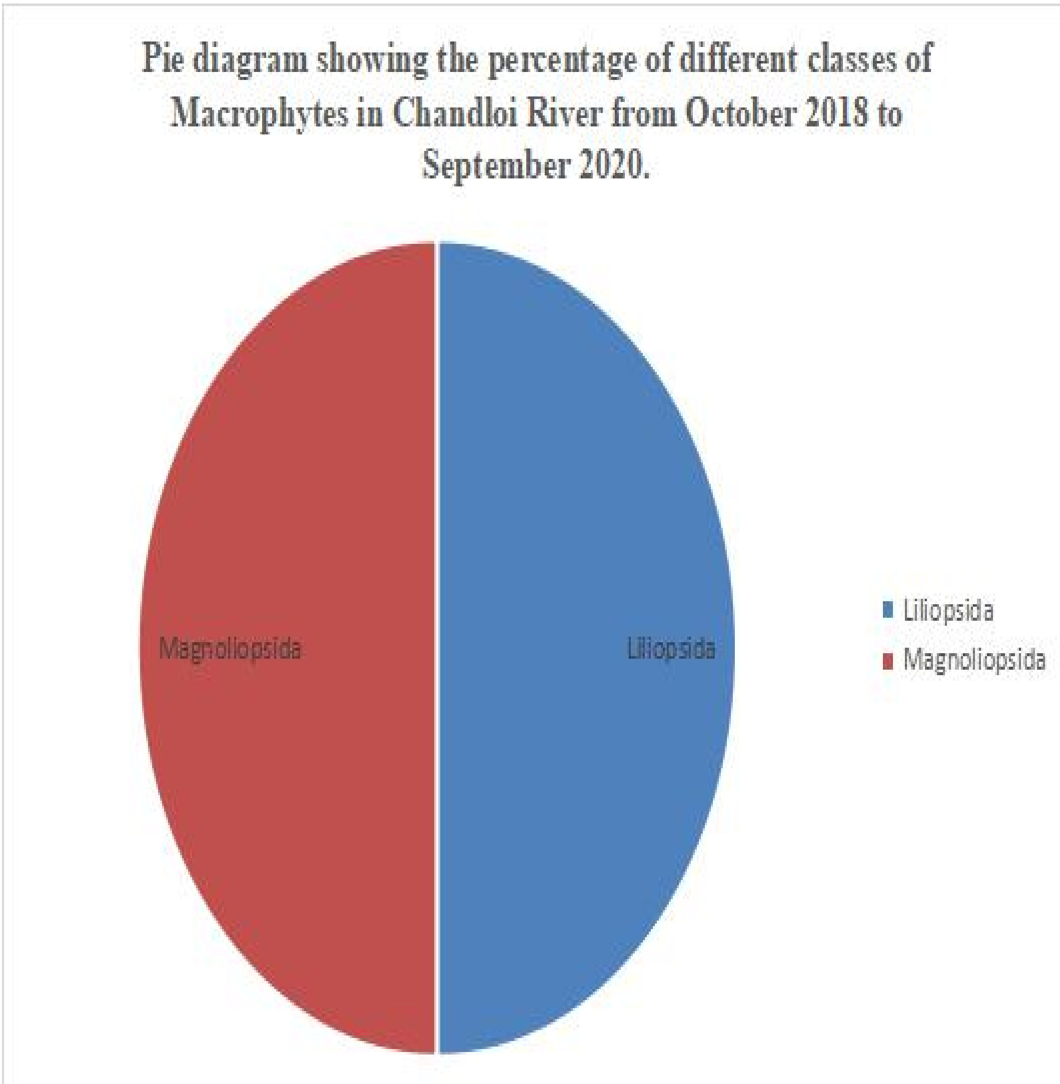

Pie diagram showing the percentage of different groups of Benthic Fauna in Chandloi River from October 2018 to September 2020.
Nematoda 23%
Mollusca 41%
Arthopoda 9%
Annelida 27%
Mollusca
Annelida
Arthopoda
Nematoda

Table 33: Qualitative estimation of macrophytes in and around of Chandloi River (Kota) during October 2018 to September 2020.

Phylum	**Class**	**Family**	**Genus& Species**
Magnoliophyta	Liliopsida	Alismataceae	*Sagittaria guayanensis*
Magnoliophyta	Liliopsida	Amaryllidaceae	*Crinum asiaticum*
Magnoliophyta	Liliopsida	Areceae	*Colocasiae sculanta*
Magnoliophyta	Liliopsida	Areceae	*Pistia stratiotes*
Magnoliophyta	Liliopsida	Cyperaceae	*Eleocharis atropurpurea*
Magnoliophyta	Liliopsida	Hydrocharitaceae	*Hydrilla verticillata, Vallisneria natans, Vallisneria spiralis*
Magnoliophyta	Liliopsida	Lemnaceae	*Wolffia arriza*
Magnoliophyta	Liliopsida	Pontederiaceae	*Eichhornia crassipes*
Magnoliophyta	Liliopsida	Typhaceae	*Typha angustata*
Magnoliophyta	Magnoliopsida	Amaranthaceae	*Alternanthera sessilis*
Magnoliophyta	Magnoliopsida	Menyanthaceae	*Nymphoides indica, N. hydrophilla*
Magnoliophyta	Magnoliopsida	Nymphaeaceae	*Nymphaea nouchali, N. pubescens*
Magnoliophyta	Magnoliopsida	Ceratophyllaceae	*Ceratophyllum*

			demersum
Magnoliophyta	Magnoliopsida	Convolvulaceae	*Ipomoea aquatic,* *Ipomoea carnea*
Magnoliophyta	Magnoliopsida	Scrophulariaceae	*Limnophila indica*
Magnoliophyta	Magnoliopsida	Aponogetonaceae	*Aponogeton natans*
Magnoliophyta	Magnoliopsida	Lentibulariaceae	*Utricularia aurea*


Pie diagram showing the percentage of different classes of Macrophytes in Chandloi River from October 2018 to September 2020.
Magnoliopsida
Liliopsida
Liliopsida
Magnoliopsida

Discussion

CHAPTER- V

DISCUSSION

LIMNOLOGICAL STUDIES OF CHANDLOI RIVER

Limnological studies includes aspects of the biological, chemical, physical and geological characteristics and functions of inland waters both running as in rivers (lotic ecosystem) and standing as lakes (lentic ecosystem), natural and man-made, fresh and saline. Limnology is closely related to aquatic ecology and hydrobiology, which study aquatic organisms and their interactions with the abiotic environment. The limnological discipline integrates the functional relationships of growth, adaptation, nutrient cycles and biological productivity with species composition, and describes and evaluates how physical, chemical and biological environments regulate these relationships. Francois-Alphonse Forel (1841-1912) was firstly proposed the term limnology. When publishing research on Lake Geneva. Forel is regarded as the founder of limnology not because his work was chronological first, but because of its long continued significance. The main aspect of the limnology is the biogenic material balance of natural waters. Ecological equilibrium between various living organism and surroundings is sustained by water.

There are many variations in the quality of water. Some water bodies have higher concentration of ions of many different kinds whereas others have extremely low concentration of a few ions. Rapid growth of industries along with urbanization has not only decreases the water availability, but also deteriorate the quality of water. Physical, chemical and biological characteristics of a water body determine how and far what water can be used and the species and ecosystem process it can support. According to WHO scarcity contamination of water supply and poor sanitation are responsible for 80% of all sickness and diseases. Health of various organisms including human being depends on good quality of water. The capacity of freshwater ecosystem to support biodiversity the natural variety, abundance and distribution of species across the aquatic environment is highly degraded at a global level.

Physico-chemical examination is important to evaluate the status of water for its best like irrigation, drinking, fisheries, industrial purpose and helpful to understand the complex processes, interaction between the biological processes in the water and climate.

The discussion is devoted for the evaluation of limnological studies of Chandloi River (from October 2018 to September 2020) and compares them with other rivers, reservoirs, lakes, streams, wetlands, groundwater, ponds and estuaries.

PHYSICO-CHEMICAL ANALYSIS OF WATER

Water temperature

The water temperature is important element for indicating the quality of water, determining aquatic life, concentration of dissolved gases and chemical solutes. The temperature not only affects of physiological process but also affects the density of water and stratification of water. Temperature of river water depends upon the season, climatic zone, where river is flowing, time of sampling, water depth besides solar radiation and topography. Most aquatic organisms have adapted to survive within a range of water temperature. Temperature also affects aquatic life sensitivity to toxic wastes and disease, either due to rising water temperature or the resulting decrease in dissolved oxygen, the consumption and physical activity and life process such as feeding, replication, motion and dispersal of aquatic organisms are greatly influenced by water temperature.

In the present study (from October 2018 to September 2020) the water temperature varied between 15.5^{0}C to 25.6^{0}C in The Chandloi River. The minimum temperature of 15.5^{0}C was recorded at site 3 in 2019 in Post Monsoon season and maximum temperature 25.6^{0}C was recorded at site 4 in 2018 in Pre Monsoon season. From October 2018 to September 2019, the water temperature was recorded from 15.9^{0}C to

25.6^{0}C. The minimum water temperature recorded in Post Monsoon and maximum in Pre Monsoon. The average of water temperature was 16.7^{0}C to 25^{0}C with average Standard Deviation of 4.55. During October 2019 to September 2020 this fluctuation was between 15.5^{0}C to 24.2^{0}C. The minimum water temperature recorded in Post Monsoon and maximum in Monsoon. The average of water temperature was 16.07^{0}C to 23.5^{0}C with average Standard Deviation of 4.21.

Kazanci and Dugel (2000) observed temperature values ranging from 21^{0}C to 32^{0}C of Yuvarlakcy Stream in the Koycegiz-Dalyan protected area, SW Turkey. Jain and Sharma (2001) studied temperature varied between 16^{0}C to 43^{0}C in Rampur Reservoir of Guna district (M.P.), India. Dwivedi and Pandey (2002) studied the temperature is one of the most important factor in the aquatic environment. Arjariya (2003) recorded temperature values range between 17.2 to 32.6^{0}C of Ranital Lake, Chhatarpur, Madhya Pradesh. Dwivedi *et al.* (2005) studied temperature between 21.5 to 32.5^{0}C in three Agro Climatic zones of Uttar Pradesh.

Kumar *et al.* (2006) studied temperature values varied between 23^{0}C to 34^{0}C in Kulahalli Tank near Harapanahalli, Karnataka. Kamal *et al.* (2007) recorded the temperature of Mouri River Khulna, Bangladesh between 21.6^{0}C to 32.2^{0}C. Prasad and Patil (2008) studied temperature between 30.3 to 31.8^{0}C in Krishna River water. Bhat *et al.* (2009) recorded water temperature ranged from 20^{0}C to 33^{0}C in some Urban Ponds of Lucknow, U.P. Joshi *et al.* (2009) recorded the water temperature of the Ganga at Haridwar ranged between 10.1^{0}C to 19.73^{0}C. The maximum water temperature started decreasing due to the melting of snow at the peaks of the Himalaya. The water temperature showed an upward trend from Winter season to Summer season followed by a downward trend from Rainy season onwards.

Singh *et al.* (2010) recorded water temperature range at Manipur River System from 16^{0}C to 28^{0}C showing minimum and maximum values during Winter and Summer seasons respectively in all the sites. Manjare *et al.* (2010) studied increased water temperature during Summer (June) may be linked to increase in day length, high air temperature, clear atmosphere and low water level in Tamdalge Tank in Kolhapur district, Maharashtra. Kumar *et al.* (2011) recorded the temperature of water bodies ranges from 18^0C to 33^0C and was highest in the month of October and the lowest in January in River Sabarmati and Kharicut Canal at Ahmedabad, Gujarat. Thirupathaiah *et al.* (2012) reported the range of temperature in between 24.75 to 28.5^0C in lower Manair Reservoir of Karimnagar district, Andhra Pradesh.

Weldermariam (2013) recorded temperature of Gudbahri River water at 12 different study points were between 20 to 30^0C and as it was Winter 26.03^0C, all samples complies with the standard. Temperature standard for sustaining aquatic life is 20 to 30^0C. Sharma *et al.* (2014) studied water temperature was corresponding the air temperature and it ranged from 11.7^0C (January) to 30.7^0C (June) of a lentic water body of Jammu, J.&K. Sarwade and Kamble (2014) recorded the temperature on both the sites of River Krishna, Sangli, Maharashtra ranged between 24.66 to 30^0C which was decreased in Post Monsoon and increased in Pre Monsoon on both the sites.

Srivastava *et al.* (2016) studied temperature of River Ganga varied from 33.8^0C to 36.5^0C. Saxena and Sharma (2017) studied temperature value ranged between 26.4^0C to 29.0^0C in and around Tekanpur area, Madhya Pradesh. Bhat *et al.* (2018) studied low water temperature was recorded in Winter 20.33^0C while the highest was recorded in the Summer 30^0C of River Yamuna. Pardesi (2019) recorded the temperature of all water samples of Pune area, India are in the range of 20 to 30^0C. Jannat *et al.* (2019) recorded the temperature range 23.3^0C to 30.8^0C of Mokeshbeel River, Gazipur, Bangladesh. Decreasing water level and increasing amount of insoluble pollutants during Summer make the water hotter as well as the discharge of pollutants can increase the temperature of water.

Abazi *et al.* (2020) recorded water temperature value of Sitnica River varied between 6.4^0C to 23.5^0C among three seasons Spring, Winter and Summer. Mishra and Kumar (2021) observed temperature value range between 21^0C to 26^0C in River Narmada.

Chouchan *et al.* (2021) studied temperature values between 22.4^0C to 32.5^0C of drinking water at various sites of Kota, Rajasthan.

Depth

Water depth is sometimes important as a determinant of volume and therefore flushing rate. The idea being that if two bodies of water have equal surface areas and hydrology the deeper one will have a greater volume and therefore lower flushing rate and nutrient concentration. Depth can also determining the likelihood of nutrient and particle re-suspension from wave action or other turbulence. Many water quality parameters such as temperature and dissolved oxygen vary with depth as well as with the time of day. The depth of light penetration, which is influenced by turbidity, has an effect on the productivity of plants in an aquatic ecosystem various depths in a river or lake host different assemblages of benthic (bottom dwelling) organisms. Plankton and fish move from one depth to another based on changing environmental conditions.

In the present study (from October 2018 to September 2020) the water depth varied between 92.25 Cm. to 310.25 Cm. in the Chandloi River. The minimum depth of 92.25 Cm. was recorded at site 3 in 2018 in Post Monsoon season and maximum depth 310.25 Cm. was recorded at site 1 in 2019 in Monsoon season. From October 2018 to September 2019, the water depth was recorded from 92.25 Cm. to 308.75 Cm. The minimum water depth recorded in Post Monsoon and maximum in Monsoon. The average of water depth was 118.5 Cm. to 296.56 Cm. with average Standard Deviation of 95.44. During October 2019 to September 2020, this fluctuation was between 94.75 Cm. to 310.25 Cm. The minimum water depth recorded in Post Monsoon and maximum in Monsoon. The average of water depth was 119.12 Cm. to 298.18 Cm. with average Standard Deviation of 96.14.

Singh *et al.* (2010) recorded depth of river varied from18.5 Cm. to 165 Cm. It was low during Summer at site III in Manipur River and deepest during Rainy at site VI in

Iril River. Sharma *et al.* (2014) studied depth of river varied from 19 Cm. during Summer to 49.7 Cm. during Monsoon season of a lentic water body of Jammu, J.&K.

Rahman *et al.* (2015) studied the maximum water depth was 385 Cm. found in August at lake 3 and minimum depth was 140 Cm. in March at lake 2 in Jahangirnagar University Campus, Madhya Pradesh. Hossain and Akther (2015) recorded water depth of Ramshagar Reservoir. Maximum depth of water was recorded in August 2012 as 10.90 m. whereas minimum one was recorded in February 2012 as 7.3 m. There is a seasonal variation in the depthness of water in water quality and rise in water level during Monsoon and Winter rains has been found.

Saxena and Sharma (2017) studied depth of bore wells ranged from 90-130 feet in all stations in and around Tekanpur area, M.P.

Turbidity

Turbidity is the cloudiness of water caused by a variety of particles and is another key parameter in drinking water analysis. It is also related to the content of diseases causing organisms in water, which may come from soil runoff. Turbidity is actually expression of optical property, in which the light is scattered by the particles present in water (Tyndall effect). Plankton and other microscopic organisms cause turbidity in water. Turbidity affects light scattering absorption properties and aesthetic appearance in a water body. Increase in the intensity of scattered light results in higher values of turbidity.

In the present study (from October 2018 to September 2020) the water turbidity varied between 8.5 NTU to 26.8 NTU in the Chandloi River. The minimum turbidity of 8.5 NTU was recorded at site 3 in 2018 in Pre Monsoon season and maximum turbidity 26.8 NTU was recorded at site 4 in 2018 in Monsoon season. From October 2018 to September 2019, the water turbidity was recorded from 8.5 NTU to 26.8 NTU. The minimum water turbidity recorded in Pre Monsoon and maximum in Monsoon. The average of water turbidity was 10.8 NTU to 24.9 NTU with average

Standard Deviation of 7.67. During October 2019 to September 2020 this fluctuation was between 9.3 NTU to 25.5 NTU. The minimum water turbidity recorded in Pre Monsoon and maximum in Monsoon. The average of water turbidity was 10.98 NTU to 24.2 NTU with average Standard Deviation of 7.40.

Garg *et al.* (2006) studied during winter and summer season settlement of silt, clay results in low turbidity and in Rainy season clay, silt and other suspended particles contribute to the turbidity high values. The average values were to 26.44, 26.18 and 25.27 NTU throughout the study period at S1, S2, S3 stations respectively of Harsi Reservoir, district Gwalior, M.P. Arasu *et al.* (2007) studied the turbidity value of Tamirabarani River water in South India. The magnificent parameter of river pollution is turbidity, the value of this parameter from the range 2 to 5 NTU which is well within the standard limit (W.H.O. 1984). It revels that the river pollution is well within the safe level. Antony *et al.* (2008) studied turbidity is significantly positively correlated with the temperature, nitrate, phosphate and free carbon dioxide where as significantly negative correlation with pH, alkalinity, transparency and dissolved oxygen. Agrawal *et al.* (2009) studied maximum turbidity 608.15 JTU in Monsoon season and minimum 19.15 JTU in Winter season of River Ganga in Haridwar district. Verma and Saksena (2010) studied turbidity is important parameter in the monitoring of water quality. The higher value of turbidity decreases light penetration in the water body.

Gupta *et al.* (2011) studied turbidity value between 3.9 to 8.2 NTU in River Chambal, Kota city. Yadav *et al.* (2012) studied the turbidity values varied between 1.1 NTU 31.4 NTU in selected groundwater samples of Agra city, India.

Kohle *et al.* (2013) recorded turbidity values varied with seasons in Godavari River, Nasik district. Monsoon season showed highest turbidity of 37.96 NTU as large quantities of suspended matter derived from catchment areas reaches the river, followed by Summer 6.64 NTU due to increased flow of water consequently enriching organic matter and least in Winter 5.70 NTU as water is less turbid and relatively clean. Tambekar *et al.* (2013) studied turbidity of water is an important parameter which influences the light penetration inside water and thus affect the aquatic life. The turbidity value of water sample of Wardha River in Pre Monsoon, Monsoon and Post Monsoon were found to be 124, 51.75, 12.02 NTU respectively.

Sarwade and Kamble (2014) studied the turbidity value of River Krishna, Sangli Maharashtra. The Maishal site showed the turbidity in the range 81.91 NTU in Monsoon to 141.16 NTU in Pre Monsoon and whereas Post Monsoon showed 66.99 NTU. Comparatively Sangli site showed lower turbidity recorded in Pre Monsoon 97.16 NTU, in Monsoon 69.875 NTU and in Post Monsoon 66.99 NTU. Turbidity of Mhaishal site was lower as that of Sangli site, which indicate high amount of suspended particles present at the Sangli site and found more polluted than Mhaishal site. Indu *et al.* (2015) recorded the turbidity range was 2 to 9 NTU in Winter and 3 to 8 NTU in Summer of surface water of Nawabganj Lake.

Saxena *et al.* (2016) recorded water turbidity values varied between 9.2 to 34 NTU in and around Jabalpur city of Madhya Pradesh. Turbidity was due to colloidal and extremely fine dispersion and was found within the limits prescribed by W.H.O. Pant *et al.* (2017) studied turbidity value range between 21.0 to 38.9 NTU in Himalayan Bhimtal Lake of Uttarakhand. Matta *et al.* (2018) recorded turbidity range between 19.15 to 608.15 JTU in Ganga River water at Rishikesh (Uttarakhand).

Kamboj and Kamboj (2019) studied maximum value of turbidity 364.15 NTU in Monsoon season while the minimum value 25.4 NTU in Winter season at riverbed-mining area of Ganga River, Haridwar. Saluja (2020) studied the turbidity value of Narmada River water in the range of 188 to 214 NTU. Abazi *et al.* (2020) recorded water turbidity value of Sitnica River varied between 2.9 NTU to 85 NTU among three seasons Spring, Winter and Summer. Mishra and Kumar (2021) recorded turbidity range between 1.1 to 15 NTU in Narmada water.

Hydrogen ion concentration (pH)

Hydrogen ion concentration is used to express the intensity of acidic or alkaline condition of the water or solution. pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. It provides an important piece factor and piece of information in many type of biochemical equilibrium or solubility calculation. At 25^0C, solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic. Solutions with a pH of 7 at this temperature are neutral (pure water). The neutral value of the pH depends on the temperature being lower than 7 if the temperature increases, the pH value can be less than 0 for very strong acids or greater than 14 for very strong bases. pH is an important quality that reflects the chemical condition of a solution. The pH can control the availability of nutrients, biological functions, microbial activity and the behaviour of chemicals.

In the present study (from October 2018 to September 2020) the water pH of Chandloi River varied between 8 to 9.2. The minimum pH of 8 was recorded at site 3 in 2019 in Monsoon season and maximum pH 9.2 was recorded at site 4 in 2018 in Pre Monsoon season. From October 2018 to September 2019, the water pH was recorded from 8.1 to 9.2. The minimum water pH recorded in Monsoon and maximum in Pre Monsoon. The average of water pH was 8.4 to 8.7 with average Standard Deviation of 0.15. During October 2019 to September 2020 this fluctuation was between 8 to 9.1. The minimum water pH recorded in Monsoon and maximum in Post Monsoon. The average of water pH was 8.4 to 8.7 with average Standard Deviation of 0.21.

Wang *et al.* (2002) studied aquatic organisms are affected by pH because most of their metabolic activities are pH dependent. Kazanci *et al.* (2003) studied pH values between 8.1 to 8.42 of Koycegiz-Dalyan Estuarine Channel System. Fakayode (2005) studied the pH of water body is very important in resolution of water quality since it affects other chemical reactions such as solvablity and metal toxicity. Parashar *et al.* (2006) studied physico-chemical characteristics in Upper Lake of Bhopal. pH was found to be all alkaline in nature in the range between 8.70 to 8.71 in Winter and 8.77 to 8.92 in Summer.

Arasu *et al.* (2007) recorded the pH values of the samples of the Tamirabarani River water in South India were between 7 and 7.4. The World Health Organization (W.H.O. 1984) prescribe the limiting value of pH as between 7.0 to 8.5 for a sample of water to be used for industrial, agricultural and domestic purposes. Kamal *et al.* (2007) recorded the pH value between 7.5 to 8.3 in Mouri River Khulna, Bangladesh. Shah *et al.* (2008) studied pH of Kharicut Canal passing through Vatva area of Ahmedabad city, Gujarat. They recorded pH range of water of 6.59 to 9.52. Malik *et al.* (2009) studied pH value varied between range as 7.25 to 8.05 minimum and maximum pH were recorded in hand pump and bore well water during Winter and Monsoon season respectively of industrial area at Gajraula (U.P.).

Singh *et al.* (2010) recorded the pH value ranged from 6.5 to 7.9 at Manipur River System, India. It was found to be alkaline in nature during Winter in all the four rivers. No significant difference in pH was observed during the study period except during Summer when the pH dropped to an acidic range 6.5 to 6.9. Varunprasath and Daniel (2010) observed pH range between 7.3 to 8.0 in Bhavani River Tamilnadu, India. Kumar *et al.* (2011) studied the pH range varied 6.50 to 9.52, whereas the canal water was found to be alkaline in River Sabarmati and Kharicut Canal at Ahmedabad, Gujarat. Khan *et al.* (2012) studied the fluctuation in the pH is because of divergence from the equilibrium due to photosynthetic activity and ionic composition to addition of agricultural and domestic waste of Triveni Lake water of Amravati district, M.P.

Gangwar *et al.* (2013) studied water quality index of River Ramganga at Bareilly, U.P. India. They recorded pH value range from 8.1 to 8.6. pH of river water was found highly basic in Winter. Tambekar *et al.* (2013) studied pH is an important parameter in evaluating the acid base balance of water. The pH of Wardha River water samples in Pre Monsoon season was found to be in the range 7.5 to 8.0, for Monsoon season in the range of 8.2 to 8.9 and for Post Monsoon 7.4 to 8.3. Devi *et al.*

(2013) recorded the pH value of aquaculture ponds in West Godavari region. Most of the water samples indicated slightly alkaline nature with pH varying from 7.5 to 8.1 with an average of 7.6. High pH was the result of high rates of carbon dioxide removal by phytoplankton for use in photosynthesis which indicates high phytoplankton density.

Sarwade and Kamble (2014) recorded the pH value was between 7.30 to 7.43 at both the sites of River Krishna, Sangli Maharashtra. Which was within the range of W.H.O. as standard of 6.50 to 6.9. Significant difference was not found in pH during the assessment period. Jadhav and Singare (2015) studied the average pH in 2012 was 7.24 and remained almost the same in year 2013 of Ulhas River water along Dombili city near Mumbai. Srivastava *et al.* (2016) studied pH of River Ganga water varied from 7.1 to 9.6. It was observed that the pH of water was found to be higher mostly during Monsoon period.

Gupta *et al.* (2017) recorded the pH values of River Narmada, Madhya Pradesh between 7.7 to 8.48. A narrow variation of pH is observed due to low annual variation in free CO_2. Bhat *et al.* (2018) studied the mean value of pH was reported to be varied from 7.03 to 7.71 at different sampling stations of River Yamuna. Jannat *et al.* (2019) recorded the pH of surface water samples of Mokeshbeel, Gazipur, Bangladesh. In study pH value varied from 7.3 to 7.7. These values of pH were within the standard limit 6.5 to 8.5 of Bangladesh Environmental Quality Standard. The result of the study revealed that the water was mostly alkaline, this may be due to the effluent containing alkali into the water.

Saluja (2020) studied the pH of the Narmada River water was found to be in the range of 7.2 to 7.8. Abazi *et al.* (2020) recorded water pH value of Sitnica River varied between 7.25 to 8.20 among three seasons Spring, Winter and Summer.

Mishra and Kumar (2021) observed pH range between 7.1 to 8.8 in Narmada River water. Chouchan *et al.* (2021) studied pH values between 6.7 to 8.3 of drinking water at various sites of Kota, Rajasthan.

Alkalinity

Alkalinity of water is interpreted as the quality and kind of compounds. Alkalinity value in water provides an idea of natural salts present in water. The cause of alkalinity is the minerals which dissolve in water from soil. The various ionic species that contribute to alkalinity includes bicarbonate, hydroxide, phosphate, borate and organic acids. Alkalinity is the measure of the capacity of the water to neutralize acids and it reflects its buffer capacity. Aquatic life require alkalinity buffer against rapid pH changes, it protects the living organisms who require a specific pH range. Alkalinity is also in important considering the treatment of wastewater and drinking water because it influences cleaning processes such as anaerobic digestion.

In the present study (from October 2018 to September 2020) the water alkalinity varied between 119.9 mg/ L. to 396.3 mg/ L. in the Chandloi River. The minimum alkalinity of 119.9 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum alkalinity 396.3 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon season. From October 2018 to September 2019, the water alkalinity was recorded from 119.9 mg/ L. to 140.05 mg/ L. The minimum water alkalinity recorded in Monsoon and maximum in Pre Monsoon. The average of water alkalinity was 123.9 mg/ L. to 133.7 mg/ L. with average Standard Deviation of 5.34. During October 2019 to September 2020 this fluctuation was between 196.1 mg/ L. to 396.3 mg/ L. The minimum water alkalinity recorded in Monsoon and maximum in Pre Monsoon. The average of water alkalinity was 201.6 mg/ L. to 384.4 mg/ L. with average Standard Deviation of 92.38.

Chatterjee and Raziuddin (2003) studied alkalinity value range between 160 to 420 mg/ L. in Loco Tank a Reservoir in Asansol Town, West Bengal. Sharma and Kumar (2004) studied the cause of alkalinity is the minerals which dissolve in water from soil. The various ionic species that contribute to alkalinity includes bicarbonate, hydroxide, phosphate, borate and organic acids. These factors are characteristics of the source of water and natural processes taking place at any given time. Surve *et al.*

(2005) studied the major portion of alkalinity in natural water is caused by hydroxide, carbonate and bicarbonate. Alkalinity itself was not harmful to human beings.

Parashar *et al.* (2006) studied alkalinity was found in the range of 76 mg/ L. to 88 mg/ L. in Winter and 88 to 90 mg/ L. in Summer in Upper Lake of Bhopal. A decline in alkalinity was observed which might be due to decomposition of organic matter during Winter. Arasu *et al.* (2007) studied all the water samples showed zero phenolphthalein alkalinity and have methyl orange alkalinity only. It indicates the alkalinity of the samples which are due to bicarbonate and not due to carbonate and hydroxide ions of the samples of the Tamirabarani River water in South India. Paulose and Maheshwari (2008) studied alkalinity range between 120 to 200 mg/ L. in Ramgarh Lake, Jaipur.

Malik *et al.* (2009) studied alkalinity in groundwater in the range between 260.17 to 339.83 mg/ L. in bore well and hand pump water during Winter and Monsoon season respectively of industrial area at Gajraula (U.P.). Singh *et al.* (2010) observed total alkalinity of the four rivers water fluctuated from 54 to 168 mg/ L. and found to be within permissible limit. It was minimum during Winter at site I in Imphal River and maximum during Summer at site IV in Thoubal River. Kumar *et al.* (2011) studied values of alkalinity varied from 110 to 190.66 mg/ L. The alkalinity of water were mainly due to bicarbonate and not due to carbonate and hydroxide ions in River Sabarmati and Kharicut Canal at Ahmedabad, Gujarat.

Yadav *et al.* (2012) studied the alkalinity value range between 330 mg/ L. to 525 mg/ L. in groundwater samples of Agra city, India. Gangwar *et al.* (2013) recorded the alkalinity value of River Ramganga at Bareilly, U.P. between 130 to 158 mg/ L. Alkalinity is influenced with carbonate and bicarbonate and other ions. The high concentration of sewage and industrial waste may be the cause of high alkalinity. Sarwade and Kamble (2014) studied alkalinity value between 193 mg/ L. (Rainy season) to 290 mg/ L. (Summer season) in Krishna River, Maharashtra.

Rajendran *et al.* (2015) recorded alkalinity ranges from 172 to 360 mg/ L. of River Cauvery in and around Nerur. The concentration of total alkalinity as $CaCo_3$ in water. The carbonate alkalinity is absent in all stations. The high alkalinity impacts water with unpleasant taste and may be deleterious to human health. Jadhav and Singare (2015) recorded the alkalinity value of Ulhas River water along Dombivali city near Mumbai. The average value of alkalinity in 2012 at sampling points S1, S2, S3 and S4 was 293.5, 354.5, 644.7 and 685.5 mg/ L. respectively. The average value of alkalinity in 2013 at sampling points S1, S2, S3 and S4 was 415.8, 416.7, 1496.7 and 1409.3 mg/ L. respectively. It is observed that the average alkalinity has increased by 89% from 494.6 mg/ L. in 2012 to 934.6 mg/ L. in 2013 at sampling point S3 after the addition of effluent discharge from Dombivli Industrial Belt.

Khadse *et al.* (2016) observed alkalinity range of 40 to 64 mg/ L. in Chenab River and its tributaries in Jammu Kashmir. Saxena *et al.* (2016) recorded alkalinity values range of 42 to 70 mg/ L. well below the values 120 and 200 mg/ L. prescribed by W.H.O. and I.S.I. respectively in or around Jabalpur city of Madhya Pradesh. Alkalinity is due to the presence of carbonates, bicarbonates and hydroxides of magnesium, calcium and sodium. Mamatha (2017) studied the alkalinity value of Hemavathi River water Tumkur, Karnataka, India. Alkalinity was found to be 140 mg/ L. for both S1 and S2 samples which is little higher than the standard limits.

Matta *et al.* (2018) recorded alkalinity ranges from 31.00 to 59.20 mg/ L. in Ganga River water. Banjara *et al.* (2019) studied the total water alkalinity value of River, Urban and Rural Ponds of Raipur district. The range of alkalinity was 151 to 190 mg/ L. Total alkalinity fluctuated in experimental water bodies, generally lower than the range (100 to 120 mg/ L.).

Saluja (2020) studied alkalinity range of Narmada River water between 148 to 176 mg/ L. Mishra and Kumar (2021) observed maximum alkalinity concentration of greater than 227 mg/ L. which might be due to excessive input of organic waste enriched wastewater from agricultural and domestic area.

Hardness

Hardness is the property of water which can enhance its potability and consumer acceptability for drinking purposes and increases the boiling point of water. Total hardness is the parameter of water quality used to describe the effect of dissolved minerals (mostly Ca and Mg) determining solubility of water for domestic, industrial and drinking purposes. Hardness of water mostly depends upon the amount of magnesium or calcium salts or both. The widespread abundance of these metals in rock formation leads often to very considerable hardness levels in surface and ground waters.

In the present study (from October 2018 to September 2020) the water hardness varied between 123.4 mg/ L. to 139.5 mg/ L. in the Chandloi River. The minimum hardness of 123.4 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum hardness 139.5 mg/ L. was recorded at site 4 in 2018 in Pre Monsoon season. From October 2018 to September 2019, the water hardness was recorded from 123.4 mg/ L. to 139.5 mg/ L. The minimum water hardness recorded in Monsoon and maximum in Pre Monsoon. The average of water hardness was 125.23 mg/ L. to 135.97 mg/ L. with average Standard Deviation of 6.12. During October 2019 to September 2020 this fluctuation was between 123.83 mg/ L. to 139.33 mg/ L. The minimum water hardness recorded in Monsoon and maximum in Pre Monsoon. The average of water hardness was 125.68 mg/ L. to 135.92 mg/ L. with average Standard Deviation of 5.76.

Garg (2003) studied hardness results from the presence of divalent cations of which Ca^{++} and Mg^{++} which are most abundant in groundwater. The higher hardness value in Summer season was mainly attributed to rising temperature thereby increasing the solubility of calcium and magnesium salts. Surve *et al.* (2005) studied the variations of total hardness are due to the fluctuations in the quality of water and waste disposals in the river. The hardness in the water is due to the dissolved minerals from sedimentary rocks, seepage and run-off.

Kumar *et al.* (2006) studied total hardness values between 70 to 94 mg/ L. in Kulahalli Tank near Harapanahalli, Karnataka. Alam *et al.* (2007) studied water quality parameter along rivers. They observed total hardness of the Surma River increases along the downstream. Hardness values of water samples varied from 30.20 to 70.20 ppm as $CaCo_3$, which is fit for drinking use. Hardness values for the dry season are higher than that for the Monsoon. Prasad and Patil (2008) recorded total hardness values of Krishna River water particularly in Western Maharashtra. Total hardness ranges from 30 ppm to 65 ppm. It is having minimum value at Arjunwad and maximum value at Narsingwadi site. The increase in hardness may be due to domestic activities like washing clothes, animals, vehicles, etc. done at the river site.

Malik *et al.* (2009) studied total hardness of groundwater range between 230.64 to 290.18 mg/ L. in bore well and hand pump water during Summer and Monsoon season respectively. Singh *et al.* (2010) studied total hardness values in the four rivers varied from 38 to 136 mg/ L. Minimum value in site I from Imphal River during Rainy season and maximum value in Thoubal River from site IV during Summer season were recorded.

Shinde *et al.* (2011) studied total hardness is due to the concentration of alkaline earth metals. Ca^{++} and Mg^{++} ions are the principal cations imparting hardness of Harsool-Savangi Dam, district Aurongabad. Yadav *et al.* (2012) studied total hardness value varied between 240 mg/ L. to 1425 mg/ L. in groundwater of Agra city. Tambekar *et al.* (2013) studied water quality around Chandrapur district, Maharashtra. Total hardness of water is a measure of the soap consuming capacity of water. Hard water also has harmful health impacts and also directly affects many industrial process including boilers. The amount of total hardness in Wardha River water samples in Pre Monsoon, Monsoon and Post Monsoon season was found to be in the range of 230-360, 196-305, 348-400 mg/ L. Mishra *et al.* (2014) recorded total hardness ranged from 210 to 400 mg/ L. of the ponds of Varanasi Holy city.

Rajendra *et al.* (2015) studied hardness of River Cauvery in and around Nerur. Hardness is measure of polyvalent cations (ions with a charge greater than +one) in water. Water with high hardness values are referred to as 'hard', while those with low hardness values are 'soft'. The total hardness in the study area varies between 164 to 1000 mg/ L. Saxena *et al.* (2016) recorded the total hardness values in the range of 320 to 670 mg/ L. in or around Jabalpur city of Madhy Pradesh, which showed some values higher than the permissible limit prescribed by W.H.O. (500 mg/ L.). Saxena and Sharma (2017) studied total hardness value varied between 310 mg/ L. to 418 mg/ L. in and around Tekanpur area, M.P.

Anusiya Devi and Lekeshmanaswamy (2018) studied the values of total hardness ranged from 156 (during April) to 670 mg/ L. (during October) of Perur Chettipalayam Lake, Coimbatore, Tamilnadu. Kamboj and Kamboj (2019) studied total hardness values in the range of 127 to 134 mg/ L. in riverbed-mining area of Ganga River, Haridwar.

Saluja (2020) studied total hardness of Narmada River water samples range between 214 mg/ L. to 262 mg/ L. Mishra and Kumar (2021) observed total hardness range between 310 to 400 mg/ L. in Narmada water.

Free Carbon Dioxide

Carbon dioxide is the end product of organic carbon degradation in almost all aquatic environment and its variation is often a measure of net ecosystem metabolism. Therefore, in aquatic biogeochemical studies, it is desirable to measure parameter. It fluxes across the air-water and sediment water interface are among the most important concerns in global change studies and are often a measure of the net ecosystem production metabolism of the aquatic system. Higher concentration of Co_2 is considered to be the indicator pollution due to higher organic waste of the animal origin and industrial effluents. The Co_2 status of river is indicate of degree of pollution especially of animal origin.

In the present study (from October 2018 to September 2020) the water concentration of free carbon dioxide varied between 0.45 mg/ L. to 2.35 mg/ L. in the Chandloi River. The minimum free carbon dioxide of 0.45 mg/ L. was recorded at site 4 in 2018 in Post Monsoon season and maximum free carbon dioxide 2.35 mg/ L. was recorded at site 2 and site 3 both in 2019 in Monsoon season. From October 2018 to September 2019, the free carbon dioxide concentration was recorded from 0.45 mg/ L. to 2.33 mg/ L. The minimum free carbon dioxide concentration recorded in Post Monsoon and maximum in Monsoon. The average of free carbon dioxide concentration was 0.55 mg/ L. to 1.76 mg/ L. with average Standard Deviation of 0.62. During October 2019 to September 2020 this fluctuation was between 0.5 mg/ L. to 2.35 mg/ L. The minimum water concentration of free carbon dioxide recorded in Post Monsoon and maximum in Monsoon. The average water concentration of free carbon dioxide was 0.57 mg/ L. to 1.81 mg/ L. with average Standard Deviation of 0.63.

Arjariya (2003) studied carbon dioxide value range between 2.95 to 7.05 ppm of Ranital Lake, Chhatarpur, M.P. Kumar *et al.* (2006) studied free carbon dioxide values range between 0.50 to 2.66 mg/ L. in Kulahalli Tank near Harapanahalli, Karnataka. Paulose and Maheshwari (2008) studied free carbon dioxide range between 0.0 to 9.6 mg/ L. in Ramgarh Lake, Jaipur, Rajasthan.

Agarwal *et al.* (2009) studied free carbon dioxide fluctuation from 1.15 mg/ L. in Winter season to 5.39 mg/ L. in Rainy season of River Ganga in Haridwar district. Sheeba and Ramanujan (2009) recorded the free carbon dioxide content in Ithikkara River, Kerala, India. Annual averages showed that carbon dioxide content of the water at upstream region was found to be high (highest at station I, 6.3 mg/ L.). The surface water of upstream region is from the flowing ground water which is filtering through the soil containing, decomposing matters. This might be the reason for the high quantity of carbon dioxide in upstream region. Similar pattern of the distribution of carbon dioxide content was observed in wet season (highest at station I, 7 mg/ L.).

Singh *et al.* (2010) studied free carbon dioxide values were found to be maximum during Summer in almost all studied sites. It's maximum value 22.3 mg/ L. in site V (Iril River). The highest values of carbon dioxide recorded in Summer might have been due to deoxygenation. Kumar *et al.* (2011) studied the average value of free carbon dioxide concentration range between 4.75 to 9.5 mg/ L. in River Sabarmati and Kharicut Canal at Ahmedabad, Gujarat.

Kohle *et al.* (2013) recorded free carbon dioxide values in Godavari River, Nasik district. Winter season showed higher amount of free carbon dioxide 8.33 mg/ L. as compared to Monsoon season 6.55 mg/ L. followed by Summer 6.45 mg/ L. Level of free carbon dioxide varies inversely with level of dissolved oxygen. Bastola (2013) recorded free carbon dioxide concentration 5.6 mg/ L. in August and lowest 1.8 mg/ L. in January of Deepang Lake in Pokhara Valley, Nepal. The photosynthetic activity of plankton in an aquatic environment is considered as an important critical factor for the fluctuation of carbon dioxide and pH level.

Sarwade and Kamble (2014) recorded the free carbon dioxide values were found to be maximum during Summer in both the sites. Carbon dioxide showed the range of 16.13 mg/ L. minimum and 66 mg/ L. maximum during the study period. It may be due to decreased in productivity leading to decomposition forming more carbon dioxide in the water. Rahman *et al.* (2015) recorded the free carbon dioxide ranged from 16 mg/ L. to 62 mg/ L. from lake 1 and lake 2 respectively was conducted Jahangirnagar University Campus, Madhya Pradesh. Hossain and Akther (2015) recorded the free carbon dioxide values in Rashagar Reservoir, Dighi, Bangladesh. Free carbon dioxide value of the water ranged from 0.00 to 2.2 mg/ L. in the months of July and December respectively during the period of May to April 2012. During the study period mean of free carbon dioxide value of the water was estimated at 0.86 mg/ L.

Sharma and Singh (2016) studied the value of free carbon dioxide ranged from 26.6 mg/ L. to 36 mg/ L. of water of Pani ki Dharamsala, Jhansi, India. Pant *et al.* (2017)

studied values of free carbon dioxide was varied between 18 to 18.7 mg/ L. The free carbon dioxide was nil during most of the year (January to July) due to optimum temperature, high rates of photosynthesis and decomposition of organic matter. Anusiya Devi and Lekeshmanaswamy (2018) studied free carbon dioxide concentration in water indicates the presence of decomposable organic matter, bacterial action on organic matter and physiological activities of biotic components. CO_2 content of water is essential sources of carbon that, can be assimilated incorporated into the skeleton of living matter especially in aquatic autotroph.

Banjara *et al.* (2019) studied the free carbon dioxide value of river, urban and rural ponds of Raipur district. The free carbon dioxide level was 2 mg/ L. to 5 mg/ L. recorded. During the Summer season highest concentration of free carbon dioxide recorded at Navagaon Pond (Urban Pond).

Nalawade and Bagul (2020) studied the mean free carbon dioxide values at S-1 and S-2 vary from 1±0.15 mg/ L. to 2.55±0.59 mg/ L. Phytoplankton and macrophytes community influences the concentration of free carbon dioxide values, as they require light and nutrient supply to convert dissolved CO_2 into plant tissue by photosynthesis.

Dissolved oxygen (DO)

Dissolved oxygen is a measure of how much oxygen is dissolved in the water. The amount of oxygen available to living aquatic organisms in a water body can tell us a lot about its water quality also this dissolved oxygen is breathed by fish and other fauna and is needed by them to survive. Bacteria in water can consume oxygen as organic matter decays. Thus excess organic material in lakes and rivers can cause eutrophic condition, which is an oxygen deficient situation that can cause a water body to die. Dissolved oxygen in surface water is used by all forms of aquatic life therefore, this constituent typically is measured to assess the health of lakes and rivers.

In the present study (from October 2018 to September 2020) the dissolved oxygen in water varied between 3.98 mg/ L. to 7.33 mg/ L. in the Chandloi River. The minimum dissolved oxygen of 3.98 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon season and maximum 7.33 mg/ L. was recorded at site 3 in 2018 in Monsoon season. From October 2018 to September 2019, the dissolved oxygen concentration was recorded from 4.13 mg/ L. to 7.33 mg/ L. The minimum dissolved oxygen concentration recorded in Pre Monsoon and maximum in Monsoon. The average of dissolved oxygen concentration was 5.31 mg/ L. to 6.39 mg/ L. with average Standard Deviation of 0.56. During October 2019 to September 2020 this fluctuation was between 3.98 mg/ L. to 7.1 mg/ L. The minimum water concentration of dissolved oxygen recorded in Pre Monsoon and maximum in Post Monsoon. The average water concentration of dissolved oxygen was 5.27 mg/ L. to 6.34 mg/ L. with average Standard Deviation of 0.57.

Kazanci and Dugel (2000) observed DO value between 5.9 to 6.6 mg/ L. of Yuvarlakcay Stream in the Kycegiz- Dalyan protected area, SW Turkey. Shanthik *et al.* (2002) studied concentration below 5 mg/ L. may adversely affect the functioning and survival of biological communities and below 2 mg/ L. may lead to fish mortality. Water without adequate DO may be considered waste water. Presence of DO in water may be due to direct diffusion from air and photosynthetic activity of autotroph. Arjariya (2003) recorded DO values between 4.5 to 14.6 ppm of Ranital Lake, Chhatarpur, M.P.

Fakayode (2005) studied DO content, plays a vital role in supporting aquatic life and is susceptible to slight environmental changes. Oxygen depletion often results during times of high community respiration. And hence DO has been extensively used as a parameter delineating water quality and to evaluate the degree of freshness of a river. Parashar *et al.* (2006) studied physico-chemical characteristics in Upper Lake of Bhopal. The DO concentration of all the stations were in the range of 7.00 to 7.30 mg/ L. in Winter and 6.50 to 7.20 mg/ L. in Summer. Value of DO increased in Winter due to circulation of cold water as well as high solubility of oxygen at low temperature. Wetzel and Likens (2006) studied DO is an important limnological parameter indicating level of water quality and organic pollution in the water body.

Alam *et al.* (2007) studied water quality parameters along rivers and they recorded DO value for Surma River, along their particular reach lies in between 5.52 mg/ L. (dry) to 5.72 mg/ L. (Monsoon) whereas for drinking purpose it is 6 mg/ L. Prasad and Patil (2008) recorded the DO value between 0.025 to 1.00 mg/ L. in Krishna River water.

Sheeba and Ramanujan (2009) recorded the DO content of Ithikkara River, Kerala, India. In all stations DO content of water was high during wet season. This may be due to the mixing up of atmospheric oxygen. The lower values of oxygen during Summer months may be due to the loss of oxygen to the atmosphere at higher temperature and utilization of oxygen for the fast decomposition of the settled organic matter. Observation shows that station 1 (8 mg/ L.) had highest value of DO and station 3 (6.6 mg/ L.) had lowest value. Bhat *et al.* (2009) recorded DO mean levels on some Urban Ponds of Lucknow, U.P. varied between 7.50 and 8.50 mg/ L.

Singh *et al.* (2010) studied DO content varied from 4.43 mg/ L. to 13.09 mg/ L. in the four rivers of Manipur River System, India. Kumar *et al.* (2011) studied the DO value at river upstream ranged from 4.998 to 7.742 mg/ L. in the month of July and January respectively. The DO value fell sharply in down stream of river in River Sabarmati and Kharicut Canal at Ahmedabad, Gujarat.

Thirupathaiah *et al.* (2012) studied DO was minimum during Summer season and maximum during Winter season. Decrease in DO value during Summer may be attributed to high temperature decreasing the oxygen holding capacity of water, increased day length light intensity which after acquiring the optimum values, start decreasing DO production, consumption due to decomposition of organic matter. Kohle *et al.* (2013) recorded dissolved oxygen value in Godavari River, Nasik district. Higher dissolved oxygen 7.21 mg/ L. in Winter was followed by Monsoon 5.03 mg/ L. and Summer 4.01 mg/ L. The depletion of dissolved oxygen values at various stations indicated that river was polluted and water quality was highly deteriorated during Summer months. Verla *et al.* (2014) studied DO ranges 4.33 to 6.00 mg/ L. in rice mill and oil industry effluent in Eastern Nigeria.

Indu *et al.* (2015) studied the DO content of surface water of Nawabganj Lake. The DO content in Winter season followed 5 to 7.7 mg/ L. and 5.1 to 7.4 mg/ L. in Summer. The introduction of oxygen demanding materials, either organic or inorganic into water causes depletion of the DO in the water. Singh *et al.* (2016) recorded the dissolved oxygen minimum value was 5.30 mg/ L. at Gangamahal Ghat and maximum was 7.3 mg/ L. at Shiwala Ghat in the Ganga River at Varanasi city in Uttar Pradesh, India. The different ghats having higher concentration of DO making it unsafe for drinking and other purposes. Saxena *et al.* (2016) recorded the dissolved oxygen values varied from 4.3 to 6 mg/ L., well within the prescribed limit (4-6 mg/ L.). Only at site S6 it was 3.4 mg/ L. in and around Jabalpur city of Madhya Pradesh. Appavu *et al.* (2016) recorded dissolved oxygen of Cauvery River water in Erode region. DO value show lateral, spatial and seasonal changes depending on industrial, human and thermal activity. In that study, the value of DO ranged from 5.04 mg/ L. in East followed by, 5.42 mg/ L. in North, 5.45 in South and 5.59 mg/ L. in West, respectively.

Gupta *et al* (2017) recorded the DO value ranges from 2.4 to 7.8 mg/ L. of river water of Narmada, Madhya Pradesh. The dissolved oxygen reveals the changes occur in the biological parameters due to aerobic or anaerobic phenomenon and signifies the condition of the river water for the purpose of the aquatic as well as human life. Bhat *et al.* (2018) studied the mean value of the DO varied from 0.08 mg/ L. (during the Summer) to 2.10 mg/ L. (during the Monsoon) in River Yamuna. Kamboj and Kamboj (2019) studied DO values in the range of 7.29 to 8.30 mg/ L. in riverbed-mining area of Ganga River, Haridwar.

Saluja (2020) studied the concentration of DO in Narmada River water in the range of 3.2 to 3.8 mg/ L. Abazi *et al.* (2020) recorded DO values of Sitnica River varied between 1.6 to 10.51 mg/ L. among three seasons Spring, Winter and Summer.

Mishra and Kumar (2021) observed DO value between 5.7 to 8.5 mg/ L. in Narmada water. Chouchan *et al.* (2021) studied DO values between 0.21 mg/ L. to 6.7 mg/ L. of drinking water at various sites of Kota, Rajasthan.

Chloride

Chloride is one of the major inorganic anion in water and water waste. Chloride usually occurs as NaCl, $CaCl_2$ and $MgCl_2$ in widely varying concentration in all natural waters. They enter water by solvent action of water on salts present in the soil, from polluting material like sewage, trade wastes and different anthropogenic activities. Higher concentration of chloride is considered to be the indicator pollution due to higher organic waste of animal origin or industrial effluents. Chloride concentration can induce a variety of ecological effects within both aquatic and terrestrial ecosystem. It can lead to the acidification of water body, mobilize toxic metals from soils through ion exchange, affect mortality and reproduction of aquatic plants and animals, alter community composition of plants.

In the present study (from October 2018 to September 2020) the chloride in water varied between 35.4 mg/ L. to 150.13 mg/ L. in the Chandloi River. The minimum chloride of 35.4 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum 150.13 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon season. From October 2018 to September 2019, the chloride concentration was recorded from 35.4 mg/ L. to 150 mg/ L. The minimum chloride concentration recorded in Monsoon and maximum in Pre Monsoon. The average of chloride concentration was 71.02 mg/ L. to 106.25 mg/ L. with average Standard Deviation of 18.28. During October 2019 to September 2020 this fluctuation was between 38.38 mg/ L. to 150.13 mg/ L. The minimum water concentration of chloride recorded in Monsoon and maximum in Pre Monsoon. The average water concentration of chloride was 72.02 mg/ L. to 106.22 mg/ L. with average Standard Deviation of 17.90.

Chatterjee and Raziuddin (2003) studied chloride value between 46 to 90 mg/ L. in Loco Tank, a Reservoir in Asansol Town, West Bengal. Ahmed (2004) recorded chloride content varied between 20.66 to 42.63 mg/ L. in Padma River at Mawa Ghat, Munshiganj. Kumar *et al.* (2006) studied high values of chloride in Summer months may be associated with high temperature which enhances the evaporation reducing the volume of water, thus resulting in the high concentration of salts and chloride also get added to water from the discharge of industrial effluents or contamination with sewage.

Arasu *et al.* (2007) studied the concentration of chloride and showed variations between 9.67 to 62.33 mg/ L. Throughout the course of the river the presence of Cl^{--} ions were within the limit. Sharma *et al.* (2008) recorded chloride between 12.8 to 28.7 mg/ L. in Ningland Stream, India. Prasad and Patil (2008) recorded chloride content of Krishna River water particularly in Western Maharashtra. Chloride content is minimum at Udgaon 3.4 ppm and maximum at Ankali that is 36.9 ppm. The high amount of chloride at Hasur may be due to local quality of soil.

Shaikh and Mandre (2009) studied chloride usually occurs as NaCl, $CaCl_2$ and $MgCl_2$ in widely varying concentration in all natural waters. They enter water by solvent action of water on salts present in the soil from polluting material like sewage and trade wastes. Malik *et al.* (2009) studied chloride values of groundwater were varied from 19.91 to 43.83 mg/ L. in bore well and hand pump water during Summer and Winter season respectively of industrial area at Gajraula, U.P. Singh *et al.* (2010) studied chloride content of the rivers varied from 20.66 to 42.68 mg/ L. in Manipur River System, India. The chloride reached their maximum value during Summer at site III when the water level was a considerably low and reached minimum during the Rainy season at site I (Imphal River) with comparatively high water levels.

Kumar *et al.* (2011) studied chloride value between 5.99 mg/ L. to 42.65 mg/ L. whereas Canal water showed extremely high values of chloride in river Sabarmati and Kharicut Canal at Ahmedabad, Gujarat. Yadav *et al.* (2012) studied chloride value varied between 295 to 1140 mg/ L. in groundwater in Agra city. Kohle *et al.* (2013) recorded chloride value in Godavari River, Nasik district. Higher values in

Monsoon 37.48 mg/ L., slightly less in Winter 37.20 mg/ L. and followed by Summer 29.95 mg/ L. Which may be due to different types of industrial wastes, activities of slum dwellers and municipal sewage drained into river water. Weldermariam (2013) recorded the mean chloride content of Godbahri River water was found 77.9 mg/ L. with a range from 18 to 92.9 mg/ L. and it is within the limit. Chloride increases with the increasing degree of eutrophication. The maximum chloride was found in site 12 and the minimum value was recorded in station 1.

Sarwade and Kamble (2014) recorded chloride value of River Krishna, Sangli, Maharashtra. Chloride showed lower value at Mhaishal site in Rainy season 66.62 mg/ L. as compared to Summer 91.09 mg/ L. and in Winter it was 131.6 mg/ L. may be due to dilution affect of rain water. Rajendran *et al.* (2015) recorded the chloride value ranges between 80 to 1700 mg/ L. in Cauvery River in and around Nerur. Chloride in surface and groundwater from both natural and anthropogenic sources, such as run off containing road deicing salts, the use of inorganic fertilizers, landfill leachates, septic tank effluents, animal feeds, industrial effluents, irrigation drainage, and sea water intrusion in coastal areas.

Appavu *et al.* (2016) recorded chloride value of Cauvery River water in Erode region. The chloride content showed very narrow changes in sampling points between four sites. The recorded values of East site 260 mg/ L., West 380 mg/ L., North 220 mg/ L. and South 159 mg/ L. Saxena and Sharma (2017) studied chloride is one of the major inorganic anions in water and wastewater. The permissible limit of chloride in drinking water was 250 mg/ L. The values observed in all samples are within the permissible limit in and around Tekanpur area, M.P.

Bhat *et al.* (2018) studied chloride from 133 to 398 mg/ L. during Monsoon and Summer season respectively of River Yamuna. Ahmed and Chaursasia (2019) studied chloride concentration between 14.32 to 25.16 mg/ L. in Ganga River at Kanpur.

Saluja (2020) studied the concentration of chloride in Narmada River water was in the range of 261 to 284 mg/ L. Mishra and Kumar (2021) observed chloride concentration between 13 to 244 mg/ L. in Narmada River.

Total Dissolved Solids (TDS)

Total Dissolved Solids is the presence of dissolved solids and it indicates the behaviour of salinity in the water. Waters with high dissolved solids generally inferior in portability and may induce an unfavourable physiological reaction in the transient consumer. TDS includes a wide range of metals, minerals, salts, anions and cations that are dissolved in water. Most often, water with a registered TDS has inorganic salts and small amounts of organic matter. TDS is directly related to the purity of water and the quality of water purification systems and affects everything that consumes, lives in, or uses water, whether organic or inorganic, whether for better or for worse.

In the present study (from October 2018 to September 2020) the total dissolved solids in water varied between 124.13 mg/ L. to 938.4 mg/ L. in the Chandloi River. The minimum total dissolved solids of 124.13 mg/ L. was recorded at site 3 in 2018 in Post Monsoon season and maximum 938.4 mg/ L. was recorded at site 4 in 2019 in Monsoon season. From October 2018 to September 2019, the total dissolved solids concentration was recorded from 124.13 mg/ L. to 927.6 mg/ L. The minimum total dissolved solids concentration recorded in Post Monsoon and maximum in Monsoon. The average of total dissolved solids concentration was 435.05 mg/ L. to 504.92 mg/ L. with average Standard Deviation of 37.66. During October 2019 to September 2020 this fluctuation was between 125.15 mg/ L. to 938.4 mg/ L. The minimum water concentration of total dissolved solids recorded in Post Monsoon and maximum in Monsoon. The average water concentration of total dissolved solids was 467.04 mg/ L. to 508.72 mg/ L. with average Standard Deviation of 21.68.

Kulshrestha *et al.* (2002) studied 840 to 1050 mg/ L. of total dissolved solids in tube well water during Summer season in Sanganer Town of Jaipur city. Jain (2002) studied TDS usually related to conductivity. Water containing more than 500 mg/ L. in Ganga River. TDS is not considered desirable for drinking water supplies, through more highly mineralized water may be used where better quality water is not available. Chatterjee and Raziuddin (2003) studied TDS value between 223 to 580 mg/ L. in Loco Tank, a Reservoir in Asansol Town, West Bengal.

Maiti (2004) studied TDS denote mainly the various kinds of minerals present in water. TDS is sum of the cations and anions concentration. A high content of dissolved solids elevates the density of water, influence osmoregulation of fresh water organism, reduces solubility of gases like oxygen and reduces utility of water for drinking, irrigation and industrial purposes. Efe *et al.* (2005) studied TDS value varied from 8363 to 9240 mg/ L. in Western Niger Delta region, Nigeria. Kumar *et al.* (2006) studied TDS values range between 109 to 275 mg/ L. in Kulahalli Tank near Harapanahalli, Karnataka. Kamal *et al*. (2007) recorded the TDS value from 255 to 305 mg/ L. in Mouri River Khulna, Bangladesh.

Paulose and Maheshwari (2008) studied TDS values between 142.2 to 603.1 mg/ L. in Ramgarh Lake, Jaipur. Malik *et al.* (2009) studied the values of total dissolved solids in groundwater ranged from 610.80 to 923.73 mg/ L. Lowest and highest values of TDS were recorded in bore well and hand pump water during Summer and Winter season respectively in industrial area at the Gajraula (U.P.). Singh *et al.* (2010) studied TDS values of water samples of Manipur River System, India. They recorded TDS values were comparatively lower at site 5th (280 mg/ L.) in Iril river during Winter season and higher at site 3rd (870 mg/ L.) during Rainy season in Manipur river. It’s lowest values were recorded during Winter season which gradually increased with the onset of Rainy season due to washed in materials from the catchment areas and erosion of river bank.

Kumar *et al.* (2011) studied TDS highest value in July 426.66 to 840 mg/ L. and minimum in January 40 to 133.33 mg/ L. in river Sabarmati and Kharicut Canal at

Ahmedabad, Gujarat. Yadav *et al.* (2012) studied the TDS values varied between 1020 mg/ L. to 4950 mg/ L. in selected ground water samples of Agra city, India.

Weldermariam (2013) recorded TDS of Gudbahri River water of Wukro, Eastern Tigrai. TDS standard in terms of inland surface water is 1000 mg/ L. (W.H.O.). The mean total dissolved solids concentration in Gudbahri River was found to be 470.17 mg/ L. which ranged from 326 to 770 mg/ L. and it is within the limit. Devi *et al.* (2013) recorded the TDS values ranged from 290 ppm to 24000 ppm with an average of 6204 ppm in West Godavari Ponds. High values of TDS can be attributed to possible seawater intrusion in Fish River in around Bhimavaram, West Godavari, district A. P. Gangwar *et al*. (2013) studied the TDS value in River Ramganga at Bareilly, U.P. India. They recorded TDS range between 250.6 to 279.3 mg/ L. TDS analysis has great implications in control of biological and physical waste water treatment processes.

Sarwade and Kamble (2014) recorded TDS values of River Krishna, Sangli, Maharashtra. The total dissolved solids found at Mhaishal site ranged between 206.83 to 360.7 mg/ L. comparatively Sangli site showed 284.66 to 479.33 mg/ L. throughout the working period. Jadhav and Singare (2015) studied average value of TDS in 2012 was 3343.7 mg/ L. which increased by 12% to 3735.4 mg/ L. in year 2013 of Ulhas River water.

Appavu *et al.* (2016) recorded TDS value of Cauvery River water in Erode region. The maximum value of TDS was at site South (1006 mg/ L.) and minimum at site East (900 mg/ L.). During the study, zone North and South relative amount of solutes were high due to decrease in the water level in the river. But slightly vary about North 1004 and West 905 mg/ L. Gupta *et al.* (2017) recorded the TDS range of 108 to 234 mg/ L. of the River Narmada, Madhya Pradesh. TDS is determined for measuring the amount of solid materials dissolved in the water.

Jannat *et al.* (2019) recorded total dissolved solids (TDS) of the water samples of surface water of Mokeshbeel, Gazipur, Bangladesh. TDS of water samples varied from 686 mg/ L. to 952 mg/ L. TDS concentration of all the water samples surpassed the maximum allowable limit (500 mg/ L.) of World Health Organization, but these values were within the allowable limit of Bangladesh Environmental Quality Standard (1000 mg/ L.). Pardesi (2019) recorded the total dissolve solids of Pavana River water, Sangvi, 315 ppm higher than standard limits (below 300 ppm). It is hard water so it should not use directly. It is necessary to make it soft by boiling and then filtration.

Saluja (2020) studied TDS value of Narmada River water in the range between 384 mg/ L. to 908 mg/ L. Abazi *et al.* (2020) recorded TDS values of Sitnica River varied between 131 to 390 mg/ L. among three seasons Spring, Winter and Summer.

Mishra and Kumar (2021) observed TDS values between 24 to 442 mg/ L. in Narmada River water. Chouchan *et al*. (2021) studied TDS value varied between 300 to 1715 mg/ L. of drinking water at various sites of Kota, Rajasthan.

Biological Oxygen Demand (BOD)

Biological Oxygen Demand is the amount of dissolved oxygen required for the biochemical decomposition of organic compound and oxidation of certain inorganic materials. The untreated discharge of municipal and domestic waste in water bodies increases the amount of organic content. It gives an indication of load of biodegradable organic material present in the water body. Dissolved oxygen measurement forms the basis of BOD analysis.

In the present study (from October 2018 to September 2020) the biological oxygen demand in water varied between 7.07 mg/ L. to 119.63 mg/ L. in the Chandloi River. The minimum biological oxygen demand 7.07 mg/ L. was recorded at site 3 in 2019 in Monsoon season and maximum 119.63 mg/ L. was recorded at site 4 in 2019 in Post Monsoon season. From October 2018 to September 2019, the biological oxygen demand concentration was recorded from 7.58 mg/ L. to 106 mg/ L. The minimum biological oxygen demand concentration recorded in Monsoon and maximum in Pre

Monsoon. The average of biological oxygen demand concentration was 24.73 mg/ L. to 61.7 mg/ L. with average Standard Deviation of 20.38. During October 2019 to September 2020 this fluctuation was between 7.07 mg/ L. to 119.63 mg/ L. The minimum water concentration of biological oxygen demand recorded in Monsoon and maximum in Post Monsoon. The average water concentration of biological oxygen demand was 45.24 mg/ L. to 69.06 mg/ L. with average Standard Deviation of 12.47.

Fokmare and Musaddiq (2002) recorded high value of biochemical oxygen demand as 20 mg/ L. in River Purna. River Purna was highly polluted due to organic enrichment, decay of plants and animal matter in the River. Chatterjee and Raziuddin (2003) studied BOD values varied between 14 to 39.60 mg/ L. in Loco Tank, a Reservoir in Asansol Town, West Bengal. Bhardwaj (2005) studied BOD values between 0.1 to 475 mg/ L. in Indian Rivers. Kumar *et al.* (2006) studied BOD values varied between 2 to 22 mg/ L. in Kulahalli Tank near Harapanahalli, Karnataka.

Alam *et al.* (2007) recorded water quality parameters along rivers. They studied BOD standard for drinking purpose is 0.2 mg/ L., which is exceeded to a great extent (dry-1.00 mg/ L., Monsoon- 0.878 mg/ L.) but for other purposes where the value is quite higher than 0.2 mg/ L., the Surma River water is quite satisfactory. Shymala *et al.* (2008) studied BOD is a measure of the oxygen in the water that is required by the aerobic organisms. The bio-degradation of organic materials exerts oxygen tension in the water and increases the biological oxygen demand.

Bhat *et al.* (2009) recorded BOD range was 0.04 to 0.6 mg/ L. in some Urban Ponds of Lucknow, U.P. Padhan and Sahu (2011) studied average BOD in rice mill effluent was 450 mg/ L. in Rice field Agroecosystem. Pathak and Limaye (2012) studied BOD value between 3.02 to 10.31 mg/ L. of ground water in rural area nearby Sagar city, M.P., India. Gangwar *et al.* (2013) studied the physico-chemical characterization of River Ramganga at Bareilly, U.P. India. They recorded BOD value ranges from 5.3 to 5.5 mg/ L. The observed BOD variations are due to the addition of little amount of organic matter. Tewari *et al.* (2014) studied BOD range 58.77 to 112.42 mg/ L. in city sewage discharged Into River, Arpa Bilaspur, India.

Indu *et al.* (2015) studied the BOD of the surface water of Nawabganj Lake. The mean BOD was similar in Winter 2 to 8 mg/ L. and in Summer 2 to 7 mg/ L. In most of the cases, the BOD was more during Summer and Winter season which might be due to reduced rate of water flow and the accumulation of waste from anthropogenic activities. Jadhav and Singare (2015) recorded BOD value of Ulhas River water along Dombivli city near Mumbai. The average value of BOD in 2012 at sampling points S1, S2, S3 and S4 was 74.7, 231.3, 296.3 and 310.3 mg/ L. respectively. The average value of BOD in 2013 at sampling points S1, S2, S3 and S4 was 76.7, 320, 366.3 and 365.3 mg/ L. respectively. The data indicate that there is an increase in the average concentration of BOD by 24% from 228.2 mg/ L. in 2012 to 282.1 mg/ L. in 2013. The values of BOD drastically increase at sampling point S2 after the addition of effluents from the Dombivli industrial area.

Appavu *et al.* (2016) studied the BOD value of Cauvery River water in Erode region. The value for BOD was found to be maximum 38 mg/ L. in West, followed by East 35 mg/ L., both North and South recorded as 25 mg/ L. Gupta *et al.* (2017) recorded the BOD values of River Narmada, Madhya Pradesh between 0.35 to 2.18 mg/ L. BOD is used for determination of requirement of oxygen for stabilizing household and industrial wastes. Bhat *et al.* (2018) studied BOD value range 8.75 ± 0.52 to 69.08 ± 6.58 mg/ L. in River Yamuna. Jannat *et al*. (2019) studied the BOD of the water samples varied from 26 mg/ L. to 102 mg/ L. of surface water of Mokshbeel, Gazipur, Bangladesh. BOD values were not suitable for fish culture or irrigation.

Saluja (2020) studied BOD value ranged from 8.6 mg/ L. to 9.4 mg/ L. in Narmada River water. Dunea *et al.* (2020) studied BOD value varied between 0.01 to 74.71 mg/ L. of Tandarei from the Ialomita River Basin.

Mishra and Kumar (2021) observed BOD ranges more than 5 mg/ L., indicating high organic loading in the river. Chouchan *et al.* (2021) studied BOD value varied between 25 to 502 mg/ L. of drinking water at various sites of Kota, Rajasthan.

Nitrate

The oxidized form of dissolved nitrogen is the main source of nitrogen for plants and the end product of the aerobic decomposition of organic nitrogenous matter. It occurs naturally in soil and dissipates when the soil is extensively farmed. Nitrates is an important parameter in understanding the nutritional status of water bodies. A nitrate content of more than 100 mg/ L. may cause physiological problem in all aquatic life. Concentration of nitrate stimulated the growth of aquatic plants and algae which provide food for fishes and other fauna. This may cause an increase in the fish population, but if algae grow too widely oxygen levels in the water will be reduced and fish and other fauna will die.

In the present study (from October 2018 to September 2020) the nitrate in water varied between 47.43 mg/ L. to 100 mg/ L. in the Chandloi River. The minimum 47.43 mg/ L. was recorded at site 3 in 2018 in Pre Monsoon season and maximum 100 mg/ L. was recorded at site 4 in 2018 in Post Monsoon season. From October 2018 to September 2019, the nitrate concentration was recorded from 47.43 mg/ L. to 100 mg/ L. The minimum nitrate concentration recorded in Pre Monsoon and maximum in Post Monsoon. The average of nitrate concentration was 59.95 mg/ L. to 85.92 mg/ L. with average Standard Deviation of 13.40. During October 2019 to September 2020 this fluctuation was between 54.65 mg/ L. to 91.68 mg/ L. The minimum water concentration of nitrate recorded in Pre Monsoon and maximum in Post Monsoon. The average water concentration of nitrate was 66.43 mg/ L. to 80.04 mg/ L. with average Standard Deviation of 7.04.

Royer *et al.* (2004) studied nitrate concentration range varied between 0.170 mg/ L. to 0.455 mg/ L. Minimum being during Winter and maximum being during Rainy season. Nitrate is attributed mainly due to anthropogenic activities such as run off water from agricultural lands, industrial wastes, discharge of household and municipal sewage from the market place and other effluents containing nitrogen. Dwivedi *et al.* (2005) studied nitrate values between 1.2 to 1.8 mg/ L. in three Agro Climatic zones of U.P. Kumar *et al.* (2006) studied nitrate value varied between 0.022 to 0.068 mg/ L. in Kulahalli Tank near Harapanahalli, Karnataka.

Arasu *et al.* (2007) recorded nitrate concentration in the River water of Tamirabarani in the range of 2.0 to 6.0 mg/ L. Nitrate is toxic and it has been reported that consumption of water with high levels of nitrate causes infantile methemoglobinemia and death. Paulose and Maheshwari (2008) studied nitrate value between 0.0 to 10.8 mg/ L. in Ramgarh Lake, Jaipur. Sheeba and Ramanujan (2009) recorded nitrate content of Ithikkara River, Kerala, India. The nitrate content of water in all stations was high between 4.9 to 4.6 µg/ L. during wet season except in station 1st (4.9 µg/ L.). The Monsoon showers might be responsible for the increase of the nitrate content during wet season. In station 1st nitrate content was high 5.6 µg/ L. in dry season, this may be due to the decomposition of the dead organic matter.

Singh *et al.* (2010) recorded nitrate concentration range 0.160 to 0.451 mg/ L. in Manipur River System. Minimum being during Winter at site II in Manipur River and maximum being during Rainy season at site IV in Thoubal River. Ghosh *et al.* (2012) studied nitrate values varied between 1.19 to 1.88 mg/ L. in different seasons in Santragachi Lake, West Bengal. Sharma and Chhipa (2013) studied nitrate was negatively correlated with pH and turbidity. Mishra *et al.* (2014) studied nitrate concentration in ponds of holy city Varanasi was found very high 52 mg/ L.

Indu *et al.* (2015) studied the nitrate content of surface water of Nawabganj Lake. Maximum and minimum range of nitrate was recorded in Winter 2 to11 mg/ L. and Summer 2 to 12 mg/ L. Rajendran *et al.* (2015) studied the physico-chemical parameters of Cauvery River in and around Nerur. They recorded nitrate level varies between 17 to 87 mg/ L. Human and animal waste, application of fertilizers and chemicals, seepage and silage through drainage system are the main sources of nitrate contamination of river water.

Singh *et al.* (2016) recorded nitrate value of Ganga River water maximum was 24.24 mg/ L. at Chedilal Ghat and minimum was 20.23 mg/ L. at Shivala Ghat at Varanasi city in Uttar Pradesh, India. Saxena *et al.* (2016) studied the nitrate content in and around Jabalpur city of Madhya Pradesh. The nitrate content range 0.2 to 9.4 mg/ L. and was found well below the permissible limit (50 mg/ L.). Nitrate concentration was found to be highest in bore well water at site S1 and surface water at Bhedaghat S10, the site which exclaim intensive human activities.

Pant *et al.* (2017) studied nitrate concentration values between 0.38 to 0.40 mg/ L. in Himalayan Lake of Uttarakhand, India. Bhat *et al.* (2018) studied the concentration of nitrate ranged from 5.59 (during Monsoon) to 25.97 mg/ L. (during Winter season) in Yamuna River water. Ahmad and Chaurasia (2019) recorded minimum mean nitrate was found 2.25 mg/ L. at S1 station and maximum was found 5.98 mg/ L. at S 5 station. Nitrate was found well within the limit at all sampling stations of Ganga River at Kanpur (U.P.).

Saluja (2020) studied the concentration of nitrate in Narmada River water in the range of 0.046 to 0.062 mg/ L. Abazi *et al.* (2020) recorded nitrate values of Sitnica River varied between < 0.1 to 11.5 mg/ L. among three seasons Spring, Winter and Summer.

Phosphate

Phosphate is very essential plant nutrient. Inorganic phosphate is soluble orthophosphate play a dynamic role in aquatic ecosystem. Natural sources of phosphorus in water are from the leaching of phosphate being rocks and organic matter decomposition but in water bodies it comes human and animal wastes, agricultural runoff, industrial wastes, and exposed soil corrosion. The significance of phosphate is mainly in regard to the phenomenon of anthropogenic lakes and rivers. It promotes the growth of algae and other plants leading to blooms.

In the present study (from October 2018 to September 2020) the phosphate in water varied between 31.68 mg/ L. to 89.68 mg/ L. in the Chandloi River. The minimum 31.68 mg/ L. was recorded at site 3 in 2019 in Pre Monsoon season and maximum 89.68 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon season. From October 2018 to September 2019, the phosphate concentration was recorded from 41.45 mg/ L. to 89.5 mg/ L. The minimum phosphate concentration recorded in Pre Monsoon and maximum in Post Monsoon. The average of phosphate concentration was 58.59 mg/ L. to 77.07 mg/ L. with average Standard Deviation of 9.59. During October 2019 to September 2020 this fluctuation was between 31.68 mg/ L. to 89.68 mg/ L. The minimum water concentration of phosphate recorded in Pre Monsoon and maximum also in Pre Monsoon. The average water concentration of phosphate was 55.90 mg/ L. to 67.69 mg/ L. with average Standard Deviation of 6.60.

Sah *et al.* (2000) studied phosphate content of varied between 0.012 mg/ L. to 0.060 mg/ L. in Narayani River, Nepal. Ranu (2001) studied phosphate concentration ranged from 0.015 to 0.0575 mg/ L. in different seasons of textile effluents to freshwater. Kazanci *et al.* (2003) studied phosphate value between 0.18 to 0.52 mg/ L. in the Koycegiz-Dalyan Estuarine Channel System. Unnisa and Khalilullah (2004) observed phosphate concentration from 6.30 mg/ L. and lowest 0.02 mg/ L. in the ground and surface water of Kattedan industrial area.

Stickney (2005) studied phosphorus is the first limiting nutrient for plants in freshwater which regulates the phytoplankton production in presence of nitrogen. It is available in the form of phosphate in natural waters and generally occurs in low to moderate concentration. Kumar *et al.* (2006) studied phosphate value range between 0.04 to 0.58 mg/ L. in Kulahalli Tank near Harapanahalli, Karnataka. Arasu *et al.* (2007) studied phosphate concentration in water samples varied from 0.18 to 0.43 mg/ L. in Tamirabarani River water in South India. Phosphate is non poisonous at that concentration and thus poses no threat to aquatic lives and health of human beings. Paulose and Maheshwari (2008) studied phosphate value between 0.04 to 0.12 mg/ L. in Ramgarh Lake, Jaipur.

Joshi *et al.* (2009) recorded the total phosphate was highest in Monsoon season (0.23 mg/ L.) and lowest in Winter season (0.037 mg/ L.) of the river water of Ganga for the drinking purpose in Haridwar district. Singh *et al.* (2010) recorded phosphate content of the river water varied from a minimum of 0.010 mg/ L. at site II in Manipur River to a maximum of 0.058 mg/ L. at site IV in Thoubal River. Chandra *et al.* (2011) studied phosphate value between 0.01 to 0.14 mg/ L. in various river water in India.

Ghosh *et al.* (2012) studied phosphate values range between 0.246 to 0.367 mg/ L. in different seasons in Santragachi Lake, West Bengal. Kohle *et al.* (2013) recorded phosphate value in Godavari River, Nasik district. Winter season showed higher phosphate concentration 2.42 mg/ L., followed by Summer 1.28 mg/ L. and Monsoon 0.34 mg/ L. Sewage effluents have been regarded as good source of phosphate. Sharma *et al.* (2014) studied phosphate value varied 0.0080 mg/ L. (August) to 0.0753 mg/ L. (November) of a lentic water body of Jammu, Jammu and Kashmir.

Jadhav and Singare (2015) recorded the phosphate value of Ulhas River water along Dombivli city near Mumbai. The average value of phosphate in 2012 was at sampling points S1, S2, S3, and S4 were 1.79, 3.41, 6.18 and 7.03 mg/ L., respectively. Whereas the average value of phosphate in 2013 at sampling points S1, S2, S3 and S4 were 3.37, 7.3, 11.48, 12.11 mg/ L., respectively. The average concentration of phosphate was 4.06 mg/ L. in 2012, which increased by 86% to 8.57 mg/ L. in 2013. The value of phosphate fluctuate from 0.71 mg/ L. to 5.75 mg/ L. The maximum value 5.75 mg/ L. was recorded in the month of August (Monsoon) and minimum value in the month of September (Winter). The highest values of phosphate in August (Monsoon) month are mainly due to rain, surface water runoff, agricultural runoff, washer man activity could have also contributed to the inorganic phosphate content.

Khadse *et al.* (2016) recorded phosphate range 0.6 to 0.29 mg/ L. in Chenab River and its tributaries in Jammu Kashmir. Saxena *et al.* (2016) recorded the phosphate content in the range of 0.00 to 0.26 mg/ L. and was found much below the permissible limit in and around Jabalpur city of Madhya Pradesh. Phosphate may occur in groundwater as a result of domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water. Pant *et al.* (2017) studied phosphate range between 0.012 to 0.036 mg/ L. in Himalayan Lake of Uttarakhand, India. Bhat *et al.* (2018) studied phosphate values ranged from 0.20 mg/ L. during the Monsoons to 1.80 mg/ L. during the Winter in Yamuna River. Ahmad and Chaurasia (2019) studied phosphate value between 0.15 to 0.88 mg/ L. in Ganga River at Kanpur.

Saluja (2020) recorded the concentration of phosphate in Narmada River water varied between 0.16 to 0.24 mg/ L. Abazi *et al.* (2020) recorded nitrate values of Sitnica River varied between 0.00 to 2.75 mg/ L. among three seasons Spring, Winter and Summer.

Electrical conductivity (EC)

Electric conductivity is the ability of any medium, water in this case to carry an electric current. The presence of dissolved solids such as calcium, chloride and magnesium in water samples carries the electric current through water. It is determined for several purposes such as determination of mineralization rate and estimating the amount of chemical reagents used to treat this water. For the industrial and agricultural activity, conductivity of the water is critical to monitor. It is useful tool to evaluate the purity of water.

In the present study (from October 2018 to September 2020) the electrical conductivity in water varied between 195.6 µmhos/ Cm. to 396.3 µmhos/ Cm. in the Chandloi River. The minimum 195.6 µmhos/ Cm. was recorded at site 3 in 2018 in Monsoon season and maximum 396.3 µmhos/ Cm. was recorded at site 4 in 2019 in Pre Monsoon season. From October 2018 to September 2019, the electrical conductivity was recorded from 195.6 µmhos/ Cm. to 393.7 µmhos/ Cm. The minimum electrical conductivity recorded in Monsoon and maximum in Pre Monsoon. The average of electrical conductivity was 200.3 µmhos/ Cm. to 384.8 µmhos/ Cm. with average Standard Deviation of 93.37. During October 2019 to

September 2020 this fluctuation was between 196.1 µmhos/ Cm. to 396.3 µmhos/ Cm. The minimum electrical conductivity recorded in Monsoon and maximum in Pre Monsoon. The average of electrical conductivity was 201.6 µmhos/ Cm. to 384.4 µmhos/ Cm. with average Standard Deviation of 92.62.

Olajire and Imeokparia (2001) studied EC is viewed as a valuable indication amount of dissolved materials in water of Osun River. Gopalsami *et al.* (2003) studied quality of water in the Bhavani River, conductance of water increased due to enrichment of organic conducting species from soaps and detergents of the bathing places. Dwivedi *et al.* (2005) studied EC range between 0.42 to 0.93 µmhos/ Cm. in three Agro Climatic zones of U.P.

Kumar *et al.* (2006) studied EC range between 280 to 406 µmhos/ Cm. in Kulahalli Tank near Harapanahalli, Karnataka. Arasu *et al.* (2007) recorded the specific electrical conductance of the water samples ranged from 80 to 350 µmhos/ Cm. and was within the standard limit of 300 µmhos/ Cm. except station 16. Thus the water has very low electrical conductivity, implying the presence of reduced level of ionic species. However the conductance of water and increases at station 16, which might be due to enrichment of organic conducting species from soaps and detergents of the bathing places.

Prasad and Patil (2008) recorded the electrical conductivity varies from 194.5 µmhos/ Cm. to 1030 µmhos/ Cm. The constant decrease in conductivity indicates that there must be reduction in number of dissolved inorganic salts. The conductivity of Krishna River water at Narsingwadi site is increased. Acharya *et al.* (2008) studied EC is a useful tool to evaluate the purity of water of groundwater in Bhiloda, North Gujarat.

Joshi *et al.* (2009) recorded the electric conductivity of water is affected by the suspended impurities and also depends upon the amount of ion in the water. The highest conductivity 415.66 µmhos/ Cm. of the Ganga water was observed in Monsoon season. From Monsoon season onwards the conductivity decreased and minimum conductivity 95.89 µmhos/ Cm. was observed in Winter season. Singh *et al.* (2010) studied electrical conductivity in the four rivers lies within the ranges of 0.20 µmhos/ Cm. at site III to 1.104 µmhos/ Cm. at site II in Manipur River with a minimum and maximum values recorded during Summer and Winter respectively.

Kataria *et al.* (2011) reported EC range between 115.11 to 212.13 µmhos/ Cm. in drinking water of Bhopal city. Ghosh *et al.* (2012) studied EC values between 244 to 262 µmhos/ Cm. in different seasons of Santragachi Lake, West Bengal.

Devi *et al.* (2013) recorded the electrical conductivity value in West Godavari Ponds. The average of electrical conductivity of water was 8606 µmhos/ Cm. High values of electrical conductivity can be attributed to possible seawater intrusion in area. Manickam *et al.* (2014) recorded EC ranges between 0.75 to 0.940 µmhos/ Cm. in Perennial Reservoir at Thoppaiyar, Dharmapuri district, South India. Jadhav and Singare (2015) studied the average conductivity in 2012 was 5871.4 µmhos/ Cm. which has increased by 6% to 6225.2 µmhos/ Cm. in 2013.

Appavu *et al.* (2016) recorded electrical conductivity is varying much having low at North 564 µmhos/ Cm. In West range was recorded as 9.20 µmhos/ Cm. But slightly vary about South 653 and East 692 µmhos/ Cm. Saxena and Sharma (2017) studied EC of the groundwater is varying from 130 to 800 µmhos/ Cm. in and around Tekanpur area, M.P. Bhat *et al.* (2018) studied EC values between 585 to 1673 µmhos/ Cm. High EC values indicated the presence of a high amount of dissolved salts and inorganic chemicals. Kamboj and Kamboj (2019) studied EC ranges between 136 to 210 µmhos/ Cm. in riverbed-mining area of Ganga River, Haridwar.

Saluja (2020) studied EC of water samples of Narmada River was observed to be in the range of 310 to 354 µmhos/ Cm. Abazi *et al.* (2020) recorded EC values of Sitnica River varied between 262 to 884 µmhos/ Cm. among three seasons Spring, Winter and Summer.

Mishra and Kumar (2021) observed EC values was obtained greater than 600 μmhos/ Cm. which indicates the presence of salt and inorganic materials in water.

BIOLOGICAL ANALYSIS OF WATER

Phytoplankton

Phytoplankton consists of the assemblage of small plants having no or very limited powers of locomotion; they are therefore more or less subject to distribution by water movements. The phytoplankton form the base of the aquatic food webs and are key players in the global carbon cycle and biological balance. They act as very good indicators of health of water resources. Phytoplankton are significant formal natural occupier of all water bodies. They may provide information on possible new introductions and may serve as early warnings system to detect the pollution level thus, phytoplankton study is a tool for the evaluation of aqua quality in any type of water bodies and also contribute to an understanding of the basic nature and general economy of the river.

The present study (from October 2018 to September 2020) underlines good phytoplankton diversity in the Chandloi River Kota, Rajasthan. Total 37 species phytoplankton belonged to 6 phylum, 7 classes and 25 families were recorded. 37 species were identified of phytoplankton representing 6 groups namely Chlorophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Cyanophyta and Dinoflagellata. Chlorophyta includes 14 species, Bacillariophyta 6 species, Xanthophyta 4 species, Euglenophyta 3 species, Cyanophyta 8 species and Dinoflagellata 2 species. Group Chlorophyta (38%) was dominated over Cyanophyta (22%), Bacillariophyta (16%), Xanthophyta (11%), Euglenophyta (8%) and Dinoflagellata (5%), respectively.

Krishnamurthy and Reddy (1996) observed measure phytoplankton forms in the drift of a tropical River Tunga, Western Ghats belonged to Chlorophyceae and Bacillariophyceae. The concentration annually varied between 5873 to 18437 ind/ m^3 and 15148 to 32348 ind/ m^3 in the two years respectively. In addition, members of

Cyanophyceae and Rhodophyceae were also recorded. However, their density was comparatively low (range 66 to 987 ind/ m^3 and 0 to 123 ind/ m^3 respectively) and were found to occur infrequently.

More and Nandan (2000) studied hydrobiological studies of algae of Panzara River (Maharashtra). They found that the algal genera, *Oscillatoria, Scenedesmus* and *Navicula* are the species found in organically polluted waters. Ponds in the study is characterized by abundance of Chlorophyceae followed by Cyanophyceae which indicates the absence of pollution. Lakshminarayan and Someshekar (2001) studied physico-chemical characteristics of Hill Stream have significantly contributed to alter the magnitude of biological dynamics and showed interrelationship either positive or negative in existed ecosystem. The present co-relation coefficient showed the inverse relationship between phytoplankton and temperature, pH, alkalinity, CO_2, biological oxygen demand (BOD), Ca, Mg, Na, K and Cl but showed the positive relationship with velocity and dissolved oxygen (DO) that indicated that plankton's growth depend on DO and the flow characteristic of running water.

Dube (2002) studied various aspects of lotic and lentic freshwater ecosystems such as quality of water, its physical, chemical and biological characteristics, phytoplankton, zooplankton, macrophytes and animal of different taxonomic categories. He reported 22 phytoplankton species in shallow water bodies in Kota region. Arjaria (2003) studied physico-chemical profile and plankton diversity of Ranital Lake, Chhatarpur, M.P. According to the study, the phytoplankton is dominated mainly by the species of Cyanophyceae, Chlorophyceae and Diatoms, which belong to the tolerant species.

Sirsat *et al.* (2004) studied phytoplankton of freshwater Pond at Dharmapuri in Beed district (Maharashtra). Four major groups of phytoplankton Chlorophyceae, Bacillariophyceae, Cynophyceae and Euglenophyceae were studied for diversity and seasonal abundance. 10 genera Chlorophyceae, 6 genera of Bacillariophyceae, 5 genera of Cynophyceae and 3 genera of Euglenophyceae were recorded. LeQuere *et al*. (2005) reported that moderate flow of water provides benefits to increase phytoplankton population during Winter and early Summer months. The lower values for the plankton communities during Monsoon season may be attributed to high in flow of water from the catchment area changing the hydrology of the river system as a result of dilution.

Kumar and Hosmani (2006) studied algal biodiversity in freshwater and related physico-chemical factors in two Lakes of Mysore district. Euglinophyceae are poorly represented, Bacillariophyceae were the most dominant and occurred throughout the study period. Cyanophyceae dominated during Winter season. Chlorococcales were less significant. Mathivanan *et al.* (2007) studied plankton of River Cauvery water (Tamilnadu), the qualitative and quantitative evolution of the variation in river water showed high quantity of phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Myxophyceae and Euglinae.

Desai *et al.* (2008) studied phytoplankton diversity in Sharavati River Basin, Central Western Ghats. During the study total of 216 species of 59 genera belonging to Bacillariophyceae, Desmidials, Chlorococcales, Cynophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae were recorded. Thirugana Moorthi and Selvaraju (2009) has reported the maximum density of Cyanophycean members during Summer and minimum during Winter and Rainy seasons. He reported abundant count of Bacillariophyceae in Monsoon season which was lowered in Pre Monsoon of Gnanaprekasam temple pond of Chidambaram in Tamilnadu.

Dube *et al.* (2010 a, b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and 24 species of phytoplankton were recorded. Sharma *et al.* (2011) recorded phytoplankton of Narmada River consisted mainly of green algae (Chlorophyceae), diatoms (Bacillariophyceae) and the blue-green algae (Myxophyceae). Phytoplankton population represented by Chlorophyceae group followed by Bacillariophyceae and Myxophyceae. Chlorophyceae consisted of 23 genera, Bacillariophyceae was represented by 10 genera where as Myxophyceae by 7 genera, respectively.

Ghosh *et al.* (2012) studied diversity and seasonal variation of phytoplankton community in the Santragachi Lake, West Bengal. A total of 29 phytoplankton taxa belonging to Cyanobacteria (8), Euglenozoa (2), Bacillariophyta (4), Charophyta (5) and Chlorophyta (10) were recorded. Euglenozoa species representatives had the least expression while Chlorophyta species dominated mostly in variety and percentage composition. Bio-indication showed a low diverse community in the Monsoon period with better water quality than in Pre and Post Monsoon. Bhatnagar and Bhardwaj (2013) studied the seasonal algal diversity and the physico-chemical properties of water of Chambal River, Kota, Rajasthan. This study shows the presence of a total of 65 algal species. Some algal forms are good indicators of water pollution and their presence show signs of water pollution. The algal forms consisted of a total of 65 taxa belonging to Chlorophyceae (32 species), Cyanophyceae (18 species), Bacillariophyceae (12 species) and Euglenophyceae (3 species).

Komala *et al.* (2013) studied on an assessment of plankton population and abundance of Arkavathi River with reference to pollution. A total of 71 species of phytoplankton were recorded. Myxophyceae species were found to be dominant at both the stations and Euglenophyceae have shown less number of phytoplankton abundance in both the sites. Polluted water shows relatively greater abundance of Myxophyceae as compared to the non polluted water. Nutrient enrichment of the river due to silk industries effluents has altered the structure of plankton community. Subhashree and Patra (2013) studied phytoplankton diversity of River Mahanadi, Cuttack city, Odisha, India. The phytoplankton composition of upstream (S1), dam reservoir (S2) and downstream (S3) was constituted mainly by Chlorophyceae, Cyanophyceae and Bacillariophyceae. The total number of species belonging to different taxonomic groups were 50, 56 and 47 at S1, S2 and S3 respectively. 35 genera comprising of 50 species (26 of Chlorophyceae, 11 of Cyanophyceae and 13 of Bacillariophyceae).

Ghorade *et al.* (2014) studied phytoplankton diversity from Godavari River water. In that study among the group of phytoplankton the Chlorophyceae were recorded maximum followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. It is observed 10 genera of Chlorophyceae, 6 genera of Bacillariophyceae, 5 genera of Cyanophyceae and 4 genera of Euglenophyceae. *Chlamydomonas, Cladophora, Oedogonium* and *Pediastrum spp.* were dominant from Chlorophyceae probably due to favourable environmental conditions.

Ansari *et al.* (2015) studied phytoplankton diversity and water quality assessment of ONGC Pond, Hazira. Phytoplankton was represented by four classes of algae Euglenophyceae, Chlorophyceae, Bacillariophyceae and Cyanophyceae. Chlorophyceae group presented maximum 52% while minimum 4% by Euglenophyceae. Levels of oxygen, nitrate, phosphate and silicate showed direct relationship with the diversity of phytoplankton. Singh (2015) observed a total of 34 species during the study period in the Gomti River at Lucknow. Only 5 planktonic classes were reported Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae and Euglenophyceae. The study confirms 6 species belonging to Bacillariophyceae, 19 were Chlorophyceae, 04 belonging to Cyanophyceae, 02 belonging to Dinophyceae and 03 belonging to Euglenophyceae. Among these Chlorophyceae was the most dominant class in the phytoplankton followed by Bacillariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae.

Balai *et al.* (2015) studied phytoplankton diversity in Lake Jaisamand, Rajasthan (India). Phytoplankton was contributed by six major groups which comprised total 83 species, out of which 13 belongs to Myxophyceae, 5 to Euglenophyceae, 38 to Chlorophyceae, 3 to Xanthophyceae, 1 to Cryptophyceae and 23 to Bacillariophyceae. Thus, Bacillariophyceae and Chlorophyceae turned up as the dominant groups in terms of density (159 to 554 numbers per litre and 24 to 485 numbers per litre) and species number 23 and 38, respectively. Saini and Dube (2015) studied phytoplankton in Narmada River, Jabalpur region (M.P.) India. The phytoplankton species observed belonging to 5 main groups. Total 19 species were observed out of which 5 species belong to Cyanophyceae, 8 species belong to Chlorophyceae, 4 species belong to Bacillariophyceae and 2 species of Euglenophyceae. Quantitatively and qualitatively, Chlorophyceae was the most dominant group followed by

Cyanophyceae, Bacillariophyceae and Euglenophyceae as third and fourth respectively.

Dhanam *et al.* (2016) studied phytoplankton diversity of Ousteri Lake in Puducherry. A total of 34 planktonic species belonging to 26 genus under the four classes were recorded. Among these Cyanophyceae comprises of 15 species (belonging to 11 genera) followed by Chlorophyceae 9 species (belonging to 7 genera), Bacillariophyceae 7 species (belonging to 6 genera) and Euglenophyceae 3 species (belonging to 2 genera). Priya *et al*. (2016) studied diversity of phytoplankton communities in Tambraparani River, Kanyakumari district, Tamilnadu. He stated phytoplankton diversity, dominance index and richness index of the river. A total of 77 algae were recorded which belong to five groups namely Bacillariophyceae, Chlorophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae.

Hossain *et al*. (2017) studied diversity of plankton communities in the River Meghna. He reported Chlorophyceae with 16 genera, Dinophyceae with 2 genera, Bacillariophyceae with 13 genera, Cyanophyceae with 2 genera, Myxophyceae with 5 genera, Euglenophyceae with 1 genera and Xanthophyceae with 2 genera. Das *et al.* (2018) studied diversity of phytoplankton in some domestic wastewater of the Chota Nagpur, Plateu. Overall 28 phytoplankton species were identified, of which 7 species belonged to the class Cyanophyceae, 14 belonged to class Chlorophyceae, 5 belonged to class Bacillariophyceae and 2 species of Euglenophyceae. The abundance of *Oscillatoria limosa* is the highest in site 1, site 3, and site 6, while *Chlorella vulgaris* in site 2, *Merismopedia minima, Anabaena cirinalis* in site 5, *Spirogyra maxima* in site 7 were most abundant.

Dixit and Sharma (2019) studied phytoplankton diversity in Gomti River at Lucknow. The phytoplankton community of the river at 6 sampling sites were represented 5 planktonic classes. A total number of 34 species of algae belonging to 6 species of Bacillariophyceae, 19 were Chlorophyceae, 4 species belonging to Cyanophyceae, 2 belonging to Dinophyceae and 3 belonging to Euglenophyceae. Among these

Chlorophyceae was the most dominant followed by Bacillariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae. Phytoplankton ranged between 220-310 ind per litre in Pre Monsoon, 142-192 ind per litre in Monsoon and 117-210 ind per litre in Post Monsoon season, respectively.

Sharma *et al.* (2019) studied the phytoplankton in the Chandloi River, Kota, Rajasthan. River Chandloi has a good diversity composed of five classes of phytoplankton namely Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae and Dinophyceae. Class Cyanophyceae represented by 5 genus and 7 species, class Chlorophyceae represented 12 genus and 17 species, class Euglenophyceae represent by 3 genus and 10 species, class Bacillariophyceae represented 5 genus and 6 species and class Dinophyceae represented 3 genus and 3 species. Chandra *et al.* (2019) studied diversity of phytoplankton in Khop tall of Chhatarpur, Madhya Pradesh. Phytoplankton were recognized of study period, in which 6 species belonging to class Cyanophyceae, 2 species belonging to class Zygnematophyceae, one one species belonging to classes Ulvophyceae, Hormogoneae, Euglenoidea and Trebouxiophyceae surrounded by algal flora, Bacillariophyceae class is a good number of a percentage composition of density (334.8%), Chlorophyceae (228.6%), Zygnematophyceae (107.2%), Cyanophyceae (81.00%), Hormogoneae (41.8%), Ulvophyceae (44.6%), Euglenoidea (61.6%) and Trebouxiophyceae (15.2%) given in.

Ray *et al*. (2020) studied phytoplankton communities of eutrophic fresh water bodies in Kerala. Altogether, 297 algal species belonging to 8 phyla, 11 classes and 26 orders were observed in the waters. Karra (2020) studied limnological studies of River Chandraloi district Kota, Rajasthan with special reference to diversity and seasonal variation in plankton. In this study 19 species of phytoplankton was represented by 5 major groups (Chlorophyceae, Bacillariophyceae, Cynophyceae, Xanthophyceae and Euglenophyceae). Chlorophyceae was the largest dominating group and Cynophyceae was second largest dominating group.

Ahmed *et al.* (2021) studied phytoplankton assemblage in the River Ganges. Phytoplankton consisted mainly of 49 taxa of 34 genera belonging to Bacillariophyceae, Chlorophyceae, Cyanophyceae and Chrysophyceae. The members belonging to Bacillariophyceae and Chlorophyceae were the two dominant classes which comprised up to 75% of the total phytoplankton. Ramond *et al.* (2021) studied phytoplankton taxonomic and functional diversity patterns across a coastal tidal front. The total phytoplankton read abundance (1.5×10^6 reads) was dominated by Bacillaryophyta (diatoms, 36% of total phytoplankton read abundance) and Dinophyta (dinoflagellates, 31%), that dominated micro-plankton. Chlorophyta (25%), Cryptophyta (5%) and Dictyochophyta (1%) were more abundant in the nano and pico-plankton. Organisms from Pelagophyta (1.5%) were observed homogenously across all size fractions but appeared mostly in September in the offshore samples.

Zooplankton

Zooplankton are small floating or weakly swimming organisms that drift with water currents and with phytoplankton makeup the planktonic food supply upon which almost all oceanic organisms are ultimately dependent. Due to their large density, shorter life span, drifting nature, high group or species diversity, different tolerance to the stress and often respond quickly to environmental change and water quality, zooplankton are being used as indicator organisms for the physical, chemical and biological process in the aquatic ecosystem.

The present study (from October 2018 to September 2020) underlines good zooplankton diversity in the Chandloi River Kota, Rajasthan. Total 29 species of zoooplankton belonged to 3 phylum, 6 classes and 16 families were recorded. 29 species were identified of zooplankton representing 3 groups namely Rotifera, Protozoa and Arthropoda. Rotifera has 8 species, Protozoa has 7 species and Arthropoda has 14 species. Group Arthropoda (48%) was dominated over Rotifera (28%) and Protozoa (24%), respectively.

Sivakumar *et al*. (2001) made qualitative and quantitative analysis of Copepods and Cladocerans of the fresh water bodies in and around Dharmapuri district of Tamilnadu. They recorded 4 Copepod species and 7 Cladoceran species. They also observed the higher population density of Copepoda and Cladocera in Winter season then in the Summer season. Sampaio *et al.* (2002) studied configuration and abundance of zooplankton in the limnetic zone of seven Reservoirs of the Paranapanema River, Brazil. Taxonomic dominance of Rotifera was reported in several water bodies. The species *B. calyciflorus* is considered to be a good indicator of eutrophication. Dube (2002) studied various aspects of lotic and lentic freshwater ecosystems such as quality of water, its physical, chemical and biological characteristics, phytoplankton, zooplankton, macrophytes and animal of different taxonomic categories. He reported 14 zooplankton species in shallow water bodies in Kota region.

Arjaria (2003) studied physico-chemical profile and plankton diversity of Ranital Lake, Chhatarpur, M.P. The zooplankton was represented by 10 genera covering different groups. Sivakumar and Altaff (2004) studied freshwater Copepods and Cladocerans from Dharmapuri district, Tamilnadu. In dissimilarity analysis values were divided into four ranges (I) 0.1-0.25, (II) 0.26-0.50, (III) 0.51-0.75 and (IV) 0.76-1.00 and were framed as matrices. In Winter season, dissimilarity values of H. Viduus and S. (R.) indicus. *T. hyalinus* were in the range of 0.51-0.75 and other animal dissimilarity values were in the same range (0.76-1.00). Different species of Copepods showed similar range of dissimilarity (0.51-0.75) in Summer season.

Saha (2004) studied zooplankton diversity in five major coalfield areas in Jharkhand and revealed 26 species of zooplankton. Cladocerans and Rotifers were abundant groups (9 species each) followed by 7 species of Copepoda and 1 species of Ostracoda. The evenness showed insignificant relationship with species diversity index, while species richness showed negative relationship with species diversity index values. The overall diversity of plankton was low due to high alkalinity of water which results due to fly ash deposition. Kudari *et al.* (2005) studied zooplankton composition in some ponds of Haveri district. They have identified 4 species of zooplankton in 19 water bodies of Haveri district.

Jayabhaye and Madlapure (2006) studied the zooplankton diversity in Parola Dam (Hingoli), Maharashtra and reported 28 zooplankton species, out of which 14 species belong to Rotifera, 5 species belong to Copepoda, 3 species belong to Ostracoda and 6 species to Cladocera. Mathivanan *et al.* (2007) studied plankton of River Cauvery water (Tamilnadu). The study showed high quantity of zooplankton population throughout the study period and Rotifers formed dominated group over other group's organisms. Gaikwad *et al.* (2008) studied the diversity of zooplankton in the water bodies of North Maharashtra region. They recorded a total of 19 species including 6 species of Copepoda, 5 species of Cladocera, 8 species of Rotifera.

Suresh *et al.* (2009) studied zooplankton of the Tungabhadra River near Harihar, Karnataka. Zooplankton population composed of 4 species of Protozoans, 16 species of Rotifers, 14 species of Crustaceans and 3 species Meroplankton organisms mainly nymph or larval forms. It is found that among zooplankton community Rotifers (43.24%) were dominated group followed by Crustaceans (37.84%), Protozoan (10.81%) and Meroplankton (8.11%).

Dube *et al.* (2010 b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and a total 60 species of plankton (24 species of phytoplankton and 36 species of zooplankton) were recorded. Vanjare *et al.* (2010) studied zooplankton from River Mula, Pune, Maharashtra. Rotifera and Cladocera are free living zooplankton elements known to dominate freshwater habitats. 18 Rotifers and 10 Cladocerans were recorded during that study. This study showed an attempt to monitor a polluted habitat for zooplankton.

Khanna *et al.* (2012) studied zooplankton diversity of River Ganga from Devprayag to Roorkee, Uttarakhand (India). Among the zooplankton Protozoa, Rotifera, Cladocera, Copepoda, Ostracoda constitute the main components. Majority of zooplankton shows maximum occurrence and abundance during the high salinity period. Zooplankton diversity was recorded maximum (890 unit per litre) in the month March 2010 at sampling site B and minimum (18 unit per litre) was recorded in the month July 2010 at sampling site A.

Singh (2013) studied biodiversity of River Gomti is heavily affected by pollution. The zooplankton community comprised Protozoa five species, Rotifera three species, Cladocera two species and Copepoda one species. The zooplankton population was observed maximum during Monsoon season but it was low in Summer season. Umadevi (2013) studied the abundance, composition and distribution of zooplankton in relation to water quality parameters in Karanja River in Karnataka. 36 species of zooplankton were identified as a total, which included 14 species of Rotifera, 11 species of Cladocera, 8 species of Copepoda and 3 species of Ostracoda.

Sarwade and Kamble (2014) studied quantitative assessment of plankton of River Krishna, district Sangli, Maharashtra. Diversity of zooplankton included Cladocera, Rotifera, Protozoa, Nematoda, Aostraca, Schizopyrenida and Copepoda as major groups, with 25 genera. Rotiferans were found dominant with 9 species. Protozoans were second dominant group with 8 diversified species. Cladocerans included 2 species. Nematoda, Aostraca and Schizopyrenide each showed one type of species. Copepoda showed 3 types of species. Balai *et al.* (2014) studied diversity and seasonal variations of zooplankton in Jaisamand Lake, Udaipur, India. In the study period 51 species of zooplankton were found. Among these 7 species of Protozoa, 17 species of Rotifera, 18 species of Cladocera, 5 species of Ostracoda and 4 species of Copepoda were observed. Among zooplankton Rotifera was (727 number per litre) observed as the dominant group throughout the study period and the highest count was recorded in the Summer or Pre Monsoon period, while low incidence was observed in Winter season.

Dede and Deshmukh (2015) studied zooplankton composition and seasonal variation in Bhima River, near Ramwadi village, Solapur district (Maharashtra), India. A total of 21 species were found, among these 9 species belongs to Rotifera, 5 species belongs to Copepoda, 5 species belongs to Cladocera and 2 species belongs to Ostracoda. Numerically Rotifera was dominant group throughout the study period. The study of season wise zooplankton analysis showed an average abundance of species in Winter season, lower in Monsoon season and maximum occurrence in Summer season due to different environmental condition of water bodies.

Kumar and Khare (2015) studied the analysis of diversity of plankton (phytoplankton and zooplankton) and their seasonal variation of density in Yamuna River at Kalpi, district Jalaun, U.P. registered zooplankton were belong to 22 species of 16 genera of different groups like as Protozoa (3 species of 3 genera), Rotifera (12 species of 6 genera), Cladocera (5 species of 5 genera) and Copepoda (2 species of 2 genera). Sivakami *et al.* (2015) studied zooplankton in a Lake Pudukkottai, district Tamilnadu, India. 40 species belonging to 5 different groups were recorded during the period of study. Out of 40 species, 2-2 species each belonged to Protozoa and Ostracoda, 27 to Rotifera, 5 to Cladocera, 3 to Copepoda and 1 to Anostraca. A percentage composition reveals that Rotifera represented 67.5%, Cladocera 12.5%, Copepoda 7.5%, Protozoa 5%, Ostracoda 5% and Anostraca 2.5%.

Das and Kar (2016) studied diversity of zooplankton in River Siang of Arunachal Pradesh, India. During the study period, 24 different genera of zooplankton were recorded. The recorded zooplankton were classified into five different groups, among which, Protozoans were represented by 6 genera, Rotifera by 7 genera, Cladocera by 5 genera, Ostracoda by 1 genera and Copepoda were represented by 5 genera. Rai *et al*. (2016) studied plankton composition, seasonal variation and diversity indices in River Narmada at Jabalpur region. The zooplankton comprises of phylum Rotifera, Cladocera, Copepoda and Protozoa. A total of 23 species of zooplankton were recorded belonging to Rotifera 7 species, Cladocera 4 species, Copepoda 5 species and Protozoa 7 species.

Robiul *et al*. (2017) studied diversity indices of plankton communities in the River Meghna of Bangladesh. Their study revealed zooplankton of Rotifer, Copepod, Cladocera and Ostracoda as major groups. The highest number of genera was found in the families of Copepoda and Cladocera. Manickam *et al.* (2018) studied seasonal changes in zooplankton biodiversity in Ukkadam Lake, Coimbatore, Tamilnadu, India. In total 28 species of zooplankton were recorded in the lake which includes 9 species of Rotifera (2 families and 3 genera), 9 of Cladocera (4 families and 6 genera), 5 species of Copepoda (2 families and 4 genera) and 5 species of Ostracoda (1 family and 5 genera). In the study, Rotifera and Cladocera holds the top rank in percentage composition with 32%, followed by Copepoda 18% and Ostracoda 18%. The population density of zooplankton was ranged between 73,085 and 110,900 ind per metre^3 during the study period.

Sharma and Dube (2019) studied population dynamics and seasonal variation of Rotifers in Chandloi River, Kota, Rajasthan. A total of 16 genera and 31 species of fresh water Rotifers recorded from Chandloi River in different seasons. Among 16 genera *Brachionus* was dominant with seven species followed by five species of *Filinia*, three species of *Rotaria*, two species of *Trichocera*. Remaining genera followed single species. Dabhade and Chhaba (2019) studied zooplankton diversity around Washim region of Maharashtra. They recorded a total of 27 zooplankton species from the different sampling site of Washim region comprising of 11 species of Rotifers, 06 Copepods, 09 Cladocera and 01 Ostracods. The community structure of zooplankton showed a mix composition of mesotrophic to eutrophic species. Meena (2019) studied ecological studies of a village Pond of Similiya, district Kota, Rajasthan. A total of 27 species of zooplankton belonging to class Ciliata (6 species), Monogonata (8 species) and Crustacea (13 species).

Sharma (2020) studied diversity of freshwater zooplankton of Uttarakhand Himalaya, India. Freshwater zooplankton of Uttarakhand are composed of the taxa of Protozoa, Rotifera, Copepoda, Cladocera and Ostracoda. Rotifera contributes maximum (40.50%) with 32 species, followed by protozoa (22.78%) with 18 species and Cladocera (22.78%) with 18 species to the total zooplankton taxa of Uttarakhand. Copepoda contributes 8.86% with 7 species, while minimum contribution (5.08%)

with only 4 species is made by Ostracoda to the total zooplankton taxa of Uttarakhand. Pandit *et al.* (2020) studied diversity of zooplankton of the River Ganga at Bihar, India in relation to water quality. A total of 23 genera of zooplankton belonging to 6 genera of Rotifera, 5 of Protozoa, 5 of Cladocera, 4 of Copepoda and 3 of Ostracoda were identified with the density from 2 to 213 ind per litre. The analysis showed that density of zooplankton declined in Post Monsoon and remained maximum in Summer because of the various environmental and inflow characteristics of the water body.

Sarkar and Pal (2021) studied zooplankton diversity in the River Jaldhaka, West Bengal, India. A total 16 zooplankton genera belonged to Protozoa (5 genera, 31%), Rotifera (5 genera, 31%), Copepod (3 genera, 19%) and Cladocera (3 genera, 19%) were recorded, presence of Rotifers *Brachionus, Filinia* and *Polyarthra* are indications of slightly eutrophic conditions of the river water. Singh *et al.* (2021) studied zooplankton diversity in a fresh water pond (Raja Bandh) of Jamtara, Jharkhand, India. That study revealed 14 different species of zooplankton belonging to 4 different groups namely 5 Rotifers, 4 Cladocerans, 3 Copepods and 2 Ostracod was observed. Rotifers were the dominant group of zooplankton recorded with respect to diversity and population density status. Rotifers and Copepoda were the most dominant during Summer followed by Cladocerans and Ostracodes. Annual percentage composition comprises of 38% Rotifer, 26% Copepod, 20% Cladocera, and 16% Ostracoda, respectively. Certain species *Brachionus spp., Daphnia spp., Cyclops spp.* and *Cypris spp.* were recorded throughout the year.

Fishes

Fishes occupy at a significant position in socioeconomic fabric of South Asian countries by providing the population not only the nutritious food and also as an employment opportunity. They are sensitive to many stresses from parasites to diseases to acidification. For scientist, fishes are use as surrogates and research models. Due to the life history traits fishes are suitable as early warning signals of anthropogenic stress on natural ecosystem dynamics or conversely, as indicators of ecosystem recovery and of resilience. Their presence in large number and variety in lentic bodies is a good indication that water is virgin and suitable for human consumption and utility.

The present study (from October 2018 to September 2020) highlights good fishes diversity in the Chandloi River Kota, Rajasthan. Total 16 species of fishes belonged to phylum Chordata, class Actinopterygii, 5 orders and 7 families were recorded. 16 species were identified of fishes representing 5 orders Cypriniformes, Anabantiformes, Siluriformes, Cichliformes and Synbranchiformes. Order Cypriniformes has 7 species, Anabantiformes has 2, Siluriformes has 5, Cichliformes has 1 and Synbranchiformes has 1 species. Order Cypriniformes (44%) has dominated over Siluriformes (31%), Anabantiformes (13%), Cichliformes (6%) and Synbranchiformes (6%).

Rao (2001) studied biological resources of Ganga River, India. The Ganga River harbors a rich fish diversity with 83 commercially important species, including Gangetic carps, large catfishes, featherbacks and murrels. The pollution of the river has become a matter of concern for structure and composition of the biotic community. Sakhare (2001) investigated the occurrence of 23 fish species belonging to 7 orders in Jawalgaon Reservoir in Solapur district of Maharashtra. The fishes belonging to order Cypriniformes were dominant with 11 species followed by order Siluriformes with 4 species, while orders like Osteoglssiformes, Perciformes and Channiformes each were represented by 2 species and the rest of the orders by single species.

Biradar (2002) studied frequency distribution of fish species at various sampling sites. On the basis of occurrence of the species in all sampling sites they were categorized into dominant (species occurred >80%), abundant (species occurred 60%-80%), less abundant (species occurred 40%-60%) and rare (<40%). Wagh and Ghate (2003) recorded 62 species of fish in the Mula and Mutha Rivers flowing through Pune.

Sewage and industrial pollution of river waters, besides prevalence of exotic fish, appear to be the seasons for the depletion of fish species. Fishes like *Rhinomugil corsula* and *Pseudosphromenus cupanus* were reported the first time. It could be due to massive sewage and industrial pollution released into these rivers. Two exotic fishes *Oreochromis* and *Gambusia* are practically everywhere. *Gambusia* was introduced for mosquito control but *Oreochromis* could be an accidental introduction from cultivation tanks.

Om Prakash (2004) studied fish species of Northern part of Raipur district, Chhattisgarh. He documented 64 species belonging to 40 genera, 19 families and 7 orders. Families like Cyprinidae, Siluridae, Channidae and Percidae were the most dominant among all 19 families. Khedkar (2005) studied fish species of Nathsagar Reservoir from Paithan, district Aurangabad. He observed 67 fish species belonging to 7 orders and 19 families. Cyprinidae family was dominant during study period.

Bakawale and Kanhere (2006) studied fish fauna of River Narmada in West Nimar, M.P. He found 150 species belonging to 26 families. Major carps, minor carps and cat fishes were the major fish abundance in the river. The several species of fishes belonging to order Cypriniformes, Beloniformes, Opiocephaliformes, Mastacambelliformes and Siluriformes. Sinha (2006) studied riverine fisheries of India. 140 fish species have been documented in the river. The mainstays of the fisheries in this region are species belonging to the family Cyprinidae and Siluridae. Some species were observed with shift in their distribution ranges. Indiscriminate and illegal fishing, pollution, water abstraction, siltation and invasion of exotic species are also threatening the fish diversity in the rivers.

Verma and Kanhere (2007) studied ichtyofaunal diversity of the River Narmada in Western Zone. He enlisted 84 species belonging to 45 genera. Shillewar and Nanware (2008) studied biodiversity of fishes of Godavari River at Nanded Maharashtra, India. The work confirm the occurrence of 26 fish species belonging to 6 orders, 18 genera and 9 families. The order Cypriniformes was dominant with 13 fish species to be followed order Siluriformes 4 species and Channiformes with 4 species, order Clupeiformes with 2 families, Perciformes, Mastacembeliformes and Mugliformes with 1 fish species each.

Heda (2009) studied fish diversity of two rivers of the Northeastern Godavari Basin, India. 3888 individuals were collected from both rivers (1502 from the Kathani and 2386 from the Adan). A total of 47 species were identified (32 Kathani 38 Adan), Cypriniformes were the dominant group in both rivers (15 species), with dominant species from both rivers being *Puntius ticto*. Cyprinidae was the most species rich family in both the rivers with 28 species, whereas 10 families were represented by only one species. Lakra *et al.* (2010) studied fish diversity, habitat ecology and their conservation and management issues of a tropical river in Ganga basin, India. In India there was about 2319 fish species that have so far been documented of which about 838 fishes inhabit freshwater.

Vijaylaxmi *et al.* (2010) studied Freshwater fishes distribution and diversity status of Mullameri River, a minor tributary of Bheema River of Gulbarga district, Karnataka. The result of the study reveals the occurrence of 14 fish species belonging to 5 orders. The order Cypriniformes was dominant with 7 fish species followed by order Siluriformes with 4 species and the order Channiformes, Mastacembeliformes and Osteoglossiformes each with one species.

Sharma *et al*. (2011) studied on limnological characteristic, Planktonic diversity and fishes (species) in Lake Pichhola, Udaipur, Rajasthan (India). 15 species of fishes belonging to 6 family and 13 genera were reported from Pichhola Lake namely *Notopterus notopterus, Catla catla, Cirrhinus cirrhinus, Ctenopharygodon idellus, Labeo gonius, Labeo rohita, Puntius sarana sarana, Puntius ticto, Chela cachius, Garra gotyla gotyla, Aorichthys seenghala, Mystus cavasius, Heteropneustes fossilis, Xenentodon cancila* and *Gambusia affinis.* Thirumala *et al*. (2011) studied fish diversity of Bhadra Reservoir of Karnataka. 33 fish fauna identified during the study belonged to Cyprinidae 18 species, Channidae 2 species, Bagridae and Siluridae with

3 species and a species each of Mastacembelidae, Ambassidae, Cichalidae, Claridae, Notopteridae, Cobitidae and Heteropneustidae. All fishes are useful as food fishes except *Ambassis, Puntius,* and *Gambusia*, which are useful as ornamental and larvicidal fishes. The species diversity is peak in Post Monsoon.

Sarkar *et al.* (2012) studied fish biodiversity in the River Ganga (India). A total of 143 species belong to 11 orders, 72 genera and 32 families were recorded across all the stretches of River Ganges, which is about 20% of freshwater fish of the total fishes reported in India. Out of 143 species, 133 species were native to River Ganga and its tributaries and remaining 10 species were exotics. There was no endemic species reported during that study.

Bakwale and Kanhere (2013) studied the fish species diversity of the River Narmada in Western zone. The fish diversity is correlated with biological and various physico-chemical parameters that regulate the productivity and distribution of different species of the fishes. The fish population is abundant and majority of fishes are exploited for human consumption. The survey indicated that 51 species of fish were found in that zone of the river. The major fish abundance was noticed major carps, minor carps and cat fishes. The several species of fish belonging order Clupiformes, Cypriniformes, Beloniformes, Opiocephaliformes, Mastacambelliformes, Siluriformes and Perciformes. In which maximum 37 species belonging to the order Cypriniformes. Some species of fishes like *Cirrihinus cirrihos, Aspidoparia jaya, Colisa fasciatus, Labeo bata, Oreichthys cosuatis, Osteobrama cotio,* etc. showed a declining trend in this stretch. The fish species diversity was decreased.

Khanna *et al.* (2013) studied fish diversity of Ganga River System in Foothills of Garhwal Himalaya, Uttarakhand, India. Besides the snow fed rivers, there are so many Spring fed rivers such as Hanwal, Hemganga, Song, Suswa, Alaknanda, Bhagirathi, Bhilangana, Ganga and hundreds of rivulets. They all contain very rich and colourful fish fauna. During the course of study a total of 53 species belonging to 11 families were reported. Out of these 52 species were reported in Ganga, 38 in

Hanwal, 36 in Hemganga, 48 in Song, 44 in River Suswa, 32 in Alaknanda, 32 in Bhagirathi and 29 in River Bhilangana.

Sarkar *et al.* (2013) studied biodiversity of fresh water fish of a protected river in India. A total of 87 species belonging to 8 orders, 22 families and 52 genera were collected while a maximum of 59 species belonging to 6 orders, 20 families and 42 genera were recorded from the unprotected areas. Cyprinids were found to be the most dominant genera and *Salmostoma bacaila* was the most numerous species, other numerous species were *Eutropiichthys vacha, Notopterus notopterus, Clupisoma garua* and *Bagarius bagarius*.

Vishwakarma *et al*. (2014) deals with the fish diversity of Barna River and its tributary in Raisen district, Madhya Pradesh, Central India. 33 fish species belonging to 5 orders, 9 families and 21 genera. The order Cypriniformes was found dominant (24 species) followed by Perciformes and Ophiocephaliformes (3 species) both, Mastacembeliformes (2 species) and Beloniformes (1 species). The most abundant family was Cyprinidae having 250 individuals (75%) followed by Cobitidae with 32 individuals (10%). Some endangered and rare fish fauna are also reported in the present investigation. Satapathy and Misra (2014) studied the fish diversity of the River Pilasalunki situated in Phulbani district, Odisha. A total of 23 fish species belonging to 9 families were recorded. Out of the recorded species 35% are enlisted as vulnerable, 52 % as lower risk near threatened category. Maximum number of fish species were collected from slow flow site (31.6%) followed by silty sand beds (17.6%), deep water zone (15.8%), gravel habitat (15.8%), fast flow zone (10.5%) and least in shallow water zone.

Balkhade and Kulkarni (2015) studied ichtyofaunal diversity of Godavari River at Dhangar Takli Tq. Purna district, Parbhani, Maharashtra. The results of investigation revealed the occurrence of 18 fish species belonging to 5 orders, 8 families and 14 genera and 1 species of freshwater prawn belonging to Decapoda order. The order Cypriniformes was dominant with 8 fish species (44%) followed by Perciformes 05

(28%), Osteoglossiformes 02 (11%) and Synbrachiformes with 1 fish species (6%) and Siluriformes with 02 (11%). Banyal and Kumar (2015) studied fish diversity of Chambal River, Rajasthan State. The Fish fauna of the Chambal River is rich and diverse. Various types of carps, catfish, and mullet reside in the river waters. 54 species of fishes were reported from the Rajasthan part of the Chambal River.

Joshi *et al.* (2016) studied fish diversity of exotic fishes in River Yamuna. The fish diversity of River Yamuna were investigated for the first time and 112 fish species belonging to 10 order, 29 families and 73 genera were identified. Indian major carp fishery has considerably declined in the system while exotics especially *Cyprinus carpio* and *Oreochromis niloticus* are increasing at an alarming rate in the middle and downstream stretches. The exotic common carp was observed at all sampling sites accept the uppermost, almost pristine Badwala and formed a maximum 27.0% of the total fish catch at Arail (Allahabad).

Saini and Dube (2017) studied fish diversity of River Narmada, Jabalpur region (M.P). 29 species of fishes were recorded in these sampling stations. The major fish abundance was noticed major carps, minor carps and cat fishes. The several species of fish belonging to order Cypriniformes, Beloniformes, Ophiocephaliformes, Perciformes and Siluriformes were recorded. Out of these Cypriniformes is the most dominant group with recorded 22 species of fishes. Some species of fishes like *Cirrhinus cirrihosa, Labeo bata* showed a declining trend in the stretch.

Sayeswara Ha (2017) studied current status of ichtyofaunal diversity of Tunga River at SMandagadde Bird Sanctuary, Shivamogga, Karnataka, India. A total of 16 species of fishes belonging to 4 orders, 8 families and 12 genera were recorded from the study area. 12 species sighted in family Cyprinidae, Channidae, Cichlidae and Siloridae were represented by 3 species each. Families Bagridae, Hateropneustidae, Notopteridae and Schilbeidae had only a single species each. Mogalekar and Canciyal (2018) studied freshwater fishes of Orissa, India. In total 186 species of fishes belonging to 11 orders, 33 families and 96 genera were recorded from various freshwater bodies of Orissa. Cypriniformes was the most dominant order and Cyprinidae was diverse family. The trophic level of fishes of Orissa ranged from 2.0 to 4.5 containing 62.41% of carnivorous species. Fishery status revealed existence of 120 species worth for capture fishery, 101 species worth for ornamental fishery, 37 species worth for culture fishery and 25 species worth for sport fishery.

Sarkar (2018) studied seasonal fish fauna diversity and water quality of Jamuna River in South Bengal region. Altogether 46 fish species belonging to 18 families and 36 genera were collected. Family Cyprinidae (24 species) comprised 56% and Notopteridae (1 species); Clupeidae (1 species), Cobitidae (1 species); Claridae (1 species); Heteropneustidae (1 species); Synbranchidae (1 species); Gobidae (1 species); Eletridae (1 species); Anabantidae (1 species); Belontidae (1 species); Channidae (1 species); Mastacembelidae (1 species) comprises 2% each of total catch whereas Bagridae (2 species); Siluridae (2 species); Ambassisae (2 species); Mugilidae (2 species); comprised 4% each of the total catch, out of the 46 species documented, 8 species showed significant variation in catch data in Pre Monsoon, Monsoon and Post Monsoon period, *Cirrhinus reba, Labeo boga* catch significantly increased in Post Monsoon period compared to Pre Monsoon and Monsoon period.

Pir *et al.* (2019) studied diversity and abundance of fishes inhabiting the Western region of Narmada River, Madhya Pradesh, India. A total of 52 species belong to 10 orders containing 16 families were observed. Family Cyprinidae contained highest number of species 25, followed by Bagridae, Siluridae and Ophiocephalidae containing 4 each, respectively. Chandran *et al.* (2019) studied diversity and distribution of fish fauna in the Ib River, a tributary of Mahanadi, India. A total of 55 species belonging to 42 genera, 21 families and 9 orders were recorded from the study area. Cypriniformes represented by 23 species was found to be the most dominant order (41.8%) followed by Siluriformes and Perciformes, both with 12 species each (21.8%). Cyprinidae was the richest family (21 species) followed by Bagridae (5 species) and Schilbidae (4 species).

Banyal *et al.* (2019) studied fish diversity in the West Banas River, Banaskantha, Gujarat. 7 species were reported from the river. Cypriniformes was the dominant order with 5 species followed by Perciformes and Osteoglossiformes represented by 1 species each. Among the reported fishes *Notopterus notopterus, Labeo boggut, Labeo calbasu* and *Systomus sarana* are commercially important. Sharma *et al.* (2019 a) studied fresh water fishes in Chandloi River. River Chandloi has a good diversity composed of 6 orders of fishes, namely Cypriniformes, Siluriformes, Perciformes, Beloniformes, Clupeiformes and Synbranchiformes. Order Cypriniformes is represented by single family Cyprinidae which is found to be most diverse and dominant family. This family have 6 genera with 8 species. Genus *Labeo* is the most diverse and dominant genus in this habitat with 3 species. All other orders are represented by single family. Each family has 1 genus representing single species.

Jia *et al.* (2020) studied seasonal variation and assessment of fish resources in the Yangtze Estuary. A total of 59 species of fish in the four seasons of the Yangtze Estuary including 16 species in Spring, 5 in Summer, 45 in Autumn and 20 in Winter. The autumn presented the lowest richness. Banyal and Kumar (2020) studied ichtyofaunal diversity of Mej River in Bundi district Rajasthan. 11 species of fishes belonging to 9 genera, 6 families and 4 orders were recorded. Essien-Ibok and Isemin (2020) studied fish species diversity, abundance and distribution in the major water bodies (Qua Iboe River, Imo River and Cross River) in Akwa Ibom State, Nigeria. A total of 356 of fishes comprising 20 species belonging 12 families in Qua Iboe River. 129 fish fauna belonging to 5 species and 4 families in Imo River. Cross River recorded 19 species belonging to 16 genera representing 13 families. Thus the three major ecosystems in the region are capable of a pronounced fishery.

Pathak and Lavudya (2021) studied diversity of fresh water fishes in Narmada River, Madhya Pradesh. A total of 176 species from freshwater habitats out of which 13 orders, 46 families, 107 genera and 176 species recorded. The order Cypriniformes represented the highest diversity with 79 species followed by Perciformes (35 species), Siluriformes (32 species), Clupeiformes (11 species), etc. Freshwater fish diversity information could also provide a baseline for future more complex ecological studies and planning the conservation and sustainable use of inshore inland water resources. Sharma *et al.* (2021) studied diversity of ichtyofauna of Maheshwar Dam in Narmada River, Madhya Pradesh. 36 fish species were recorded which belong to 7 order, 12 families and 22 genera. Out of the 6 orders Cypriniformes (44.44%) was dominant with 16 species followed by Siluriformes (27.77%) with 10 species, order Ophiocephaliformes (11.11%) with 4 species, order Perciformes (5.56%) with 2 species, order Mastacembeliformes (5.56%) with 2 species, Beloniformes (2.77%) and Clupeiformes (2.77%) represented by one species each.

Benthic Fauna

Benthic Fauna refer to the organisms that inhabit the bottom substrates (sediments, debris, logs, macrophytes, filamentous algae, etc.) of freshwater habitats for at least part of their life cycle. Benthic invertebrates contribute to many important ecological functions, such as decomposition, nutrient cycling, as well as serve an important role in aquatic food webs as both consumers and prey. Benthic communities have been the best indicators of water quality and organic pollution because of their constant presence and relatively long sedimentary habitats, comparatively large size and varying tolerance to stress.

The present study (from October 2018 to September 2020) highlights good benthic diversity in the Chandloi River Kota, Rajasthan. Total 22 species benthos belonged to 4 phyla, 8 classes and 17 families were recorded. 22 species were identified of benthic invertebrates representing 4 groups Mollusca, Annelida, Arthopoda and Nematoda. Mollusca 9 species, Annelida 6 species, Arthopoda 2 species and Nematoda includes 5 species. Mollusca (41%) dominated over Annelida (27%), Nematoda (23%) and Arthopoda (9%). Nematodes were available round the year. The species of Chironomidae were found maximum in polluted water sites during the investigation because these species have a high tolerance and found in all water from clean to highly polluted. Among Oligochaeta *Tubifex* was most common observed in fresh water sites, this is a typical Indian freshwater species with wide distribution. The importance of *Tubifex* as pollution indicator.

Nocentini *et al.* (2001) reported the presence of bioindicators, *Tubifex spp.* and *Chironomus spp.* larvae indicate the effect of pollution. Reese and McDonald (2002) studied benthos own their abundance and position as “middlemen” in the aquatic food chain, they plays a critical role in the natural flow of energy and nutrients. As benthic invertebrates die, they decay, leaving behind nutrients that are reused by aquatic plants and other animals in the food chain. Biological assessments rely on indicators or metrics to measure the condition of aquatic communities to perturbations.

Davis *et al.* (2003) studied macro invertebrate bio-monitoring in Intermittent Coastal Plain Streams impacted by animal agriculture. The results obtained Ephemeroptera, Plecoptera, Trichoptera, Crustacea and Isopoda order were much higher at the reference site or unpolluted area. Meanwhile, this study was only recorded one taxa namely Ephemeroptera. Haase *et al.* (2004) studied benthic macro invertebrates, particularly aquatic insect larvae and Crustacean had been widely used as indicator of the health and condition of water bodies.

Hart and Zabbey (2005) recorded 30 taxa belonging to 5 classes of macro invertebrates in Woji Creek in the upper reaches of Bonny River in the lower Niger Delta. The population of macro invertebrates fluctuated in different seasons and months. The macro invertebrates diversity was maximum in Post Monsoon and Summer and was very low in Monsoon season. Sikoki and Zabbey (2006) identified 14 species of macro invertebrates in Imo River. Carlisle *et al.* (2007) studied benthic macro invertebrates populations in streams and rivers can assist in the assessment of the overall health of the streams and rivers. Biological assessment and criteria can be used as the basis for management programs, restoring and maintaining the chemical, physical and biological integrity of freshwater.

Merritt *et al.* (2008) studied benthic invertebrates are typically less mobile than fish, they provide a more localized assessment of their representatives of many Insect orders, as well as Crustaceans, Gastropods, Bivalves, Oligochaetes and they contribute many important ecological functions. George *et al.* (2009) studied the benthic macro invertebrate fauna and physico-chemical parameter in Okpoka Creek sediments and a total of 19 species recorded of benthic invertebrates fauna belonging 4 phyla Annelida, Amphipoda, Arthropoda and Mollusca, 6 classes Oligochaeta, Polychaeta, Crustacea, Insecta, Bivalvia and Gastropoda.

Strayer and Duolgeon (2010) studied examination of parameters like richness, diversity, abundance, evenness and community composition are essential to determine the natural or anthropogenic changes with time. In riverine ecosystem macro benthic invertebrates show an uneven distribution.

Slavevska-Stamenkovic *et al.* (2011) studied water quality assessment based on the macro invertebrate fauna in the Pcinja River case study. During the investigation of the bottom fauna from the Pcinja River 40 families from 13 animal groups were recorded. Trichoptera (10), Ephemeroptera (6) and Diptera (5) were the most diverse groups with families. The other groups were found to be less diverse. The number of families decreased in the longitudinal direction. The upper and middle part of the river was characterized by a higher taxa richness (16-22 families) in comparison with the lower stretch of the Pcinja River (13 families).

Vesna *et al.* (2012) was recorded the dominant in the composition of macro zoo-benthos communities of the investigated Morevica River at South West Serbia were larvae of the insect groups Ephemeroptera, Trichoptera, Plecoptera, Chironomidae, Diptera, Coleoptera and Heteroptera. Increased representation and diversity of members of the Oligochaeta and family Chironomidae was recorded at the downstream localities. There are river's current slows down, the channel widens, sedimentation is greater and soft types of substrate (mud and sand) are present to a greater extent.

Sharma and Dube (2013) studied the benthic fauna of Kishore Sagar Reservoir, Kota, Rajasthan. They studied total 19 species benthos belonged to 4 phyla, 8 classes and

17 families. 19 species were identified of benthic invertebrates representing 4 groups Nematode, Mollusca, Arthopoda and Annelida. Mohan *et al.* (2013) recorded the benthic macro invertebrate fauna of River Tawi was represented by 13 species belonging to 3 groups Annelida (4 texa), Arthropoda (6 texa) and Mollusca (3 taxa). Chaurasia (2013) studied water quality assessment of Kunda River (M.P.) with special reference to the benthic macro invertebrates. In the study 43 species comprising of 3 phyla of Annelida, 9 species of Oligocheates; phyla Arthropodes 8 species of Crustaceans and 10 species of Insects; phyla Mollusca 8 species of Gastropodes and 8 species of Pelecypodes were recorded. The study reveals that the benthic fauna mainly dominates during Winter at all the studied sites and lowest number were observed during the Rainy season, due to influx of more water and high water velocity.

Ansari *et al*. (2014) studied organic enrichment and benthic fauna - some ecological consideration. Increased organic enrichment brings changes in physical environment and biological parameter and the consequent changes in benthic community. Benthic fauna show characteristic response gradient with distance from the source of organic inputs in space and time. Population increases with moderate input of organic enrichment. An excessive organic load, on the other hand, create stress condition for benthos. Changes in the trophic structure and sedimentary stability along the gradient are accompanied by changes in the genera and families.

Olomukoro and Oviojie (2015) studied benthic macro invertebrates fauna of Obazuwa Lake in Benin city, Nigeria. They recorded a total of 748 benthic invertebrates composing of 46 taxa, 13 groups and 25 families. Dominant taxonomic taxa varied considerably; Hemiptera (64.56%), Coleoptera (48.43%), Mollusca (29.06%), Oligocheata (19.28%), Nematoda (16.03%) and Odonata (15.83%). The variations in taxa and number of individuals between stations were not significantly different ($P > 0.05$).

Nair and Prajapati (2016) studied benthic macro invertebrates communities of Narmada River in Madhya Pradesh. In this study 33 species of benthic macro invertebrates belonging to 5 groups (Worms, Crustacians, Molluscs, Dipteria and Ephemeroptera) were recorded from Narmada River. The population of benthic macro invertebrates fluctuated in different seasons and months. The benthic macro invertebrates diversity was maximum in Post Monsoon and Summer and was very low in Monsoon season. Golwalkar *et al.* (2016) studied diversity of benthic macro invertebrates in four tributaries of River Narmada. A total of 30 taxa were found from 8 sampling stations which belong to 2 phylum, Mollusca was represented by 2 classes Gastropoda and Bivalvia whereas, phylum Arthopoda was represented by 3 classes Insecta, Crustacea and Arachnida. In that investigation phylum Arthropoda was found in dominant position with 63% followed by phylum Mollusca with 37% occupancy in total faunal assemblage.

Francis and Keke (2017) studied the intensive intensity of human induced impacts on the distribution and diversity of macro invertebrates and water quality of the Gbako River, North Central, Nigeria. A total of 676 individuals from 41 invertebrate taxa in 27 families from 9 orders were collected from the four stations during the study. Aquatic insects represented 35.4% of the taxa and 76.6% of all individuals collected. The rest of the fauna was composed of Mollusca, Crustacea and Gastropoda. 10 macro invertebrate genus *Philaccolus, Pseudocloeon, Bugilliesia, Calopteryx, Coenagrion, Brachythemis, Leucostica, Gomphus, Hydrometra, Sphaerudx* and *potadoma* species were found in all the 4 sampled stations.

Bahuguna and Negi (2018) studied the benthic fauna consisted of 35 genera belonging to 8 orders (Ephemeroptera, Trichoptera, Diptera, Coleoptera, Odonata, Acariformes, Plecoptera and Hemiptera). During the study period the maximum macrozoobenthos density was recorded as 145 ind./ m^2 in January and minimum density was noticed as 44 ind./ m^2 in July.

Semwal and Mishra (2019) studied benthic invertebrates play important ecosystem roles in the cycling and outflow of nutrients. The benthos transforms organic detritus from sedimentary storage into dissolved nutrients that can be mixed into overlying waters and used by rooted plants and algae to enhance primary productivity. Singh *et al.* (2019) studied diversity and composition of macro invertebrates in flood plain Lakes of North Bihar, India. In total 26 species belonging to 3 phyla, 5 classes, 17 families and 17 genera were recorded during the study. Macro invertebrates communities were comprised of 5 major groups Oligochaeta, Hirudinea, Insecta, Pelecypoda and Gastropoda. Among these Gastropod (12 species) was the most dominant group followed by Pelecypod (5 species), Insect (1 larva and 3 nymphs), Oligochaete (3 species) and Leech (2 genera). Number of species was higher in clean water environments than in poor water quality.

Musonge *et al.* (2020) studied drivers of benthic macro invertebrate assemblages in Equatorial Alpine Rivers of the Rwenzoris (Uganda). A total of 1623 individuals were collected. They identified 44 macro invertebrates families of which Caenidae were the most common family with the taxon recorded at 50% of the sites. The most abundant taxa constituting 67% of the total individuals identified were: Simuliidae (26%), Baetidae (14%), Chironomidae (14%) and Caenidae (13%). The midstream sites had the highest total abundance (793 individuals) with downstream and upstream sites having lower abundance scores (573 and 257 individuals, respectively). Singh and Sharma (2020) studied benthic invertebrates owing to their wide variation of response to environmental changes have been extensively utilized to evaluate the water quality and health of the aquatic ecosystems. Seasonal sampling of the benthic invertebrates can indicate the effects of anthropogenic activities on the community. A total of 29 taxa of benthic invertebrates was found in the wetland Dodital, Garhwal Himalaya, India. Some species *Enchytreaus spp.* (Oligochaeta), *Isoperla spp.* (Plecoptera), *Orthrotrichis spp., Mystacides spp.* (Trichoptera) were identified as excellent bio-indicator on the basis of their abundance for assessing the health of the high altitude wetland.

Negi *et al.* (2021) studied biodiversity of mites in Khankra gad a Spring-Fed tributary of River Alaknanda in Uttarakhand. A total of 2537 Hydrachnidia samples were collected, belonging to 6 families Torrenticolidae, Sperchontidae, Feltriidae, Hygrobatidae, Lebertiidae and Aturidae. A total of 19 aquatic mite species were recorded in Spot-1 and 25 species in Spot-2 throughout the study period. Aquatic mites showed maximum density in December and minimum density in July.

Macrophytes

Macrophytes are those plants that grows in or near water and is either emergent, submerged and floating. They modify themselves to survive in aquatic environment. They serve as the bio-indicator for the possible degree of damage in aquatic ecosystem. They have a significant effect on soil chemistry and light levels as they slow down the flow of water and capture pollutants and trap sediments otherwise cause eutrophication of the water body. Aquatic macrophytes absorb nutrient mineral ions from water columns and influence metal retention indirectly by acting as traps for particulate matter by slowing the water current and favoring sedimentation of suspended particles. Aquatic macrophytes have the capability to remove excessive nutrient load from the water that otherwise cause eutrophication of the water body. Aquatic plant species are very specific for the uptake of nutrients. The use of aquatic macrophytes for treatment of wastewater to mitigate variety of pollution level is one of the most researched issues all over the world.

In Chandloi River was studied for a period of two years from October 2018 to September 2020. A total of 22 species were recorded of macrophytes belonging 16 families and 18 genera. All 22 species belonged to phylum Magnoliophyta and 2 classes Liliopsida and Magnoliopsida. Class Liliopsida and Magnoliopsida each has 11 species. Semi aquatic plants and aquatic wetland plants were included into general survey.

Virola *et al*. (2001) studied environmental factors associated with the richness and species composition of macrophytes. Thus, an assembly of such organisms in a river or lake can be an effective indicator of the integrated combination of the pressure and stress disorders that affect their habitat. Aquatic macrophytes are one of the important biotic entities in aquatic ecosystem, as they provide food, oxygen and shelter to the other aquatic organisms. Hill (2003) studied several species of freshwater aquatic plants, all notorious weeds in other parts of the world have also become invasive in many of the rivers, man-made impoundments, lakes and wetlands of South Africa.

Germ *et al*. (2004) determined 39 macrophytes species in the Krka River. Among submerged macrophytes *Potamogeton nodosus, Ceratophyllum demersum, Myriophyllum spicatum, Potamogeton filiformis* and *Najas marina* were abundant species composition changed significantly form Novo mesto downstream as a consequence of lower water quality. *Najas minor* that was only found in one stretch has the status of a vulnerable species in Slovenia.

Sharma *et al.* (2005) studied response of selected aquatic macrophytes towards textile dye waste waters. Among the various plant species studied, *Phragmites* is the only macrophyte species tolerant to textile waste waters and therefore it has been used for polishing partially treated textile waste waters in a constructed wetland at Sanganer. However, the highly sensitive species such as *Ceratophyllum, Azolla, Lemna* and *Spirodela*, to waste waters may also be used as a marker for assessing toxicity of textile dye waste waters; more particularly *Lemna*, since it allows comparison of toxicity of textile waste waters with other pollutants.

Zafari and Gunale (2006) studied hydrobiological study of algae of an Urban Freshwater River at Pune city. As the river enter into urban influence, inflow of sewage helps to increase plant nutrients, particularly phosphate and nitrates, thereby increasing growth of plants. The *Eichhornia* is slowly replaced by *Pistia* indicating changes in water quality resulting in to change in weed formation. Hrivnak *et al.* (2006) studied diversity of aquatic macrophytes in relation to environmental factors in the Slatina River (Slovakia). Total 8 vascular plants and 3 mosses were detected in the River. Most of them belong to hydrophytes (7), only 4 to helophytes or amphiphytes. Algae were not determined and they were asigned into a common group. *Algae filomentous*, *Myriophyllum specatum* were the species with the highest RPM value, moss species (*Fontinalis antipyretica, Rhynchostegium riparioides*) have a similarly higher RPM. The RPM of other 7 species was neglected and thus they were included into the group “Other species”.

Devi and Sharma (2007) studied the diversity of the macrophytes in Awangsoipat Lake (Bishnupur), Manipur. Transparency, nutrient concentration and land are the different factors responsible for proper growth and distribution of macrophytes in the reservoirs and rivers. Giri *et al.* (2008) studied hydrobiological status of Kansai and Divarkeshwar Rivers in West Bengal, India. Total of 84 macrophytes species belonging to 73 genera and 34 families were observed during the study period. Among these 55 terrestrial plants (66%), 11 aquatic plant species (13%) and 18 semi aquatic plant species (21%) have been found.

Sondergaard (2010) studied submerged macrophytes are considered to be suitable eutrophication indicators and are sensitive to local environmental conditions. Rejmankova (2011) studied the role of macrophytes in wetland ecosystem. Wetland macrophytes comprise taxonomically highly diverse group of plants. Their functions in wetland ecosystems impact many processes such as nutrient availability often result in replacement of low productivity high species diversity systems with highly productive species monoculture.

Vyas *et al.* (2012) studied distribution of macrophytes in River Narmada near water intake. A total 8 species of macrophytes were recorded indicating rapid growth of macrophytes with minimum species diversity. These species were categorized under emergent and submerged macrophytes. Emergent macrophytes belong to one class (Mangnoliopsida), 3 families (Polygonaceae, Onagraceae and Convolulaceae) and 3 orders (Polygonales, Myrtales and Solonales) while submerged macrophytes belong to one class (Monecotyledons), 4 families (Potamogetonaceae, Hydrocharitaceae, Najadaceae and Aracaceae) and 4 orders (Potamogetonales, Butomales, Najadales and Alismatales). Results showed that submerged species of macrophytes represent 63% and acquires a dominant position in the study area where as emergent species of macrophytes are only 37%.

Kshirsagar and Gunale (2013) studied diversity of aquatic macrophytes from River Mula, Pune city, Maharashtra, India. Total 74 species of plants were recorded from Mula River flowing through the Pune city. *Eichhornia crassipes* and *Pistia stratiotes* as weeds was predominant at sampling stations which are the most tolerant and could be regarded as pollution tolerant aquatic macrophytes and be used as a biological indicator for water pollution.

Mone (2014) studied ecology and vegetation of Godavari River in Nanded district, Maharashtra. During the course of study a total of 30 aquatic macrophytes were collected belonging to 16 different families. Among these 7 were submerged, 4 were free-floating and remaining are emergent. Out of 30 macrophytes observed the emergent were dominant in River Godavari. Sharma and Deka (2014) studied quantitative analysis of macrophytes and physico-chemical properties of water of two Wetlands of Nalbari district of Assam, India. Species diversity was highest for the emergent in Summer followed by the submerged, rooted floating leaf type and free floating species respectively. Species diversity is a useful parameter for the comparison of communities under the influence of biotic disturbance or to know the state of succession and stability in the community.

Ghosh and Biswas (2015) studied bio monitoring macrophytes diversity and abundance for rating aquatic health of an Oxbow Lake Ecosystem in Ganga River Basin. They recorded altogether 45 genera of macrophytes. It was found altogether 13 genera of aquatic macrophytes belonging to 10 families and 24 plant species (bank flora) belonging to 16 families. In terms of genus number of plant, emergent showed the largest number in study followed by free floating, submerged and rooted floating leaf genus.

Reddy and Chaturvedi (2016) studied macrophytes from the major rivers of the Chandrapur district, Maharashtra. The major Rivers Wardha, Painganga and Waineganga of the district were studied for a period of two years from 2013-2015. During study 16 hydrophytes and 56 other macrophytes were recorded from 21 selected sites of the rivers. Among the enlisted macrophytes 2 were algae, 2 were Pteridophytes and 68 were Angiosperms.

Narsimha and Benarjee (2016) studied diversity and distribution of macrophytes in Nagaram Tank of Warangal district, Telangana State. Total 25 macrophytes species were recorded from littoral and sub littoral zones of the tank near by sampling stations. In the free floating macrophytes 6 species were recorded of which *Hydrilla spp.* and *Lemna spp.* were dominant on all the sampling stations. Among rooted floating *Nymphaea spp.* and *Nelumbo spp.* recorded from all the sampling stations. In free submerged two species were recorded *ceratophyllum* and *utricularia* species showed it appearance on all the four stations.

Sharma and Singh (2017) studied macrophytes of sacred Himalayan Lake Dudital, India: quantitative and diversity analysis. A total of 45 macrophytes species belonging to 29 families and 34 genera were reported. Maximum number of species were represented by emergent (30) followed by submerged (10), rooted-floating leaf type (3) and free floating (3) macrophytes. Joshi (2018) studied floristic diversity in the wetlands of Kota district, Rajasthan. The study revealed that the occurrence of 51 aquatic and semi aquatic families with 90 genera and 113 species of Angiosperm and two species of Pteridophytes were identified. The most dominant vascular family with respect to number of species is Poaceae with 11 plants, 34 families were Dicot, remaining 16 were Monocot and rest of two families were Pteridophytes.

Sethu *et al.* (2019) studied the physico-chemical parameters and distribution of aquatic macrophytes of seasonal wetlands flowing into the coast of Palk Bay, South East Coast of India. A total of 7 submerged macrophytes, 6 rooted floating weeds, 1 floating and rooted macrophyte were recorded in Tharavai Wetland. Submerged aquatic vegetation is used as the water quality key indicator and it exists where there is a better quality condition. Tenna Riis *et al*. (2019) studied riverine macrophytes control seasonal nutrient uptake via both physical and biological pathways. Metabolic activities of macrophytic communities accelerate the metabolic and the physico-chemical condition of stream water.

Rawlekar and Sawane (2020) studied macrophytes diversity of a Tropical River from Nagpur, India. A total of 25 species from three groups were recorded from Kolar Lotic Ecosystem under study which was categorized by free-floating, submerged and marginal aquatic weeds. *Azolla* species were not recorded from Kolar River while *Eichhornia crassipes* was recorded. The *Azolla* species is considered as pollution free species and *Eichhornia* as pollution tolerant species during investigation period of total macrophytes. Free floating 20%, submerged 48% and marginal aquatic weeds 32% were observed. Harney (2020) studied macrophytes biodiversity of Waigaon Tukum Lake near Bhadrawati, district Chandrapur (Maharashtra) India. A total 26 species representing 17 families belonging to 8 groups such as 3 submerged floating weeds, 3 rooted floating leaves weeds, 1 rooted emergent with heterophile weeds, 6 free-floating suspended submerged, 3 rooted submerged hydrophytes, 7 emergent weeds, 2 submerged weeds and one anchored floating weeds. Sarkar *et al*. (2020) studied that macrophytes are important structural components and bio indicators of freshwater lakes and its occurrence and species composition are dependent on the nutrient conditions, water level, water temperature and transparency. Variations in macrophytes species is affected by changing environmental conditions. Comparatively highest level of pollution status was observed in pond B then in pond A due to the presence of some macrophytes (*Eichhornia* and *Lemna*).

Kamble *et al.* (2021) studied wetland flora of Gorewada International Biopark, Nagpur. A total of 114 species from 33 families were identified from the Gorewada wetland area. 67 species belong to Dicot and 47 are Monocots. Some of major dominant wetland macrophytes are *Hydrilla, Azolla, Utricularia, Ipomea, Lemna, Nymphoides indica, Ceratophyllum,* etc. Submerged species are represented by *Naias,* *Nechmandra, Vallisneria, Hydrilla* and *Ceratophyllum*, while *Aponogeton, Limnophyllum* and *Ottelia* forms the floating leaves category. *Typha* and *Ipomea fistulosa* are the most frequent taxa of category. Besides these Algae, Aquatic Fungi, Bryophytes and Pteridophytes are also measure parts of the wetland ecosystem.

Sharma and Dube (2021) studied aquatic plant diversity of Chandloi River, Kota district, Rajasthan. They recorded 21 species of macrophytes belonged to 17 genera and 17 families.

Conclusion

CHAPTER-VI

CONCLUSION

LIMNOLOGICAL STUDIES OF RIVER CHANDLOI (DISTRICT KOTA, RAJASTHAN) WITH SPECIAL REFERENCE TO ICHTHYOFAUNAL DIVERSITY.

Limnology study of a small River Chandloi, district Kota, Rajasthan was conducted from October 2018 to September 2020 covering all three prevailing seasons (Pre Monsoon, Monsoon, Post Monsoon). The River Chandloi is a left tributary of perennial River Chambal and is a very good for conducting studies of a lotic aquatic ecosystem. The physico-chemical factors were analyzed and biological factors were studied during October 2018 to September 2020.

(1) STUDY SITE AND SAMPLING SITES

1. Four sampling sites (S-1, S-2, S-3 and S-4) were selected after an initial field survey.

2. To carry out the study, surface water samples were collected twice in a month from selected sites (S-1, S-2, S-3, and S-4).

(2) METHODOLOGY

For collection, transport, preservation and physico-chemical analysis of water samples standard methods of Golterman (1978), Welch (1998), APHA (2005) were followed.

Plankton studies: collection of plankton using plankton nets (No. 25) was done followed by their preservation in 5% formalin. The identification of plankton was made with the help of standard taxonomic keys, which are available in literature.

Study of Ichtyofauna: collection of fishes using suitable nets and hooks was done followed by their preservation in 5% formalin. Help of local fisherman was also taken for procurement of fish specimens. The identification of fishes was made with the help of standard taxonomic books by Day (1889), Shrivastava (1980), Jayaram (1999), Talwar and Jhingran (1991).

Study of Benthic Fauna: collection of benthic fauna using D- net and Ekman grab (for deeper sites) was done followed by their preservation in 5% formalin. The identification of benthic fauna was made with the help of standard books by Needham and Needham (1969), Pennak (1989) and APHA (2005).

Study of Macrophytes: collection of Macrophytes by hand picking and help of a boat in deeper site further than iron hook. The identification of benthic fauna was made with the help of standard books by Adoni (1985), Cook (1996), Fasett (2000).

For photography in Nikon 35 SLR camera was used.

(3) **FINDINGS**

The findings of the current investigation can be concluded as follows:

1. The study was carried out from October 2018 to September 2020 over three well marked seasons that is Pre Monsoon (March to June), Monsoon (July to October), and Post Monsoon (November to February).

2. The seasonal variation in physico-chemical parameters were statistically analyzed and diagrammatically presented. The lowest, highest values and standard deviation were also recorded.

3. In the light of present findings it can be inferred that there is a clear difference in the physico-chemical parameters of experimental water bodies.

4. A gradual fall in the Depth from November onwards. Depth was minimum in the month of June and with the start of Monsoon depth started increasing gradually and it was maximum in the month of September.

5. Most of water quality parameters including Temperature, Turbidity, Water pH, Alkalinity, Hardness, Chloride, Total Dissolved Solids, Biological Oxygen Demand, Nitrate, Phosphate and Electrical Conductivity were highest at site 4 and lowest value of Dissolved Oxygen and Free Carbon Dioxide was also recorded site 4.

6. The qualitative study of plankton in the surface water samples collected from different sampling sites was undertaken. It was observed during the period of investigation that phytoplankton species were more diverse than the zooplankton species. Phytoplankton communities were found to be dominant over the zooplankton communities. These were found to be present in the ratio of percentage 56% phytoplankton and 44% zooplankton.

7. Phytoplankton were represented by the following classes: Chlorophyceae, Bacillariophyceae, Fragilariaceae, Xanthophyceae, Euglenophyceae, Cyanophyceae and Dinophyceae.

8. Zooplankton were represented by the following classes: Monogonata, Ciliata, Branchiopoda, Cladocera, Ostracoda and Copepoda.

9. Benthic fauna were represented by the following classes: Gastropoda, Bivalvia, Hirudinea, Polychaeta, Oligochaeta, Insecta, Phasmidia, Aphasmi.

10. Macrophytes were represented by the following classes: Liliopsida and Magnoliopsida.

11. All 16 species of fishes belonged to phylum Chordata, class Actinopterygii, 5 orders and 7 families. 16 species identified of fishes representing 5 orders Cypriniformes, Anabantiformes, Siluriformes, Cichliformes and Synbranchiformes. Order Cypriniformes has 7 species, Anabantiformes has 2, Siluriformes has 5, Cichliformes has 1 and Synbranchiformes has 1 species. Order Cypriniformes (44%) has dominated over Siluriformes (31%), Anabantiformes (12.5), Cichliformes (6%) and Synbranchiformes (6%), respectively

Fishes are moving from one place to another, so it is difficult to find their diversity at one site. In the present study of Chandloi River, it was found that the diversity of all 16 fish species at site 2 and site 3 was found very good. Because these sites temperature, pH, turbidity, DO and food availability factors are fish-friendly, as well as no anthropogenic activities here and due to very less. These sites were absolutely pollution free and all the species were seen in large number. Among all species *Labeo rohita, Labeo catla, Labeo calbasu, Mastacembelus moorii, Sperata aor, Channa argus, Channa striata, Wallago attu* seen more comparatively other fishes. Whereas, not all 16 species appeared on site 1 and site 4. *Oreochromis niloticus, Crucian carassius, Cirrhinus cirrhosus, Ompok bimaculatus* seen more with other species in site 1 whereas only species *Oreochromis niloticus* and *Crucian carassius* were recorded in site 4. Because in these sites anthropogenic activities, sewerage of village, industrial water, etc. gets mixed in the river. So temperature, pH, turbidity of water increases and reduces the amount of DO and availability of food, which were not favourable for fishes. That showed these species tolerance quality, not only tolerance to chemical stress but also tolerance to high water temperature, pH, trophic status, prior invasion success may play more important role. Thus the diversity of fishes told, site 1 was an indication that that site is heavily polluted. Human activities were the main cause of water pollution. Site 2 was not completely unpolluted but some pollution of site 1 was reaching here but it was not much polluted yet. Site 3 was near origin of river so anthropogenic activities were not here right now, That was completely unpolluted site. Site 4 suggested, that site was completely polluted. That was the result of industrialization and anthropogenic activities.

In the end it may be concluded that the water of River Chandloi showed variation in the various physico-chemical parameters in all three seasons at all experimental sites. The Biodiversity of organisms Phytoplankton, Zooplankton, Ichthyofauna, Benthic fauna and Macrophytes were also showing seasonal variations. The health status of site 4 was significantly inferior. The reason may be due to the high level of anthropogenic activities, industrialization and poor management of this River. After studying all the parameters it can be concluded that the ecological condition of site 2 and site 3 was better than site 1 and site 4. The values of certain parameters were giving an alarm towards its pollution. With the industrialization, increasing population and anthropogenic factors there were urgent need of continuous monitoring, conservation and scientific management of the river and its biodiversity.

This study would be useful for future assessment after interlinking. Issues related to various threats to aquatic environment and conservation management strategies have been discussed.

Summary

CHAPTER- VII

SUMMARY

LIMNOLOGICAL STUDIES OF RIVER CHANDLOI (DISTRICT KOTA, RAJASTHAN) WITH SPECIAL REFERENCE TO ICHTHYOFAUNAL DIVERSITY

Water is the most abundant and renewable resource, which helps to maintain the earth climate and dilute environmental pollution. Water is essential for life next to the air and it sustains life on the earth. All animals and human beings depend on water for their growth, development and survival. Rivers have been the most important freshwater resources and our ancient civilization have flourished along the banks of rivers. River water finds multiple uses like agriculture, industry, transportation, aquaculture, public water supply and they have been used for cleaning and disposal purposes. Due to a lot of load growing problems of degradation of river ecosystem has necessitated the monitoring of water pollution and water quality to evaluate their production, capacity, utility potential and to plan restoration measures. The quality of river water can be analyzed by the changes in the physico-chemical and biological properties.

Present investigation was carried out on Chandloi River in Kota, district Rajasthan. Chandloi River originates near Aalania village and meets the River Chambal near village Kashoroipatan. It's location is 25.23 Latitudnal and 75.99 Longitudnal in Kota city. The river flows nearly 100 Km. before entering River Chambal and it's average width is 50 to 80 m. Kesar, Dhani, Mawasa, Kaithoon, Borkhandi, Raipura, Mandaniya, Hathikheda and Chandresal villages are situated on the bank along this river path.

The study area Kota city located in $23^{0}53'$ to North and $75^{0}9'$ to $77^{0}27'$ to East longitude and total area is 5,217 kilometre square. The information contributed by this investigation will be highly significant and useful in order to create a general awareness in the people to prevent further water pollution and improve aquaculture and other uses of such valuable water resources in the near future.

The present study incorporates the various physico-chemical aspects and biological components. A brief account of the present investigation is as follows:

Present study was carried out from October 2018 to September 2020. Therefore 4 sampling sites (site 1, site 2, site 3 and site 4) were selected. The month wise water samples were collected from every sampling station during entire period of study and were taken to laboratory for further qualitative analysis of certain physico-chemical and biotic parameters. The data recorded from present River was statistically analyzed and the calculated values were noted.

The seasonal and spatial changes of certain physico-chemical parameters namely Water Temperature, Depth, Turbidity, pH, Alkalinity, Hardness, Free Carbon Dioxide, Dissolved Oxygen (DO), Chloride, Total Dissolved Solids (TDS), Biological Oxygen Demand (BOD), Nitrate, Phosphate, Electrical Conductivity (EC) and Biodiversity of Plankton, Fishes, Benthic Fauna and Macrophytes analysis were well documented in every month at present River and are presented seasonally in Table Number 1 to 33.

The qualitative estimate of physico-chemical factors were done by using the standard methods as suggested by APHA (2005).

The water Temperature varied between 15.5^0C to 25.6^0C in two years of study period. The minimum Temperature of 15.5^0C was recorded at site 3 in 2019 in Post Monsoon Season and maximum Temperature 25.6^0C was recorded at site 4 in 2018 in Pre Monsoon Season. From October 2018 to September 2019, the water Temperature was recorded from 15.9^0 C to 25.6^0C. The minimum water Temperature recorded in Post Monsoon and maximum in Pre Monsoon. The average of water Temperature was 16.7^0C to 25^0C with average Standard Deviation of 4.55. During October 2019 to September 2020 this fluctuation was between 15.5^0C to 24.2^0C. The minimum water Temperature recorded in Post Monsoon and maximum in Monsoon. The average of water Temperature was 16.07^0C to 23.5^0C with average Standard Deviation of 4.21.

The water Depth varied between 92.25 Cm. to 310.25 Cm. in the Chandloi River in two years of study period. The minimum Depth of 92.25 Cm. was recorded at site 3 in 2018 in Post Monsoon Season and maximum Depth 310.25 Cm. was recorded at site 1 in 2019 in Monsoon season. From October 2018 to September 2019, the water Depth was recorded from 92.25 Cm. to 308.75 Cm. The minimum water Depth recorded in Post Monsoon and maximum in Monsoon. The average of water Depth was 118.5 Cm. to 296.56 Cm. with average Standard Deviation of 95.44. During October 2019 to September 2020 this fluctuation was between 94.75 Cm. to 310.25 Cm. The minimum water Depth recorded in Post Monsoon and maximum in Monsoon. The average of water Depth was 119.12 Cm. to 298.18 Cm. with average Standard Deviation of 96.14.

The water Turbidity varied between 8.5 NTU to 26.8 NTU in the Chandloi River in two years of study period. The minimum Turbidity of 8.5 NTU was recorded at site 3 in 2018 in Pre Monsoon Season and maximum Turbidity 26.8 NTU was recorded at site 4 in 2018 in Monsoon season. From October 2018 to September 2019, the water Turbidity was recorded from 8.5 NTU to 26.8 NTU. The minimum water Turbidity recorded in Pre Monsoon and maximum in Monsoon. The average of water Turbidity was 10.8 NTU to 24.9 NTU with average Standard Deviation of 7.67. During October 2019 to September 2020 this fluctuation was between 9.3 NTU to 25.5 NTU. The minimum water Turbidity recorded in Pre Monsoon and maximum in Monsoon. The average of water Turbidity was 10.98 NTU to 24.2 NTU with average Standard Deviation of 7.40.

The water pH varied between 8 to 9.2 in the Chandloi River in two years of study period. The minimum pH of 8 was recorded at site 3 in 2019 in Monsoon season and maximum pH 9.2 was recorded at site 4 in 2018 in Pre Monsoon Season. From October 2018 to September 2019, the water pH was recorded from 8.1 to 9.2. The minimum water pH recorded in Monsoon and maximum in Pre Monsoon. The average of water pH was 8.4 to 8.7 with average Standard Deviation of 0.15. During October 2019 to September 2020 this fluctuation was between 8 to 9.1. The minimum water pH recorded in Monsoon and maximum in Post Monsoon. The average of water pH was 8.4 to 8.7 with average Standard Deviation of 0.21.

The water Alkalinity varied between 119.9 mg/ L. to 396.3 mg/ L. in the Chandloi River in two years of study period. The minimum Alkalinity of 119.9 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum Alkalinity 396.3 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season. From October 2018 to September 2019, the water Alkalinity was recorded from 119.9 mg/ L. to 140.05 mg/ L. The minimum water Alkalinity recorded in Monsoon and maximum in Pre Monsoon. The average of water Alkalinity was 123.9 mg/ L. to 133.7 mg/ L. with average Standard Deviation of 5.34. During October 2019 to September 2020 this fluctuation was between 196.1 mg/ L. to 396.3 mg/ L. The minimum water Alkalinity recorded in Monsoon and maximum in Pre Monsoon. The average of water Alkalinity was 201.6 mg/ L. to 384.4 mg/ L. with average Standard Deviation of 92.38.

The water Hardness varied between 123.4 mg/ L. to 139.5 mg/ L. in the Chandloi River in two years of study period. The minimum Hardness of 123.4 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum Hardness 139.5 mg/ L. was recorded at site 4 in 2018 in also Pre Monsoon Season. From October 2018 to September 2019, the water Hardness was recorded from 123.4 mg/ L. to 139.5 mg/ L. The minimum water Hardness recorded in Monsoon and maximum in Pre Monsoon. The average of water Hardness was 125.23 mg/ L. to 135.97 mg/ L. with average Standard Deviation of 6.12. During October 2019 to September 2020, this fluctuation was between 123.83 mg/ L. to 139.33 mg/ L. The minimum water Hardness recorded in Monsoon and maximum in Pre Monsoon. The average of water Hardness was 125.68 mg/ L. to 135.92 mg/ L. with average Standard Deviation of 5.76.

The water concentration of Free Carbon Dioxide varied between 0.45 mg/ L. to 2.35 mg/ L. in the Chandloi River in two years of study period. The minimum Free Carbon Dioxide of 0.45 mg/ L. was recorded at site 4 in 2018 in Post Monsoon Season and maximum Free Carbon Dioxide 2.35 mg/ L. was recorded at site 2 and site 3 in 2019 in Monsoon season. From October 2018 to September 2019, the Free Carbon Dioxide concentration was recorded from 0.45 mg/ L. to 2.33 mg/ L. The minimum Free Carbon Dioxide concentration recorded in Post

Monsoon and maximum in Monsoon. The average of Free Carbon Dioxide concentration was 0.55 mg/ L. to 1.76 mg/ L. with average Standard Deviation of 0.62. During October 2019 to September 2020 this fluctuation was between 0.5 mg/ L. to 2.35 mg/ L. The minimum water concentration of Free Carbon Dioxide recorded in Post Monsoon and maximum in Monsoon. The average water concentration of Free Carbon Dioxide was 0.57 mg/ L. to 1.81 mg/ L. with average Standard Deviation of 0.63.

The water concentration of Dissolved Oxygen (DO) varied between 3.98 mg/ L. to 7.33 mg/ L. in the Chandloi River in two years of study period. The minimum Dissolved Oxygen of 3.98 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season and maximum 7.33 mg/ L. was recorded at site 3 in 2018 in Monsoon season. From October 2018 to September 2019, the Dissolved Oxygen concentration was recorded from 4.13 mg/ L. to 7.33 mg/ L. The minimum Dissolved Oxygen concentration recorded in Pre Monsoon and maximum in Monsoon. The average of Dissolved Oxygen concentration was 5.31 mg/ L. to 6.39 mg/ L. with average Standard Deviation of 0.56. During October 2019 to September 2020 this fluctuation was between 3.98 mg/ L. to 7.1 mg/ L. The minimum water concentration of Dissolved Oxygen recorded in Pre Monsoon and maximum in Post Monsoon. The average water concentration of Dissolved Oxygen was 5.27 mg/ L. to 6.34 mg/ L. with average Standard Deviation of 0.57.

The water concentration of Chloride varied between 35.4 mg/ L. to 150.13 mg/ L. in the Chandloi River in two years of study period. The minimum Chloride of 35.4 mg/ L. was recorded at site 3 in 2018 in Monsoon season and maximum 150.13 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season. From October 2018 to September 2019, the Chloride concentration was recorded from 35.4 mg/ L. to 150 mg/ L. The minimum Chloride concentration recorded in Monsoon and maximum in Pre Monsoon. The average of Chloride concentration was 71.02 mg/ L. to 106.25 mg/ L. with average Standard Deviation of 18.28. During October 2019 to September 2020 this fluctuation was between 38.38 mg/ L. to 150.13 mg/ L. The minimum water concentration of Chloride recorded in Monsoon and maximum in Pre Monsoon. The average water concentration of

Chloride was 72.02 mg/ L. to 106.22 mg/ L. with average Standard Deviation of 17.90.

The water concentration of Total Dissolved Solids (TDS) varied between 124.13 mg/ L. to 938.4 mg/ L. in the Chandloi River in two years of study period. The minimum Total Dissolved Solids of 124.13 mg/ L. was recorded at site 3 in 2018 in Post Monsoon Season and maximum 938.4 mg/ L. was recorded at site 4 in 2019 in Monsoon season. From October 2018 to September 2019, the Total Dissolved Solids concentration was recorded from 124.13 mg/ L. to 927.6 mg/ L. The minimum Total Dissolved Solids concentration recorded in Post Monsoon and maximum in Monsoon. The average of Total Dissolved Solids concentration was 435.05 mg/ L. to 504.92 mg/ L. with average Standard Deviation of 37.66. During October 2019 to September 2020 this fluctuation was between 125.15 mg/ L. to 938.4 mg/ L. The minimum water concentration of Total Dissolved Solids recorded in Post Monsoon and maximum in Monsoon. The average water concentration of Total Dissolved Solids was 467.04 mg/ L. to 508.72 mg/ L. with average Standard Deviation of 21.68.

The water concentration of Biological Oxygen Demand (BOD) varied between 7.07 mg/ L. to 119.63 mg/ L. in the Chandloi River in two years of study period. The minimum Biological Oxygen Demand 7.07 mg/ L. was recorded at site 3 in 2019 in Monsoon season and maximum 119.63 mg/ L. was recorded at site 4 in 2019 in Post Monsoon Season. From October 2018 to September 2019, the Biological Oxygen Demand concentration was recorded from 7.58 mg/ L. to 106 mg/ L. The minimum Biological Oxygen Demand concentration recorded in Monsoon and maximum in Pre Monsoon. The average of Biological Oxygen Demand concentration was 24.73 mg/ L. to 61.7 mg/ L. with average Standard Deviation of 20.38. During October 2019 to September 2020 this fluctuation was between 7.07 mg/ L. to 119.63 mg/ L. The minimum water concentration of Biological Oxygen Demand recorded in Monsoon and maximum in Post Monsoon. The average water concentration of Biological Oxygen Demand was 45.24 mg/ L. to 69.06 mg/ L. with average Standard Deviation of 12.47.

The water concentration of Nitrate varied between 47.43 mg/ L. to 100 mg/ L. in the Chandloi River in two years of study period. The minimum 47.43 mg/ L. was recorded at site 3 in 2018 in Pre Monsoon Season and maximum 100 mg/ L. was recorded at site 4 in 2018 in Post Monsoon Season. From October 2018 to September 2019, the Nitrate concentration was recorded from 47.43 mg/ L. to 100 mg/ L. The minimum Nitrate concentration recorded in Pre Monsoon and maximum in Post Monsoon. The average of Nitrate concentration was 59.95 mg/ L. to 85.92 mg/ L. with average Standard Deviation of 13.40. During October 2019 to September 2020 this fluctuation was between 54.65 mg/ L. to 91.68 mg/ L. The minimum water concentration of Nitrate recorded in Pre Monsoon and maximum in Post Monsoon. The average water concentration of Nitrate was 66.43 mg/ L. to 80.04 mg/ L. with average Standard Deviation of 7.04.

The water concentration of Phosphate varied between 31.68 mg/ L. to 89.68 mg/ L. in the Chandloi River in two years of study period. The minimum 31.68 mg/ L. was recorded at site 3 in 2019 in Pre Monsoon Season and maximum 89.68 mg/ L. was recorded at site 4 in 2019 in Pre Monsoon Season. From October 2018 to September 2019, the Phosphate concentration was recorded from 41.45 mg/ L. to 89.5 mg/ L. The minimum Phosphate concentration recorded in Pre Monsoon and maximum in Post Monsoon. The average of Phosphate concentration was 58.59 mg/ L. to 77.07 mg/ L. with average Standard Deviation of 9.59. During October 2019 to September 2020 this fluctuation was between 31.68 mg/ L. to 89.68 mg/ L. The minimum water concentration of Phosphate recorded in Pre Monsoon and maximum also in Pre Monsoon. The average water concentration of Phosphate was 55.90 mg/ L. to 67.69 mg/ L. with average Standard Deviation of 6.60.

The Electrical Conductivity (EC) in water varied between 195.6 µmhos/ Cm. to 396.3 µmhos/ Cm. in the Chandloi River in two years of study period. The minimum 195.6 µmhos/ Cm. was recorded at site 3 in 2018 in Monsoon season and maximum 396.3 µmhos/ Cm. was recorded at site 4 in 2019 in Pre Monsoon Season. From October 2018 to September 2019, the Electrical Conductivity was recorded from 195.6 µmhos/ Cm. to 393.7 µmhos/ Cm. The minimum Electrical Conductivity recorded in Monsoon and maximum in Pre Monsoon. The average of Electrical Conductivity was 200.3 µmhos/ Cm. to 384.8 µmhos/ Cm. with average Standard Deviation of 93.37. During October 2019 to September 2020 this fluctuation was between 196.1 µmhos/ Cm. to 396.3 µmhos/ Cm. The minimum Electrical Conductivity recorded in Monsoon and maximum in Pre Monsoon. The average of Electrical Conductivity was 201.6 µmhos/ Cm. to 384.4 µmhos/ Cm. with average Standard Deviation of 92.62.

The diversity and seasonal variation of aquatic communities (Plankton, Fishes, Benthic Fauna and Macrophytes) ascertained and identified by various standard keys and books under various magnification microscopes and were well documented at present River and are presented in table number 29 to 33.

Phytoplankton were represented 37 species belonged to 6 phylum, 7 classes and 25 families. 6 groups namely Chlorophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Cyanophyta and Dinoflagellata. Chlorophyta includes 14 species, Bacillariophyta 6 species, Xanthophyta 4 species, Euglenophyta 3 species, Cyanophyta 8 species and Dinoflagellata 2 species. Group Chlorophyta (38%) was dominated over Cyanophyta (22%), Bacillariophyta (16%), Xanthophyta (11%), Euglenophyta (8%) and Dinoflagellata (5%), respectively.

Zooplankton were represented 29 species belonged to 3 phylum, 6 classes and 16 families. 3 groups namely Rotifera, Protozoa and Arthropoda. Rotifera has 8 species, Protozoa has 7 species and Arthropoda has 14 species. Group Arthropoda (48%) was dominated over Rotifera (28%) and Protozoa (24%), respectively.

Ichtyofauna were represented 16 species by group Chordata, class Actinopterygii and 5 orders and 7 families. 5 orders namely Cypriniformes, Anabantiformes, Siluriformes, Cichliformes and Synbranchiformes. Order Cypriniformes has 7 species, Anabantiformes has 2, Siluriformes has 5, Cichliformes has 1 and Synbranchiformes has 1 species. Order Cypriniformes (44%) has dominated over Siluriformes (31%), Anabantiformes (12.5%), Cichliformes (6%) and Synbranchiformes (6%), respectively.

Benthic Fauna were represented 22 species by 4 phyla, 8 classes and 17 families. 4 groups namely Mollusca, Annelida, Arthopoda and Nematoda. Mollusca has 9 species, Annelida 6 species, Arthopoda 2 species and Nematoda includes 5 species. Mollusca (41%) dominated over Annelida (27%), Nematoda (23%) and Arthopoda (9%), respectively.

Macrophytes were represented 22 species by group Magnoliophyta and 2 classes Liliopsida and Magnoliopsida and 16 families. Both these Classes Liliopsida and Magnoliopsida have 11-11 species each, and 50%-50% of total community.

In the end, it may be concluded that the water of River Chandloi showed variation in the various physico-chemical parameters in all three seasons at all experimental sites. The Biodiversity of organisms Phytoplankton, Zooplankton, Ichthyofauna, Benthic fauna and Macrophytes were also showing seasonal variations. The health status of site 4 is significantly inferior. The reason may be due to the high level of anthropogenic activities, industrialization and poor management of this water body. After studying all the parameters, it can be concluded that the ecological condition of site 2 and site 3 is better than site 1 and site 4. The values of certain parameters are giving us an alarm towards its pollution. With the industrialization, increasing population and anthropogenic factors there is urgent need of continuous monitoring, conservation and scientific management of the river and its biodiversity.

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CHAPTER- VIII

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Annexure-1

List of Publication

LIST OF PUBLICATION

Sharma, J. and Dube, P. (2021): Survey of some aquatic plant diversity (periphyton) of Chandloi River, Kota district, Rajasthan, India. *Review of research*. 10(7): 1-6.

Sharma, J. and Dube, P. (2020): Diversity of aquatic herpitofauna of River Chandloi, Kota, Rajasthan. *International Journal of Recent Advances in Multidisciplinary Research.* 7(8): 6115-6116.

Sharma, J. and Dube, P. (2019): Population dynamics and seasonal variation of rotifers in Chandloi River, Kota, Rajasthan. *International Journal of Applied and Universal Research*; 6(5): 1-3.

Sharma, J., Dube, P. and Sood, Y. (2019): Checklist of phytoplankton in the Chandloi River, Kota , Rajasthan, India. *International Journal of Environmental Sciences*; 8(4): 57-59.

Sharma, J., Dube, P. and Karra, V. D. (2019 b): A critical evolution of literature on freshwater fishes research in India. *International Journal of current research*; 11(7): 5104-5108.

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Sharma, J., Dube, P. and Karra, V. D. (2018): A critical review of studies related to diversity and seasonal variation of phytoplankton. *International Journal of Basic and Applied Sciences*; 7 (3): 92-95

Karra, V. D., Sharma, J., Malav, A. and Dube, P. (2018): A review on the studies of zooplankton in the lotic water of India. *International Journal of Global Science Research*; 5(1): 62

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SURVEY OF SOME AQATIC PLANT DIVERSITY (PERIPHYTON) OF CHANDLOI RIVER, KOTA DISTRICT, RAJASTHAN, INDIA

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ABSTRACT

Present work deals with a survey during my research work of limnological and ichthyologic study of River Chandloi Kota District, Rajasthan, India with aquatic vegetation found near the bank and marginal areas of river under study. It is aimed basically to understand whole river ecosystem. In all 17 (seventeen) families with 17 Genera and 21 species were identified during present survey. These plant species play an important role in functioning of this river aquatic ecosystem.

KEYWORDS: *Limnological, Ichthyologic study, Chandloi river.*

INTRODUCTION

Diversity of organism makes the biotic components of ecosystem. Plants as producers of food and oxygen are very important ecologically. These are not only contribute positively in functioning of ecosystem but have some negative aspects also. Diversity of periphyton is studied in ecological studies. Earlier studies on systematic listing and preparing check lists of southeastern Rajasthan with special emphasis on Kota district had been contributed by Majumdar (1971, 1976 and 1980), Sharma and Tiagi (1979) Sharma and Shringi (1986) and Sharma (2002a, b). This paper described results of present survey along both the banks of the River Chandloi, Kota District, Rajasthan, India.

MATERIAL AND METHODS

Study was based on surveys along the banks of the River Chandloi, Kota District, Rajasthan, India for all three seasons during one year (2019) and confirmed in the surveys conducted next year (2020). Plant specimens were collected and identified in laboratory using different available floras (Sharma 2002a,b), Flora of Rajasthan by N. K. Sharma.

RESULTS AND DISCUSSION

The present investigations resulted into identification of 17 (seventeen) aquatic families with 17 Genera and 21 species (collected and studied specimens). These are listed in table number 1.

Table-1: List of vegetation (periphyton) observed on margins and in the River Chandloi (Kota, Rajasthan)

SN	Family	Name of the Plant	Season	Special feature
01	ALISMATACEAE	*Sagittaria guayanensis* H. B. & K.F.	Pr M, PM	Shallow, marginal
02	AMARANTHACEAE	*Alternanthera sessilis (Linn.)* R. Br.	All	Shallow, marginal
03	AMARYLLIDACEAE	*Crinum asiaticum* Linn	PM, Pr. M	Shallow, marginal
04	ARECEAE	*Colocasia esculenta* Linn	All	Open, margin
05	ARECEAE	*Pistia stratiotes* Linn.	All	Open water
06	CERATOPHYLLACEAE	*Ceratophyllum demersum* Linn.	All	Submerged, Free Floating herb
07	CONVOLVULACEAE	*Ipomoea aquatic* Forsk. *Ipomoea carnea* Jacq	All	Perennial Herb, in margins of river, amphibious/floating
08	CYPERACEAE	*Eleocharis atropurpurea (Retz.) Kuntz.*	All	A tufted perennial herb
09	HYDROCHARITACEAE	*Hydrilla verticillata* (L.f.) Royle *Vallisneria natans* (Lour.) Hara *Vallisneria spiralis* Linn.	All	Glabrous, submerged weed; fully submerged
10	LEMNACEAE	*Wolffia arrhiza* (Linn.) Horkel ex Wimmer (Smallest flowering plant of world)	All, more in PM	Minute, free floating, rootless
11	MENYANTHACEAE	*Nymphoides indica* (Linn.) O.Kuntz. *N. hydrophylla* (Lour.)	All	floating annual herb
12	NYMPHAEACEAE	*Nymphaea nouchali* Burm. F *N. pubescens Willd*	All	floating annual herb
13	PONTEDERIACEAE	*Eichhornia crassipes* (Mart.)Solms.	M	Leaves emerged
14	SCROPHULARIACEAE	*Limnophila indica* (Linn.) Druce.	PM	Leaves submerged
15	TYPHACEAE	*Typha angustata Bory & Chaub*	All	Perennial herb, very long linear leaves, bank of river
16	APONOGETONACEAE	*Aponogeton natans* (Linn.)Engl. & Krause	PM	rooted at base, leaves long linear
17	LENTIBULARIACEAE	*Utricularia aurea* Lour	All	Floating herb with numerous bladders

In the present study, 17 (seventeen) families with 17 Genera and 21 species were identified. Semi aquatic plants and aquatic wetland plants were included into general survey. Submerged aquatic plants produce oxygen in the process of photosynthesis at the littoral zone of ponds. This oxygen controls the dissolve oxygen in the ponds. That result into balance of oxygen in the water and this water is suitable for pisciculture, irrigation, livestock keeping, household and general utility services for aquatic ecosystem. In this study both the aquatic and amphibious specimens were studied.

A -*Alternanthera sessilis* (Linn.)D.C.
(AMARANTHACEAE)

B - *Colocania esculanta* Linn.
(ARECEAE)

C - *Crinum asiaticum* Linn.
(AMARLLIDACEAE)

D:- *Eichhornia crassipes* (Mart.) Solms
(PONTEDERIACEAE)

A - *Nelumbo nucifera* Gerth
(NELUMBONACEAE)

B - *Nymphaea pubescens* Willd.
(NYMPHAEACEAE)

C - *Nymphaea nouchali* Burm. f.
(NYMPHAECEAE)

D - *Nymphoides indica* (Linn.) Kuntz
(MENYANTHACEAE)

A :- *Utricularia aurea* Lour.
(LENTIBULARIACEAE)

B :- *Utricularia stellaris* Linn
(LENTIBULARIACEA)

C :- *Typha angustata* Bory & Chaub.
(TYPHACEAE)

D - *Vallisneria natans* (Loureiro) H
(HYDROCHARITACEAE)

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RESEARCH ARTICLE

DIVERSITY OF AQUATIC HERPITOFAUNA OF RIVER CHANDLOI, KOTA, RAJASTHAN

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ABSTRACT

Herpetofauna includes the reptiles and amphibians of a particular region, habitat or geological period. This paper is a report of field study of aquatic amphibians and reptiles observed and recorded during January 2018 to December 2019. Chandloi River is a left bank tributary of Chambal River. It originates near Aulania village and meets the River Chambal near Mavasa village. The river flows nearly 90 km before entering Chambal River. The studies were carried out for a period of 2 years from January 2018 to December 2019. The present study revealed that class amphibia is represented by 5 species belonging to 4 genera of 2 families while class reptilia is represented by 4 species of 4 genera belonging to 4 families. The species richness is less in site 3,4 while species richness was more in site 1 and 2. Abundance of animals of these two classes were more at site 2 in comparison to all other sites (1,3,4).

INTRODUCTION

Herpetofauna includes two groups of tetrapod vertebrates: Amphibians and Reptiles. Amphibians are ectothermic animals including frogs, salamanders and caecilians. Similarly reptiles are terrestrial ectotherms comprising of lizards, snakes, turtles and crocodiles. Herpetofauna plays a crucial role in ecosystem function. They are important predators of many insects and agricultural pests are therefore valuable for natural biological pest control (Kumar, Kumar and Kumar, 2017) and intermediate role in food web. Herpetofauna often benefits to humanity in the study of the role of amphibians and reptiles in global ecology. Especially because amphibians are often very sensitive to environmental changes, offering a visible warning to humans that significant changes are taking place. They are well suited for rapid assessments as they are often easy to sample. Reptiles are also sensitive to changes in microhabitat. Presence of turtles and tortoises can also be a good indicator of hunting pressure. Some toxins and venom produced by reptiles are useful in human medicine. Currently some snake's venom has been used to create anticoagulants that work to treat strokes and heart attacks. Their biology contributes to their value as a focal group for biotic surveys. Therefore present study aimed at studying herpetofauna of studying area Chandloi River.

MATERIAL AND METHOD

Chandloi River is a left bank tributary of Chambal River. It originates near Aulania village and meets the river Chambal near Mavasa village. The river flows nearly 90 km before entering Chambal river. The studies were carried out for a period of 2 years from January 2018 to December 2019. Active survey was done randomly for the species in each month along 4 selected potential habitats of herpetofauna. Visual encounters were employed for the species counting by walking in both day and early evening time. We used 3 to 4 times surveys in each month during these two years of study. Species survey was made Woodlands, plantations, bushes very near present surrounding agricultural fields and in the river. For amphibians and nocturnal snake surveys were made throughly in all the suitable habitats such like bushes near river, under rocks, logs and big stones and alteration habitats with the help of lights in the early evening. Identification and photographed the species. Secondary data were also collected from the adjacent villages by taking interviews with the local people by photographs. Total 4 Points were surveyed. Notes were made for observation on habitats of each species, roadkills, anthropogenic activities in the area, threats to the herpetofauna, interaction between human and snakes etc.

RESULTS

The studied area site 2 has a good potentiality of herpeto fauna diversity throughout the annual. It is due to availability of diets and adaptation with habitats. Among 9 recorded species, 5 species were amphibians and 4 species were reptiles. 5 amphibian species belonging to 4 genera of 2 families while 4 reptilian species belonging 4 genera of 4 families.

DISSCUSSION

Herpetofauna species richness is less in site 3,4 due to poor availability of diets and adaptation with habitats.

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Table 1. Aquatic herpetofauna of River Chambal, Kota, Rajasthan

CLASS	FAMILY	GENUS	SPECIES
1. Amphibia	Microhylidae	Microhyla	ornata
		Microhyla	rubra
	Dicroglossidae	Hoplobatrachus	tigerinus
		Euphlyctis	cyanophlyctis
		Fejervarya	limnocharis
2. Reptilia	Trionychidae	Lissemys	punctata
	Colubridae	Oligodon	taeniolatus
		Xenochrophis	piscator
	Gavialidae	Gavialis	gangeticus

Fig. 1. Familywise % composition of Amphibia in Chambal River, Kota Rajasthan

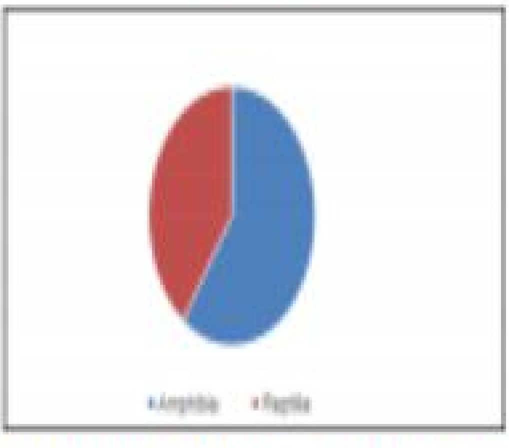

Fig. 2. Classwise % composition of Herpetofauna in Chambal River, Kota, Rajasthan

Species richness was more in fig. 1 and 2 because of good availability of diets and adaptation with habitats. During the study period (January 2018 to December 2019) 5 amphibians and 4 reptilians species were taxonomically identified and listed table number 1.

It is clearly visible in table-1 that in amphibia family Microhylidae has one genus microhyla which belonging two species *Microhyla ornata* and *Microhyla rubra*, while in family Dicroglossidae has three genus hoplobatrachus, euphlyctis and fejervarya. Each genus has one species *Hoplobatrachus tigerinus* (old name *Rana tigerina*), *Euphlyctis cyanophlyctis* (old name *Rana cyanophlyctis*), and *Fejervarya limnocharis* (old name-Rana limnocharis).

Class reptilia has three families Trionychidae, Colubridae and Gavialidae belonging to one, two and one species *Lissemys punctata*, *Oligodon taeniolatus*, *Xenochrophis piscator* and *Gavialis gangeticus*. The study is in continuation and there are few more specimens yet to be identified. This reporting is first of its kind from the River Chambal. Results presented here are comparable to earlier similar studies done in running waters (Muhammad Rais *et al*., 2012; Sanjeev Kumar and H. S. Banyal, 2016; A. Das *et al*., 2012; Amita Kanaujia *et al*., 2017; T. Frank *et al*. 2018; S. N. Stuart *et al*. 2004)

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POPULATION DYNAMICS AND SEASONAL VARIATION OF ROTIFERS IN CHANDLOI RIVER, KOTA RAJASTHAN

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ABSTRACT: The study presented a population dynamics and seasonal variation of fresh water rotifers recorded from River Chandloi, District Kota Rajasthan, India. It listed 16 genera and 31 species of fresh water rotifers found in the river in different seasons. This study was conducted for one year that is July 2018 to June 2019. This type of study related to population dynamics and seasonal variation of rotifers from the River Chandloi is prepared for the first time. The study also discussed dominance and abundance of the species.

KEYWORDS:- Population dynamics, Abundance, Dominance, Chandloi River.

INTRODUCTION:-

Zooplanktons are microscopic free floating heterogenous animals which play a vital role in aquatic ecosystem. They are divided into wide range of taxonomic group viz. Protozoa, Rotifera, Cladocera, Copepoda, Ostracoda and Crustacia.

Rotifera are called Rotatoria or wheel animalcules. It is the group of small usually microscopic, peseudocoelomate animals having a length of 0.4 to 2.5 m.m. (Kumar, Kiran 2015). A rotifer has a transparent, cylinderical body, lined by a thin cuticle. In majority of rotifers cuticle form a lorica. The body is divided into head, trunk, neck and foot. Rotifers have been variously regarded either as a class of phylum Aschelminthes or as a separate minor phylum. They are omnipresent in nature and occurring in almost all types of fresh water habitats from large permanent lakes to small temporary puddles and feed on algae and bacteria. Being prey for play a plankton feeders. Rotifers play a crucial role in many fresh water ecosystems. They are permanently and obligatory connected to aquatic habitats in all active stages, only their resting stages are draught resistant. (Hardrik, 2007).

Rotifer distribution and diversity is influenced primaril by deteriorating quality of water in primary productio temperature, abundance of predators and competitor potential food resources and various physical, chemica geographical, biological and ecological parameters. A these factors play an individual role in the formation rotifer assemblages and their seasonal occurrence but th ultimate effect is produced due to interplay an interaction of all these factors.

There has been lack of studies regarding the populatio of rotifers from Chandloi River, Kota. Keeping this i view, the aim of the present study was to collect, identif and to determine monthly variations of density rotifers.

MATERIAL AND METHODS:-

Chandloi River is a left bank tributary of Chambal Rive It originates near Aalania village and meets the Rive Chambal near Mawasa village. The river flows nearly 9 Km before entering Chambal River. The studies wer continued for a period of one year from January 18 t December 18. Zooplankton samples were collecte during early morning on monthly basis from fo different locations.

100 litres of water sampled from different areas an depths of the river was filtered through plankton n made up of bolting silk (No: 10; mesh size 150 micr meter) and the plankton biomasses were transferred t the specimens bottles (pre filed with 5% formaline) an subjected to microscopic analysis. The zooplankton wa segregated group wise like rotifer, cladocera, copepo ostracoda, etc. They were separated under a binocul stereo zoom dissection microscope using a fine needl and brush. Quantitative analysis was done by putting ml. of the preserved sample on a Sedgwick-Raft counter cell and studying it under an inverte microscope. The identification of rotifers was made b using standard keys of Michael and Sharma (1998

Sharma and Sharma (2008), Altaff (2004) were utilized and results were expressed as organisms per liter (O/L).

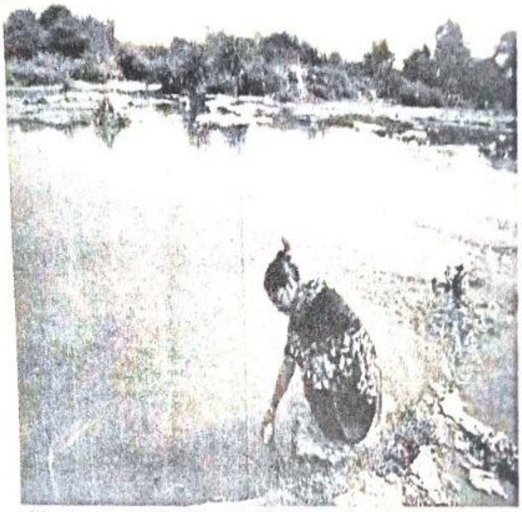

Fig. 1- Study Site Chandloi River at Kota Rajasthan

RESULTS:-

A total 16 genera of rotifers were recorded from Chandloi River. Among 16 genera *Brachionus* was dominant with 7 species followed by 5 species of *Filinia*, 3 species of *Lepadella*, 3 species of *Rotaria*, 2 species of *Trichocera*. Remaining genera followed single species. Monthly number variation from July 2018 to June 2019 recorded of rotifers population in table-1.

The total number of species recorded was 31. The occurrence of the season wise rotifers was dominant in following increasing order table-2.

DISSCUSSION:-

The number of Rotifers increased in summer which may be due to the higher population of bacteria and organic matter of dead and decaying vegetation (Majagi an Vijay Kumar, 2009). When primary production is foun to be low, small species dominate the consumption (available resources and may exclude the bigger specie (De Mott and Kerfoot, 1982). Segers (2003) studying th dominance of rotifer population which was due to i preference for warm waters. Kudari et al. (200(studying rotifer taxonomic richness is common i tropical fresh waters. Bharati et al. (2014) reported th the abundance of rotifer species such as *Brachioni* indicates nutrient rich water body which may underg the state of eutrophication. Kumar and Kiran (201: studied that rotifer fauna of Jannapura tank (Bhadravathi taluk can be linked with favourab conditions and availability of abundant food. Dirican (al. (2009) studied permanent dominancy of rotif species such as Brachionus and Keratella are indicati of eutrophic condition and their abundance was due t the presence of high levels of organic matter. Sharma (al. (2010) studied presence of rotifer in the wat indicates the water quality deterioration and onset (eutrophication at alarming rate.

Present study indicates population dynamics an distribution of rotifers maximum number were found i during summer, followed by winter and minimum durin monsoon. In summer season the absence of inflow of th water brings stability to the water body and availabilit of food is more. Normally monsoon is associated wi lower densities due to its dilution effect and decrease photosynthesis by primary production.

High diversity of rotifer indicates the presence of hig amount of suspended material in the water body whic may lead to the eutrofication of the water body. Thu from the present investigation it is obvious that ste should be taken immediately for the preservation (river.

Table-1: Monthly variation of Rotifers (no/lit.) at four stations of Chandloi River, kota, Rajasthan

Station/Months	S1	S2	S3	S4
January	150	124	130	135
February	185	160	125	130
March	170	153	132	140
April	240	245	160	165
May	370	340	270	250
June	357	333	258	236
July	279	250	220	201
August	155	102	129	108
September	120	151	100	116
October	109	128	120	87
November	180	150	142	124
December	195	179	169	14
Total	2690	2435	2055	1939

Table 2: Seasonal variation of rotifer in Chandloi River, Kota, Rajasthan

S. No.	Seasons	Rotifers
1.	Summer	3,819
2.	Monsoon	2,426
3.	Winter	2,375
Summer > Winter > Rainy		

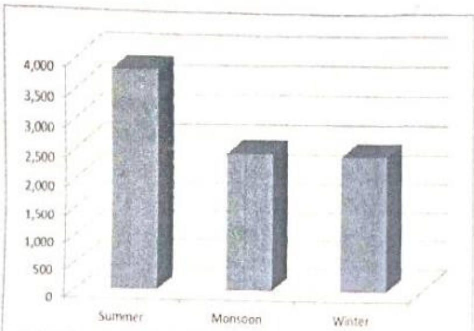

Fig-2: Season wise graph of Rotifers in Chandloi River, Kota, Rajasthans

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Review Article

Checklist of Phytoplankton in the Chandloi River Kota Rajasthan India

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ABSTRACT

The study presented a checklist of Phytoplankton recorded from River Chandloi District Kota Rajasthan, India. It listed five families, twenty eight genera, forty three species of fresh water phytoplankton found in the river in different seasons. This study was conducted for two years that is May 2017 to April 2019. This checklist from the River Chandloi is prepared for the first time. The study also discussed dominance and abundance of the listed species.

Introduction

Phytoplankton is free floating unicellular, filamentous and colonial autotrophic forms of aquatic habitat whose movement is more or less dependent on water currents. Phytoplankton's occurrence and dynamics in rivers are mainly based on physico-chemical conditions and nutrient availability in water. They are not only serving as food for aquatic animals, but also play an important role in maintaining the biological balance and quality of the aquatic ecosystem. The phytoplankton of an aquatic ecosystem is central to its normal functioning. While they constitute the starting point of energy transfer, they are highly sensitive to externally imposed changes in the environment (Khattak *et al.*, 2005; Ekhator *et al.*, 2005). Thus the species composition, biomass, relative abundance, spatial and temporal distribution of these aquatic biota are an expression of the environmental health or biological integrity of a particular water body. Phytoplankton fixes solar energy and carbon through photosynthesis making it available for higher trophic levels (Anar *et al.*, 2004). The magnitude and dynamics of phytoplankton are increasingly considered as bioindicators to assess the trophic status of an aquatic ecosystem.

The qualitative and quantitative studies of phytoplankton have been successfully utilized to assess the quality of water. Several species have served as bio- indicators and it is a well suited tool for understanding water pollution studies. Phytoplankton are consumed by zooplankton and facilitate the conversion of plant material into animal tissue and in turn constitute the basic food for higher animals including fishes, particularly their larvae. In this way, Plankton are the basis of aquatic food chain and food webs.

Materials and methods

Chandloi River is a left bank tributary of Chambal River. It originates near Adania village and meets the River Chambal near Manasa village. The river flows nearly 90 Km before entering Chambal River.

The studies were continued for a period of two year from May 2017 to April 2019. Phytoplankton samples were collected during early morning on monthly basis from five different locations. 10 liters of water sampled from different areas and depths of the river was filtered through 25 micron mesh plankton net. The collected sample was then concentrated in 30 ml receptacle glass tube, attached at the end of the plankton net. Plankton samples were then preserved in phosphate buffered formalin at 3% concentration along with one drop of glycerine. After that the preserved samples were kept in refrigerated condition for further analysis. Plankton was identified up to generic level following earlier documented plankton identification key and monographs. The total number of organisms per millilitre for each sample was determined by simple calculation after counting the number in the 5 ml sub-sample examined. Plankton identification up to genus level was performed by using standard identification key (Taylor, et al. 2007; Dillard 1999).

Result and Discussion

During the study period (May 2017 to April 2019) species were taxonomically identified and listed in table - 1. It is clearly visible in table that River Chandloi has a good diversity composed of five classes of phytoplankton, namely

Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae and Dinophyceae. Class Cyanophyceae represented by five genera and seven species. *Aphanocapsa subtilissima* and *Chroococcus cohaerens* species are rare in river because they found only last two sites remaining are common species because they found almost each 5 sites. Class Chlorophyceae represented twelve genera and seventeen species. In all species *Staurastrum cuspidatum* is rare and two species *Staurastrum limneticum* and *Treubaria triappendiculata* are endangered, remaining are common. Class Euglenophyceae represent by three genera and ten species. *Trachelomonas lacustris* and *T. hispida* are rare in all species. Class Bacillariophyceae represented five genera and six species. In all species *Cyclotella kutzingiana* is rare and remaining are common. Class Dinophyceae represented three genera and three species. Each genus has one species. Species *Peridinium bipestatia* is rare species *Didinium balbianii* is endangered and species *Oodinium limneticum* is common.

Table 1: Phytoplankton of Chambal River, district Kota (2017-19)

S.N.	Class	Genus and species	S1	S2	S3	S4	S5	Abundance
1.	Cyanophyceae	*Anabaena circinalis*	+	+	+	+	+	C
		Anabaena subcylindrica	+	+	+	+	+	C
		Oscillatoria tenuis agardh	+	+	+	+	+	C
		Oscillatoria ornemophorica	+	+	+	+	+	C
		Oscillatoria solitaria	+	+	+	+	+	C
		Aphanocapsa subtilissima	–	–	–	+	+	R
		Chroococcus cohaerens	–	–	–	+	+	R
2.	Chlorophyceae	*Scenedesmus quadricauda*	+	+	+	+	+	C
		Scenedesmus bijuga	+	+	+	+	+	C
		Ankistrodesmus falcatus	+	+	+	+	+	C
		Microspora floccosa	+	+	+	+	+	C
		Coelastrum sphaericum	+	+	+	+	+	C
		Hyalotheca sp.	–	+	+	+	+	C
		Closterium setiferum	–	+	+	+	+	C
		Cosmarium sp.	-	+	+	+	+	C
		Staurastrum cuspidatum	+	–	–	+	+	R
		Staurastrum limneticum	+	–	–	+	+	E
		Staurastrum trifidum	+			+	+	C
		Staurastrum sp.	+	+	+	+	+	C
		Gonatozygon monotaenium	–	+	+	+	+	C
		Chlorococcum minor	–			+	+	C
		Sphaerocystis schroeteri	-	+	+	+	+	C
		Treubaria triappendiculata	+	+	+	+	+	E
		Treubaria crassispina	+	+	+	+	+	C
3.	Euglenophyceae	*Euglena caudata*	+	+	+	+	+	C
		Trachelomonas lacustris	–	–	–	+	+	R
		T. ensifera	+	+	+	+	+	C
		T. armata	+	+	+	+	+	C
		T. horrida	–	+	+	+	+	C
		T. similis stokes	+	+	+	+	+	C
		T. hispida	–	–	–	+	+	R
		Phacus longicauda	+	+	+	+	+	C
		P. suecicus	+	+	+	+	+	C
		P. orbicularis	+	+	+	+	+	C
4.	Bacillariophyceae	*Synedra fasciculata*	+	+	+	+	+	C
		Cyclotella comta	+	+	+	+	+	C
		C. kutzingiana	–	–	–	+	+	R
		Stephanodiscus hantzschii						
		Surirella tenera	+	+	+	+	+	C
		Tabellaria sp.	+	+	+	+	+	C
			+	+	+	+	+	C
5.	Dinophyceae	*Peridinium bipestatia*	–	–	–	+	+	R
		Didinium balbianii	–	–	–	–	+	E
		Oodinium limneticum	+	+	+	+	+	C

Conclusion

A total of 43 species of 28 genera, belonging to 5 families were identified during the study. The Class Chlorophyceae was the most abundant with 17 species belonging to 12 genera. On the other hand Class Dinophyceae found lowest rank among all families with 3 species belonging 3 genera.

Taxa richness was highest in site 4 and 5 with highest values, while the lowest taxa richness were recorded in site 1 and 2 respectively.

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RESEARCH ARTICLE

A CRITICAL EVALUATION OF LITERATURE ON FRESHWATER FISHES RESEARCH IN INDIA

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ABSTRACT

Fishes constitute an economically significant group of aquatic animals due to their importance in providing food to riverine communities and urban sectors. As a food, fishes provide a wide range of nutritional gains, including fish meal, fish protein, manure, shagreen, isinglass, glue and other products. The term "fish" is usually a convenient description for a group of poikilothermic (cold blooded) aquatic vertebrates under the chordate phylum that breathe with gills (Nelson, 2006). Actinopterygians, the bony or ray finned fishes, are without a doubt the majority of fishes found in freshwater.

Fish can be divided into 3 classes:

- Agnatha: jawless fish such as hagfish and lampreys.
- Chondrichthyes: Fish whose skeleton is made of cartilage such as sharks, rays and skates.
- Osteichthyes: Fish whose skeleton is composed mostly of bone such as bass, perch, catfish.

Fish biodiversity can be defined as variety of fish species. Fish biodiversity encompasses freshwater ecosystems, including lakes, ponds, reservoirs, rivers, streams, ground water and wet lands as well as marine ecosystems including oceans and estuaries. Fish biodiversity includes all unique species, their habitats and interactions between them. Due to the life history traits fishes are suitable to early warning signals of anthropogenic stress on natural ecosystem dynamics, or conversely, as indicators of ecosystem recovery and of resilience. Their presence in large number and variety is itself an indicator to good indication that water is virgin and suitable for human consumption and utility.

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INTRODUCTION

Bhatt 2000 deals Book Reviews In India 2500 fish species have been reported, of which 930 (40%) are freshwater inhabitant. Sakhare 2001 investigated the occurrence of 23 fish species belonging to 7 orders in Jawalgaon reservoir in Solapur district of Maharashtra. The fishes belonging to order Cypriniformes were dominant with 11 species followed by order Siluriformes with 4 species, while orders like Osteoglossiformes, Perciformes and Channiformes were represented by 2 species and the rest of the orders by single species. Bhadra, R. S. 2002 studied frequency distribution of fish species at various sampling sites. On the basis of occurrence of the species in all sampling sites they were categorized into, dominant (species occurred >80%), abundant (species occurred 60%-80%), less abundant (species occurred 40%-60%) and rare (<40%). Yadava and Singh 2002 studied fish fauna of Ujjain. They found 34 species belonging to 15 families. Wagh and Ghate 2003 studied 62 species from Mula and Mutha River in Pune. Om Prakash 2004 studied Fish species of Northern part of Raipur district Chhattisgarh. He documented 64 species belonging to 40 genera, 19 families and 7 orders. Desai and Shrivastava 2004 reported 48 species belonging to 32 genera and 15 families in Ravishankar Reservoir in Dhamtari district, Chhattisgarh. Khedkar 2005 studied fish species of Nathsagar Reservoir from Paithan, Dist. Aurangabad. He observed 47 fish species belonging to 7 orders and 19 families. Bakawale and Kanhere 2006 studied Fish fauna of River Narmada in West Nimar M. P. He found 150 species belonging to 26 families. Verma and Kanhere 2007 studied Ichthyofauna of the River Narmada in Western Zone. He enlisted 58 species belonging to 43 genera. Sarkar et al. 2008 studied conservation of freshwater fish resources of India. Fish forms highest species diversity among all vertebrates and their loss is one of the world's most pressing crises as human life and livelihood largely depend on the status of biological resources. The freshwater fish is one of the most threatened taxonomic groups due to their high sensitivity to the quantitative and qualitative alteration in aquatic habitats. He enlisted many fish species of India. Dubey 2008 studied fish diversity in the riverine resources of Janjgir-Champa district of Chhattisgarh. He enlisted 67 fish species under 41 genera, 19 families and 7 orders. Singh and Sohal 2009 studied fish diversity of River Ganga of India in the vicinity of Allahabad. This river stretch supports 76 fish species belonging to 53 genera 24 families and 10 orders. Bisht et al. 2009 studied ecology and fish fauna of some of the tributaries of Ganga River system. Small hill-streams are highly torrential with huge altitudinal variation. These streams provide variety of habitat for subsistence of varied and large fish fauna. The habitat has been identified as one of the primary criteria on which many biological communities are organized.

Vijaylaxmi 2010 studied Freshwater fishes distribution and diversity status of Mullameri River, a minor tributary of Bheema River of Gulbarga district, Karnataka. The result of the study reveals the occurrence of fourteen fish species belonging to five orders. The order Cypriniformes was dominant with seven fish species followed by order Siluriformes with four species, and the order Channiformes, Mastacembeliformes and Osteoglossiformes each with one species. Atkore et al., 2011 studied Patterns of diversity and conservation status of freshwater fishes in the tributaries of River Ramganga in the Shiwaliks of the Western Himalaya. In total, 43 species belonging to eight families and five orders were recorded which included 29 species belonging to the threatened category. Family Cyprinidae was represented by the maximum number of species.

Sharma et al., 2011 Studies on Limnological Characteristic, Planktonic Diversity and Fishes (Species) in Lake Pichhola, Udaipur, Rajasthan (India). 15 species of fishes belonging to 6 family and 11 genera were reported from Pichhola lake namely *Notopterus notopterus, Catla catla, Cirrhinus cirrhosus, Ctenopharyngodon idella, Labeo gonius, Labeo rohita, Puntius sarana sarana, Puntius ticto, Chela cachius, Garra gotyla gotyla, Aorichthys seenghala, Mystus cavasius, Heteropneustes fossilis, Xenentodon cancila* and *Glossogobius giuris*.

Kumar and Dua (2012) studied fish diversity of River Ravi in Indian region. The main threats to fish diversity of the Ravi are flow modification, degradation of habitat, availability of water, building of dams and emergence of new canals. In the present study, thirty eight fish species were recorded from the River Ravi. Of these, nine species are vulnerable species and two are endangered species (according to IUCN conservation status).

Bakawale and Kanhere 2013 studied the Fish Species Diversity of the River Narmada in Western Zone. The fish diversity is correlated with biological and various physicochemical parameters that regulate the productivity and distribution of different species of the fishes. The fish population is abundant and majority of fishes are exploited for human consumption. The survey indicated that 51 species of fish were found in this zone of the river. The major fish abundance was noticed viz. major carps, minor carps and cat fishes. The several species of fish belonging order Clupiformes, Cypriniformes, Beloniformes, Ophiocephaliformes, Mastacembeliformes, Siluriformes and Perciformes. In which maximum 27 species belonging to the order Cypriniformes. Some species of fishes like Cirrhinus mrigala, Aspidoparia jaya, Catla catla, Labeo fimbriatus, Labeo bata, Ompok bimaculatus, Chitala chitala etc. showed a declining trend in this stretch. The fish species diversity was decreasing.

Galib et al., 2013 studied Fish diversity of the River Choto Jamuna, Bangladesh. A total of 63 species of fishes have been recorded belonging to 41 genera, 23 families and 9 orders. Cypriniformes was recorded as the most diversified fish group in terms of both number of species and individuals observed. He found 41.27% species were threatened in Bangladesh including 15.87% vulnerable, 15.87% endangered and 9.52% critically endangered species. Overall values of diversity, richness and evenness indices were found to be 3.717, 6.931 and 0.897, respectively. Cypriniformes was recorded as the most diversified fish group in terms of both number of species and individuals observed.

Sarkar et al., 2013 studied Biodiversity of freshwater fish of a protected river in India: comparison with unprotected habitat. Results showed that in the protected area, a total of 87 species belonging to eight orders, 22 families and 52 genera were collected, while a maximum of 59 species belonging to six orders, 20 families and 42 genera were recorded from the unprotected areas. Cyprinids were found to be the most dominant genera and *Schistura beavani* was the most numerous species in the sanctuary area. Other numerous species were *Eutropiichthys vacha, Notopterus notopterus, Chanda nama* and *Barilius barna*. The results indicated more species, greater abundance, larger individuals, and higher number of endemic and threatened fishes within the sanctuary area when compared to the unprotected area. Analysis on the mean abundance of endangered and vulnerable species for the evaluated areas in the sanctuary versus unprotected ones indicated significant differences in fish abundance ($p<0.05$). Khedkar et al., 2014 studied DNA Barcodes for the fishes of the Narmada, One of India's Longest Rivers. This study describes the species diversity of fishes of the Narmada River in India. A total of 820 fish specimens were collected. Fish were taxonomically classified into one of 90 possible species based on morphological characters, and then DNA barcoding was employed using COI gene sequences as a supplemental identification method. A total of 314 different COI sequences were generated, and specimens were confirmed to belong to 85 species representing 63 genera, 34 families and 10 orders. Findings of this study include the identification of five putative cryptic or sibling species and 43 species not previously known from the Narmada River basin. Five species are endemic to India and three are introduced species that had not been previously reported to occur in the Narmada River.

Satapathy and Misra 2014 studied the fish diversity of the River Pilasalunki situated in Phulbani district, Odisha. A total of 23 fish species belonging to 9 families were recorded. Out of the recorded species, 35% are enlisted as vulnerable, 52 % as lower risk near threatened category. Maximum number of fish species were collected from slow flow site (33.6%) followed by silty sand beds (17.56%), deep water zone (15.57%), gravel habitat (15.9%), fast flow zone (10.25%) and least in shallow water zone. Vishwakarma et al., 2014 deals with the fish diversity of Barna River and its tributary in Raisen district, Madhya Pradesh, Central India. 33 fish species belonging to 5 orders, 9 families and 21 genera. The order Cypriniformes was found dominant (20 species) followed by Perciformes and Ophiocephaliformes (3 species) both, Mastacembeliformes (2 species) and Beloniformes (1 species). The most abundant family was Cyprinidae, having 230 individuals (75%) followed by Cobitidae with 32 individuals (10%). Some endangered and rare fish fauna are also reported in the present investigation. Pathak et al., 2014 Ichthyofauna of Western Region of Narmada River, Madhya Pradesh. Narmada River is the largest Westward flowing river of India. It is also referred as the life line of Madhya Pradesh. Present study was aimed to generate information on the ichthyofauna of Western Region of the River Narmada. During the study period, 38 fish species have been identified belonging to 33 genera, 16 families and 6 orders. The fishes caught are divided into commercially important species like *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*; locally important species like *Bar* spp., *Channa* spp., *Mystus* spp. etc. and ornamental fishes like *Nandus nandus*, *Nemacheilus botia*, *Salmostoma bacaila*, *Colisa fasciatus* etc. *Tor tor* and *Chitala chitala*, once abundant in the river, now are registered under endangered condition.

Bargal and Kumar 2015 studied Fish Diversity of Chambal River, Rajasthan State. The Fish fauna of the Chambal River is rich and diverse. Various types of carps, catfish, and mullet reside in the river waters. Fifty-four species of fishes were reported from the Rajasthan part of the Chambal River.

Bano *et al*., 2015 studied Fish biodiversity and conservation aspects in an aquatic ecosystem in River Narmada. Ichthyodiversity refers to a variety of fish species, depending on context and scale; it could refer to alleles or genotypes within piscian population, to species of life forms within a fish community, and to species or life forms across aquaregimes. 48 fish species, 25 genera, 15 families and 6 orders were recorded in the three stations of Narmada near Hoshangabad Region. Among them the Cyprinidae contribute 66.6% of their total population. Due to some anthropogenic activities fish diversity of this river is in decline mode. Sarkar *et al*., 2015 studied A Review on the Fish Communities in the Indian Reservoirs and Enhancement of Fisheries and Aquatic Environment. In India, reservoirs are playing a crucial role in the fisheries. Fish communities are often used as indicators of environmental quality. In terms of fish diversity altogether 117 fish species were recorded from Indian reservoirs exhibiting rich fish diversity. These reservoirs have both positive and negative impacts on fishes and other aquatic environment. Therefore, present study is emphasized on synthesizing the available information on fish diversity and community structure of the potential Indian Reservoirs and its effects on fisheries and other aquatic environment in reservoirs in India.
Jain *et al*., 2016 studied diversity of Ichthyofauna in Central India. Biodiversity is the variation in the genetics and life forms of populations, species, communities and ecosystems. Biodiversity affects the capacity of living systems to respond to changes in the environment and is essential for providing goods and services from ecosystems. Fish diversity depends on geographical position, varied aquatic ecological conditions, health of aquatic bodies and optimum exploitation of the commercial fish species, enforcement of laws, rules and regulations and their implementation and fish habitat restoration programs. They collected many fish species in Central India.

Bhanarik *et al*., 2017 deals a case study of the Narmada River system in India with particular reference to the impact of dams on its ecology and fisheries. They studied Currently, three dams have been built in Madhya Pradesh and one is under construction in Gujarat. A comparison of pre- and post-impoundment eco-environment and fisheries revealed changes in water quality, productivity, and aquatic flora and fauna of the river system. Among the fish species like *Tor* spp, *Labeo fimbriatus* and *Labeo dyocheilus* suffered most. The percentage contributions to total yield of Carp, Catfish, and miscellaneous groups have significantly changed, indicating falls of 77%, 16% and an increase of 418%, respectively. Percentage contributions to catches of *Macrobrachium rosenbergii* and *Tenualosa ilisha* have also declined by 46% and about 70% in the estuarine stretch of the river system. Shukla *et al*., 2017 studied Fish Species Diversity of Beehar and Bihar Dam, Turki, Satna (M.P.) India. Fish fauna of Beehar dam consists of 31 species belonging to 11 families. Among the collections 4 species of Clupeiformes, order Cypriniformes consists of 20 species, order Siluriformes consists of 3 species, Perciformes consists of 03 species and order Mugiloidae consists of one species. Saini and Dubey 2017 studied Fish diversity of River Narmada, Jabalpur Region (M.P.) 29 species of fishes were recorded in three sampling stations. The major fish abundance was noticed viz. major carps, minor carps and cat fishes. The several species of fish belonging to order Cypriniformes, Siluriformes, Ophiocephaliformes, Perciformes and Siluriformes are recorded too. Out of these Cypriniformes is the most dominant group with recorded 22 species of fishes. Some species of fishes like *Cirrhinus cirrhosus*, *Labeo bata* showed a declining trend in the stretch.

Jayaram Ha 2017 studied current status of Ichthyofaunal diversity of Tunga River at Mandagadde bird sanctuary, Shivamogga, Karnataka, India. A total of 16 species of fishes belonging to 4 orders, 8 families, and 12 genera were recorded from the study area. Six species sighted in family cyprinidae, channidae, cobitidae and siluridae were represented by two species each, families *Bagridae*, *Mastacembelidae*, *Nandidae* and *Schilbeidae* had only a single species each.
Rathore *et al*. 2017 studied Fish biodiversity and fisheries potential of Reservoir Udaisagar (Udaipur, Rajasthan). The reservoir has a fairly rich fish fauna and so far 31 species representing 9 families have been recorded in the present investigation, of these, 12 species predominantly contributed to the commercial fisheries of this reservoir. During study period, the Indian major carps dominated the catch by contributing 98 percent to the total landings from this reservoir. Besides Indian major carps, minor carps and catfishes were reported to be 0.38 and 069 %, respectively. Among the Indian major carps, the *Catla catla* (70%) dominated the groups followed by *Labeo rohita* (25%) and *Cirrhinus mrigala* (5%). B. Sukhani 2018 studied Fish Diversity in a Kumaun Himalayan River, Kosi, at Almora Uttarakhand. 12 species of fish fauna were observed. All the recorded fish species belonged to the families Cyprinidae and Balitoridae. Cyprinidae was the dominant family having 9 fish species out of the 12 species. The family Balitoridae comprised of 3 fish species. Hasan *et al*., 2018 Fish biodiversity of River Dakatia and its conservation aspects in Bangladesh. 72 fish species were recorded including 12 orders and 27 families. Cypriniformes constitutes highest number of fish population (28%). Cyprinidae shows the highest percentage (19%) among the recorded family. Catfish was found to be the biggest group (27%) among the recorded 14 common names. The lowest habitat was found to be Riverine-Estuary (43%). Among the identified threatened fish species (28) of River Dakatia, 11 species (39%) were recorded as Vulnerable (VU), 5 species (40%) as Endangered (EN) and 1 species (3%) as Critically Endangered (CR). AD Shelke 2018 studied the Ichthyofaunal diversity of Girna River. A total of 35 fish species belongs to 08 orders, 27 genera of 17 families were recorded. Order Cypriniformes was most dominant group represented by 20 (57.14%) species, followed by orders Perciformes with 06 (17.14%) species, Siluriformes with 03 (8.57%) species, Synbranchiformes 02 (5.71%) species, Beloniformes 01 (2.85%) species, Synodontidae 01 (2.85%) species, Scorpaeniformes 01 (2.85%) species and Osteoglossiformes 01 (2.85%) species. Thus the Girna River

has good potential for fish fauna. Out of 35 fish species 29 have least concern status, 01 are near threatened, 02 are Vulnerable, 02 are not evaluated and one is data deficient. R.Rawal 2018 studied Diversity of hill stream fishes in Sahastradhara Region of Narmada River Maheshwar, District Khargone, Madhya Pradesh. Total 8 species of hill stream fishes obtain from the Sahastradhara sampling station of Narmada River.

L. Sarkar 2015 studied Seasonal fish faunal diversity and water quality of Jamuna River in South Bengal Region. Altogether 46 fish species belonging to 18 families and 36 genera were collected. Family Cyprinidae (20 species) comprised 56% and Notopteridae (1 species), Clupeidae (1 species), Cobitidae (1 species), Claridae (1 species), Heteropneustidae (1 species), Synbranchidae (1 species), Gobiidae (1 species), Eleotridae (1 species), Anabantidae (1 species), Belontidae (1 species), Channidae (1 species), Mastacembelidae (1 species) comprises 2% each of total catch whereas Bagridae (2 species), Siluridae (2 species), Ambassidae (2 species), Mugilidae (2 species) comprised 4% each of the total catch, out of the 46 species documented, 8 species showed significant variation in catch data in pre monsoon, monsoon and post monsoon period. *Cirrhinus reba*, *Labeo bata* catch significantly increased in post monsoon period compared to premonsoon and monsoon period. Bargal and Kumar 2019 studied The fish diversity of Mahi River in Rajasthan. Order cypriniformes was recorded with maximum fish diversity (13). Order siluriformes and perciformes each represented with 5 species, order osteoglossiformes, synbranchiformes, clupeiformes represented with 2 species each, whereas beloniformes only by 1 species.

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CHECKLIST OF FRESH WATER FISHES IN THE CHANDLOI RIVER, KOTA, RAJASTHAN

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ABSTRACT: The study presented a checklist of fresh water fishes recorded from River Chandloi District Kota Rajasthan, India. It listed six orders, six families, eleven genera, thirteen species of fresh water fishes found in the river in different seasons. This study was conducted for two years that is July 2017 to June 2019. This checklist from the River Chandloi is prepared for the first time. The study also discussed dominance and abundance of the listed species.

KEYWORDS:- *Diversity, Abundance, Dominance, Chandloi River, Cypriniformes, Siluriformes, Perciformes, Osteoglossiformes, Beloniformes, Synbranchiformes, Clupeiformes.*

INTRODUCTION:-

Fish diversity, which provides food security to the poorest of communities of India, is not only important to fisherman community but also for the better health of water resources. Fish forms highest species diversity among all vertebrates and their loss is one of the world's most pressing crises as human life and livelihood largely depend on the status of biological resources. The freshwater fish is one of the most threatened taxonomic groups due to their high sensitivity to the quantitative and qualitative alteration in aquatic habitats (Sarkar *et al.*, 2008). India is endowed with vast and varied resources possessing river ecological heritage and rich biodiversity. Freshwater fishery sites are varied like 45,000 Km of rivers, 1,26,334 Km of canals, ponds and tanks 2.36 million hectares and 2.05 million hectares of reservoirs (Ayyappan *et al.*, 2004). In India 5.5 million people are employed in inland fisheries (Dugan *et al.*, 2010). Recent study aimed at contributing a better knowledge of the fish fauna of Chandloi River (a tributary of Chambal, District Kota).

MATERIAL AND METHODS:-

Chandloi River is a left bank tributary of Chambal River. It originates near Adania village and meets the River Chambal near village Mavasa. The river flows nearly 90 Km before entering River Chambal. Specimens of fishes were procured from different selected localities during the study period of July 2017 to June 2019, once in a month of the entire fishing season. The help of local marketers and fishermen who were using different types of nets namely gillnets, cast nets and dragnets was taken.

Immediately after procurement of the specimens, photographs were taken prior to preservation since formalin decolorizes the fish. Formalin solution was prepared by diluting one part of concentrated formalin (commercial formaldehyde) with nine parts of water i. e., 10% formalin. Fishes brought to the lab were fixed in this solution in separate jars according to the size of species. Smaller fishes were directly placed in the formalin solution while larger fishes were given an incision on the abdomen before they were labelled giving serial number tag bearing certain information such as collection site, date, time, weight and length etc.

Identification of collected specimens was done using keys (Day, 1889; Jayaram, 1999; Srivastava, 1995) for fishes of the Indian subcontinent. . The identification of the species was done mainly on the basis of the colour pattern, specific spots or marks on the surface of the body, shape of the body, structure of various fins etc. and also with the help of taxonomic expertise.

RESULT AND DISCUSSION:-

During the study period (July 2017 to June 2019) 13 species were taxonomically identified and listed in table number 1.

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Table - 1: Checklist of fishes of Chandloi River, district Kota, Rajasthan.

S. No.	Order	Family	Genus	Species	Common Name	Abundance (C/R/T/E)
1.	Cypriniformes	Cyprinidae	*Puntius*	*sophore*	Pool barb	R
			Rasbora	*daniconius*	Darka	R
			Cirrhinus	*mrigala*	Naren	T
			Osteobrama	*cotio cotio*	-	R
			Labeo	*bata*	Bata	C
			Labeo	*rohita*	Rohu	C
			Labeo	*calbasu*	Kalbasu	R
			Gudusia	*chapra*		T
2.	Siluriformes	Heteropneustidae	*Heteropneustes*	*fossilis*	Magur	C
3.	Perciformes	Channidae	*Channa*	*punctata*	Sanval	C
4.	Beloniformes	Belonidae	*Xenentodon*	*cancila*	Niddle fish	T
5.	Clupeiformes	Clupeidae	*Gonialosa*	*manmina*	-	E
6.	Synbranchiformes	Mastacembelidae	*Mastacembelus*	*armatus*	Bam	T

It is clearly visible in table that River Chandloi has a good diversity composed of six orders of fishes, namely Cypriniformes, Siluriformes, Perciformes, Beloniformes, Clupeiformes and Synbranchiformes. Order Cypriniformes is represented by single family Cyprinidae which is found to be most diverse and dominant family. This family have 06 genera with eight species. Genus *Labeo* is the most diverse and dominant genus in this habitat with three species. All other orders are represented by single family. Each family has 1 genus representing single species. The study is in continuation and there are few more specimens yet to be identified. This reporting is first of its kind from the River Chandloi. Results presented here are comparable to earlier similar studies done in running waters of Rajasthan state (Banyal and Kumar, 2015; Nair and Chaitanya Krishna, 2013; Datta, 2018; Sood, *et al.*, 2019).

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Review

On the impact of Tilapia (*Oreochromis mossambicus* Peters, 1852) on the Icthyodiversity: A Review

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Abstract: Tilapia (*Oreochromis mossambicus)* is African mouth-brooder cichlid fish. It is native to the eastward flowing rivers of central and southern Africa. Morphological features are quite distinctive such as laterally compressed body, approx 35cm in length and up to 1.13 kg in weight. It are omnivorous. In India it was brought from Sri Lanka for the first time.It's invasion is problematic for native diversity in many countries. It is listed in Global Invasive Species Database (2006). It is creating threat to local fish fauna in India and other countries. Therefore, it is very important to understand the impact of it's presence in Indian waters. Rajasthan is known for his great Thar desert but south eastern part is blessed with many perennial and emprical rivers and lentic water bodies. Very less work is carried out regarding impact of tilapia on biodiversity of south eastern part of Rajasthan. Present paper tries to review the available literature on this area of study which would be a great help to conserve the native fish diversity.

Key words: fish diversity, tilapia, invasive species, morphological features.

INTRODUCTION:

Tilapia is the common name for nearly a hundred species of cichlid fish from the tilapiine cichlid tribe. Tilapia are mainly freshwater fish inhabiting shallow streams, ponds, rivers and lakes and less commonly found living in brackish water. Historically, they have been of major importance in artisan fishing in Africa and the Middle East, and they are of increasing importance in aquaculture and aquaponics. Tilapia can become problematic invasive species in new warm-water habitats such as Australia, whether deliberately or accidentally introduced, but generally not in temperate climates due to their inability to survive in cold water.

The native Mozambique tilapia is laterally compressed, and has a deep body with long dorsal fins, the front part of which has spines. Native coloration is a dull greenish or yellowish, and there may be weak banding. Adults reach approximately 35 centimetres (14 in) in length and up to 1.13 kilograms (2.5 lb). Size and coloration may vary in captive and naturalized populations due to environmental and breeding pressures. It lives for up to 11 years.

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Mozambique tilapia are omnivorous. They can consume detrital material, diatoms, invertebrates, small fry and vegetation ranging from macro-algae to rooted plants. This broad diet helps the species thrive in diverse locations

The African mouth-brooder cichlid, the Mozambique tilapia, *Oreochromis mossambicus* Peters 1852, is native to the eastward flowing rivers of central and southern Africa (Philippart and Ruwet, 1982; Trewavas, 1982). Due to their perceived utility as an aquaculture species, *Oreochromis mossambicus* are now widely distributed around the world (Arthington et al., 1984; Philippart and Ruwet, 1982). However, *Oreochromis mossambicus* have now not liked as a preferred aquaculture species because of their propensity to 'stunt' and their general poor quality due to the small size of founder stocks (Pullin, 1988). Invasive populations are now causing environmental and ecological problems in many countries (Canonico et al., 2005) and as such, *Oreochromis mossambicus* is listed in the Global Invasive Species Database (2006) as being in the top 100 invasive alien species on the planet.

The species has been described as a 'model invader' due to a number of key biological characteristics including tolerance to wide ranging ecological conditions, generalist dietary requirements, rapid reproduction with maternal care, and the ability to successfully compete with native fish through aggressive behavior (Pe´rez et al., 2006b). Therefore, given suitable environmental conditions, *Oreochromis mossambicus* have become successfully established in almost every region in which they have been cultured or imported (Costa-Pierce, 2003; Cucherousset and Olden, 2011; Diana, 2009; Strecker et al., 2011). Official records show that *Oreochromis mossambicus* was first introduced to India from Sri Lanka in 1952 and thereafter stocked in several reservoirs of southern India for production enhancement (Sugunan, 1995). Tilapia now forms a part of fish fauna in the Godavari, Krishna, Cauvery, Yamuna and Ganga Rivers (Lakra et al., 2008).

In earlier studies, tilapia attracted the attention of scientific communities due to its mouth brooding behaviour (Perez et al., 2006; Russell et al., 2012). Tilapia has remained an objective of astonishment to ethnologists for years but its present behaviour, that is, prolific feeder and prolific breeder changed the scenario. Tilapia is now known for its invasion to the non-native water bodies and destruction of their flora and fauna.

REVIEW:

The Icthyodiversity and impact of invasive species on it has been a popular subject among the scientist all over the globe. The most widely dispersed tilapia species the Mozambique tilapia *(Oreochromis mossambique)* which was once known as the Java tilapia since most introduction of this fish originated from west Jawa, Indonesia, its first established local outside Africa (Hickling 1960). Due to the small size of founder stocks, by the mid -1970 the Mozambique tilapia deteriorated in many recipient environment and small sized, poor quality fish lost consumer acceptance [Pullin1988].

Allonson et al., (1971) suggested that *Tilapia mossambicus* to estuaries at the southern end of its distribution at the sourthen Africa related to the maintenance of near normal Na and Cl ion concentration at low temperature during winter water.

Moriarty (1973) reported that the cells of blue green algae are lysed by high concentration of acid (pH 1.9 – 1.4) in the stomach of *Tilapia nilotic.* After laysis, cell contain are digested in the intestine. Acid secretion follows diuranal cycle

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related to feeding and thus there is a cycle from zero to maximum digestion each day. Kutty and Sukumaran (1975) reported that *Tilapia mossambicus* to 30^{0}C in fresh water and forced to swim at current speeds 36, 66 and 82 cm/s in Blazka's activity apparatus failed to swim at 39.7, 38.4 and $37^{0}C$ respectively when temperature become increase lower critical temperature of swimming failure at the same three of ambient water was gradually increased from the acclimation temperature swimming speeds were 17.4, 10.8 and 19.8^{0} C the pattern of swimming failure at the critical temperature was similar to that at critical ambient O_2 concentration.

Bruton et al., (1975) reported that *Tilapia mossambicus* inhabits the littoral and sub-littoral in the warm and transition period (Aug. Apri) but move into deep water in the cool season (May- July). Exposed and sheltered areas are utilized for different purpose by adult fishes, the former for nesting, and latter for feeding and mouth brooding.

Hwang (1987) reported that the development of leaky junctions and interdigitations in branchial chloride cells appear to correlate to seawater adaptation in *Oreochromis mossambicus*. These change of seawater-adapted chloride cells seem to be associated with the increase of ion permeability in the gills of teleosts adapted to seawater rather than those adapted to fresh water.

Pullin and Cupili (1987) reported the tilapia are cultured throughout the tropics and subtropics for genetics improvement. They also reported that largest tilapia culture industries are in Asia. The emphasis is on the most popular cultured species, *Oreochromis niloticus*

De Silva and Sirisena (1988) reported that *Oreochromis mossambicus* formed nest build in five manmade lake Sri Lanka. The nest always found generally located in or near cover in shallow water. The nests ranged from 11 to 110 cm in diameter, two size groups of nest recognizable small, with diameter 10-50 cm and large with diameter >50 cm. At any nesting site only one size group of nest was found.

Amarasinghe and de Silva (1992) have reported that the performance of *Oreochromis mossambicus* in Kaudulla and Minneriya reservoirs was better than is other various geographical area. This may be due to very favorable environment for *Oreochromis mossambicus* in Sri Lanka reservoirs which provide variety of nutrition food source.

Yada et al., (1994) observed that the changes in GH (growth hormone) which occurred when tilapia were moved between fresh water and sea water are compatible with idea proposed by other for salmonids that GH may have important role for sea water.

Oliveira and Almada (1995) reported that sexual dimorphism in growth of conventional morphometric character was investigated in juvenile and young adult (size range 31 to 91 mm) of *Oreochromis mossambicus*. A closely associated set of traits was identified that shows sexually dimorphic growth which was positively allometric in the male. These traits correspond to two different morphological complexes. Jaw structure and anal /dorsal fins. The best sex discriminates among this set of traits were premaxilla width and fin height and snout. These finding may be explained in term of intra and inter sexual selection acting together and favouring males with strong and large mouth and high dorsal and anal fin, traits that are important in agonistic display (jaw and fins) fighting and nest digging (jaw).

Jayaprakas et al., (1996) observed that carnitine induced lipid catabolism leading to reduction in lipid content of cultured fish, using lipid as energy source while sparing protein for anabolic processes. Significantly high GSI, sperm cell concentration, motaility and percentage

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viability of the spermatozoa in carnitine treated tilapia.

Vanzyl et al., (1997) reported that 24 *Oreochromis mossambicus* from the Hardapdam, Namibia were introduced during 1986, into salt pans at Swakopmund on the Namibia coast. The salt concentration of the salt pans is higher than of sea water. The *Oreochromis mossambicus* adapted well to the condition, breed successfully and maintained a healthy population.

Nakano et al., (1998) suggested that glucose is an important energy source for osmoregulation during the acclimation to hyperosmotic environments in *Oreochromis mossambicus*.

Kumar (2000) reported that exotic species and other anthropogenic activities the exotics compete with the indigenous species for food, habitat and may even prey open them, introduced new parasites and diseases. *Oreochromis mossambicus* in India has been claimed as a success story by expect. He found that tilapia now dominates indigenous icthyofaunal in many water bodies of India.

Canonica et al., (2005) has reported that tilapia species are highly invasive and exist under feral condition in every nation in which they have been introduced. They also found that tilapia damage to native fish species and biodiversity.

Raghavan et al., (2007) reported that five exotic found Chalakudy river in Kerala, India. *Oreochromis mossambicus* was ubiquitous in occurrence with large shoals being encountered at all sampling sites along the downstream upstream gradient of the river.

Marjani et al., (2009) observed that 17-alpha Methyl Testosterone [MT] receiving treatment showed a significantly higher male proportion than the control experiment of *Oreochromis mossambicus*. Dose rate of 75 mg/kg MT of feed resulted in maximum male population [98.09%] with 1.91% sterilized fish. The dose rate of 75 mg/kg MT gave the maximum gain in body weight i.e., 11.8g which is 1.2 time greater than the control.

Singh and Lakara (2011) have reported that in India over 300 alien species are present 291 invasive species, for example *Cyprinus carpio, Oreochromis niloticus, Aristichthys nobilis, Pygocentrus natereri* and *Pterygolichthys sps*. They reduce the availability of local species and establish in natural water bodies becoming invasive and consequently adversely affecting fish biodiversity and aquatic ecosystem.

Adriana et al., (2011) reported that Nile and mozambique tilapia harbour a number of different species of Gyrodactylus, with *Gyrodactylus cichlidarum* being the most frequently encountered and being associated with mortalities of juvenile *Oreochromis niloticus niloticus*.

Russell et al., (2012) reported that two invasive tilapia species, *Oreochromis mossambicus* and *Tilapia mariae* in fresh water habitat in north-eastern Australia was investigated *Oreochromis mossambicus* length and age considerably depending on habitat male and *Oreochromis mossambicus* in a large impoundment were considerably greater than for those resident in small coastal drain.

Singh (2014) reported that number of invasion of fresh water exotic fishes have taken place into India over the past decade and adversely affected the fish biodiversity. Many more change are predictable to occur with the expected climate invading near area and ecosystem. The estimated annual average production of alien species fit for human consumption amount to around 18.2 to 34.5% of the annual average production of marketable fish culture in India. A significant negative impact of the introduced species on native icthyo fauna has been ascertiained as regard to its ecological, biological characteristic biodiversity and health. Concidered a typical invasive alien

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species, *Oreochromis mossambicus, Oreochromis niloticus* and *Cyprinus carpis* heavily depressed the occurrence and numbers of Indigenous population and also contributed to the declined fishery of native cyprinid fish in several natural aquatic body of the country.

Ujjania et al., (2015)has reported that during 1990-90 in Jaisamand IMC (37%), Minor carp (59%) and Cat fishes (9%) total production 287 metric ton but due to invasion of tilapia where only IMC (11%), Minor carp (3%), Cat fish (4%) and Tilapia is dominating 82% out of total production 119 Meteric ton.(2012-13)

Sakhare and Jetithor(2016) reported that 80 specimens of *Oreochromis mossambicus* collected from Borna Reservoir of Maharashtra, India revealed that the food of juvenile mainly is rotifer(35%), copepode(30%), chlorophyceae(20%), bacillariophyceae(10%) and aquatic insect(5%). While in adult gut chlorophycaea (40%), bacillariophyceae(30%), rotifer(15%) and aquatic insect(5%).Intense feeding was noticed during summer season and juvenile was the active feeder.

Laxmappa (2016) reported that presence of exotic fishspecies such as *Oreochromis niloticus, Oreochromis mossambicus, Claris gariepinus* etc have impacted the population of indigenous species and contributed towards the decline in the fishery of native cyprinid fish species in several natural aquatic bodies of Telangana state.

Renjithkumar et al., (2016) reported that the contribution of non native species to the total fishery of Bharathapuzha River was estimated to be 13.93%. Indian major carp [*Gibelion catla, Labeo rohita, Cirrhinus mrigala*] and *Oreochromis mossambicus* were the non native species represented in the exploited fishery. *Gibelion catla*[3.98t], *Labeo rohita* [5.14t] and *Cirrhinus mrigala* [3.14t] were the transplanted species which together formed 11.43% in the total landing of the river. The size range of Catla Rohu, Mrigal in the catch were 240-720mm, 290-560mm and 190-360mm respectively. The exotic fish Oreochromis mossambicus accounted for 25% of the fishery

CONCLUSION:

Concluding the above account we can state that tilapia [*Oreochromis mossambicus*] are popular exotic fish in fresh water resources It's invasion harm full for other indigenous fishes species. Thus tilapia [*Oreochromis mossambicus*] study is very important for aquatic diversity.

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Review Paper

A Critical Review of Studies Related to Diversity and Seasonal Variation of Phytoplanktons

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Abstract
The phytoplankton is defined as the microscopic plant life of the water, which functions as primary producers synthesizing the food. It belongs to the class Algae, which besides chlorophyll possess other characteristic pigments. The important components of phytoplankton are Diatoms (Bacillariophyceae), Dinoflagellates (Dinophyceae), Chrysophyceae, Haptophyceae, Cryptophyceae) and Nanoplankton (Chlorella, Nannochloropsis etc.). In addition to these two other classes namely Silicoflagellates and Coccolithophores also belong to the category of phytoplankton. The present paper discusses comprehensive review of phytoplankton diversity, seasonal variation and related aspects.

Keywords: Phytoplankton, Diversity, Chlorophyta, Chromophyta, Rhodophyta, Ecological indicator.

Introduction

Plankton are those organisms which spends either part or all of their life in a drifting state, with no ability to swim against a current. Phytoplankton produce their own food and thus are very important part of food chain and food web. They act as very good indicators of health of water resources.
Plankton can be divided into two basic categories
(a) *Phytoplankton: organisms that are plant like.*
(b) *Zooplankton: organisms that are animal like.*

Phytoplankton on the basis of cell structure may be divided into two categories

1. *Prokaryotes: Prokaryotes have only one group - Cyanobacteria*
2. *Eukaryotes: Eukaryotes have 3 Divisions: Chlorophyta, Chromophyta and Rhodophyta*

Chlorophyta has 3 classes, Chromophyta has 7 classes and Rhodophyta has mostly macrophytes. In India, Plankton has been subject of study for nearly two centuries. A good amount of literature has been generated by several workers during this period. Many review papers appeared time to time, covering one or many aspects of plankton biology. During the survey of literature it has been observed that recently publish research work should be reviewed in terms of diversity, seasonal variation and applied aspects.

Review

Ansari and Aparia (2008) studied physico-chemical profile and plankton diversity of Rantal Lake, Chhatarpur, M.P. According to the study, the phytoplankton is dominated mainly by the species of Cyanophyceae, Chlorophyceae and Diatoms, which belong to the tolerant species.

Kumar and Hosmani (2006) studied Algal Biodiversity in Freshwaters and related Physico-Chemical Factors in two Lakes of Mysore District. Euglenophyceae are poorly represented, Bacillariophyceae were the most dominant and occurred throughout the study period. Cyanophyceae dominated during winter season. Chlorococcales were less significant.

Mathivanan *et al.*, (2007) studied plankton of River Cauvery water (Tamil Nadu), the qualitative and quantitative evaluation of the variation in river water showed high quantity of phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Myxophyceae and Euglenas. This study revealed that the water of River Cauvery is highly polluted by direct contamination of sewage and other industrial effluents.

Desai *et al.*, (2008) studied Phytoplankton diversity in Sharavati River basin, Central Western Ghats. During this study total of 216 species of 59 genera belonging to Bacillariophyceae, Desmidials, Chlorococcales, Cyanophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae were recorded. Various pollution indices showed the oligotrophic nature of the reservoir waters with slight organic pollution in stream waters. Ali *et al.*, (2009) studied an ecological study with special reference to phytoplankton (algal) component River Gomti in Jaunpur City. The phytoplankton (algal) community of river was represented by four algal groups viz., Cyanophyceae, Chlorophyceae, Euglenophyceae and Bacillariophyceae. Out of 44 algal species, 16 species of Cyanophyceae and Chlorophyceae, 1 species of Euglenophyceae and 11 species of Bacillariophyceae were recorded from different sites of the river. Phytoplankton population showed a positive correlation with pH, DO, alkalinity, phosphate and nitrate and negative correlation with temperature and chloride. Many of the algal species, of the total 44 reported from the river like *Anabaena, Microcystis, Oscillatoria, Chlamydomonas, Chlorella, Pediastrum, Euglena, Cyclotella, Navicula, Nitzschia* were recognized as pollution indicators.

Dube *et al.*, (2010 a, b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and twenty four species of phytoplankton were recorded. Sharma and Mankodi (2011) studied the diversity of various types of plankton like, phytoplankton and zooplankton in Narmada River. The phytoplankton were represented by Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae, out of which generic diversity of Bacillariophyceae was more.

Bhatnagar and Bhardwaj (2013) studied the seasonal algal diversity and the physico-chemical properties of water of Chambal River. This study shows the presence of a total of 65 algal species. Some algal forms are good indicators of water pollution and their presence show signs of water pollution. The algal forms consisted of a total of 65 taxa belonging to Chlorophyceae (32 species), Cyanophyceae (18 species), Bacillariophyceae (12 species), and Euglenophyceae (3 species).

Negi and Rajput (2013) studied Phytoplankton Community Structure in Ganga River at Bijnor. They reported 43 genera of phytoplankton belonging to 5 groups viz. Chlorophyceae 16 genera, Bacillariophyceae 12 genera, Cyanophyceae 10 genera, Euglenophyceae 4 genera and Xanthophyceae 1genera. Chlorophyceae exhibited maximum abundance and generic diversity and Xanthophyceae exhibited minimum abundance and generic diversity.

Subhashree and Patra (2013) studied phytoplankton of River Mahanadi of Odisha. This study revealed that diversity of species Chlorophyceae 53.45% whereas Cyanophyceae 20.70% and Bacillariophyceae 25.77% were compared. Malik *et al.*, (2014) studied phytoplankton ecology in Narmada River of West Nimar, M.P. India. Ten species of phytoplankton have been collected from various freshwater habitats in the West Nimar. This study revealed Cyanophyceae has a dominant class. Phytoplankton belonging to Cyanophyceae (4 species), Charophyceae (3 species), Trebouxiophyceae (1), Ulvophyceae (1), Zygnematophyceae (1) were reported from River Narmada.

Singh (2015) deals seasonal study of phytoplankton diversity of Gomti River Lucknow, (U.P.) India. Various genera of algae belonging to chlorophyceae viz. *Chlamydomonas, Spirogyra, Oedogonium, Ulothrix, Hydrodictyon, Vaucheria, Scenedesmus, Desmidium, Zygnema, Mougeotia spp., Microspora spp., Closterium acicularis, Pediastrum, Ranunculus aquatilis;* Various genera of bacillariophyceae viz. *Fragilaria gracilis, Cymbella [illegible], Navicula [illegible], Synedra ulna, Navicula-sphaerophora, Nitzschia [illegible], Tabellaria,* Myxophyceae viz. *Volvox aureus, Oscillatoria, Spirogyra* have been recorded. Phytoplankton are significant formed natural occupies of all water bodies. Monitoring programmes of phytoplankton are very important. They may provide information on possible new introductions and may serve as early warning system to detect the pollution level. *Chlamydomonas, Ranunculus aquatilis Microspora* spp, *Volvox aureus* were the most abundant followed by *Ulothrix, Hydrodictyon, Desmidium.* High concentration of diatoms at Daliganj bridge and Nishatganj bridge indicate polluted zone of the river. *Oscillatoria* and *Spirogyra* spp. at polluted sites can be used as an indicator of organic pollution in the river. This study is very important from pollution indicator point of view.

Anand *et al.*, (2015) studied phytoplankton diversity and water quality assessment of ONGC Pond, Hazira. Total seventy three genera of phytoplankton belonged to four classes viz., Euglenophyceae, Chlorophyceae, Bacillariophyceae and Cyanophyceae were identified. Chlorophyceae group was dominated among the four Classes. Trivedi and Kataria (2015) studied diversity of phytoplankton in Kshipra river at Triveni station, Ujjain (M.P.). They reported 21 genera belonging to Chlorophyceae, 16 belonging to Bacillariophyceae and 10 to Cyanophyceae were recorded and *Rhoicosphenia* sp. is most dominant species among the Bacillariophyceae group.

Solanki and Shukla, (2016) studied preliminary study of phytoplankton diversity in River Narmada valley of Jabalpur region (M.P.). A total 30 algal taxa belonging to 16 genera have been collected and identified from different sessions. The number of various members of class Chlorophyceae with 12 taxa (40%), Euglenophyceae with 3 taxa (10%), Bacillariophyceae with 7 taxa (23%), Trebouxiophyceae with 1 taxa (3%), Ulvophyceae with 1 taxa (3%), Zygnematophyceae with 1 taxa (3%) and Cyanophyceae with 5 taxa (17%).

Kumar and Khare, (2015) studied the analysis of diversity of plankton (i.e., phytoplankton and zooplankton) and their seasonal variation of density in the Yamuna River at Kalpi, District Jalaun, U. P. Phytoplankton were belong to 35 species of 25 genera of different groups like as Chlorophyceae (12 species of 11 genera), Euglenophyceae (3 species of 2 genera), Bacillariophyceae (5 species of 5 genera) and Cyanophyceae (15 species of 7 genera). Chlorophyceae was dominated over rest of the phytoplankton population. Kalbar Bee *et al.*, (2015) studied Plankton diversity and water quality of Ambattur Lake, Tamil Nadu. Water quality of the freshwater habitats provides substantial information about the existing resources which depends on the influences of physico-chemical parameters and biological features. According to the report, 22 species of plankton consisting phytoplankton and zooplankton were recorded and fluctuations among physico-chemical parameters. Shukla *et al.*, (2013) studied phytoplankton diversity in River Ganga at Allahabad U.P. plankton identify in the river mainly composed of the members of Bacillariophyceae, Chlorophyceae and Cyanophyceae families. The abundance of phytoplankton in April was greater than in march. Dhanam *et al.*, (2016) studied physico-chemical parameters and phytoplankton diversity of Ousteri Lake in Puducherry. A total of 34 plankton species belonging to 26 genera under the 4 classes among these Cyanophyceae comprised of 15 species (belonging to 11 genera) followed by Chlorophyceae 9 species (belonging to 7 genera) Bacillariophyceae 7 species (belonging to 6 genera) and Euglenophyceae 3 species (belonging to 7 genera) were recorded. Cyanophyceae algal growth is dominated over Chlorophyceae, Bacillariophyceae and Euglenophyceae.

Gupta *et al.*, (2016) studied the seasonal fluctuation of plankton and to examine the healthiness of water by analyzing the diversity and density of plankton in Kirat Sagar pond at Mahoba district. Phytoplankton population in various sites of Kirat Sagar pond indicated the order of dominancy among the group with regards to their density and diversity as chlorophyceae > bacillariophyceae > myxophyceae. Maximum density of phytoplankton were found in the months of summer due to scarcity of water while minimum density was found in the months of winter and monsoon season due to low evaporation and inflow of water in the pond.

Suraja and Gopal (2017) studied Variations in the phytoplankton communities like Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, and Dinophyceae in two lakes of Udupi district, Karnataka have been discussed. This lake during a certain period supported as many as 26 species of Cyanophyceae, 80 species of Chlorophyceae, 7 species of Euglenophyceae, 8 species of Bacillariophyceae and 2 species of Dinophyceae. The growth of phytoplankton influenced by physicochemical parameters such as water temperature, dissolved oxygen, water pH, biological oxygen demand, chemical oxygen demand, nitrates, phosphates etc.

Goswami *et al.*, (2017) studied the quantitative study of plankton diversity in three urban ponds (P-1, P-2 and P-3) of Kolkata in West Bengal. Three classes of phytoplankton (Chlorophyceae, Cyanophyceae and Euglenophyceae) were recorded from all three ponds during the study period. Chlorophyceae was encountered as the most significant group of phytoplankton with a contribution of 65% in P-1 followed by Cyanophyceae (20%) and Euglenophyceae (15%) of total population. Similarly it was also dominant in both P-2 and P-3 with a contribution of 60% followed by Cyanophyceae (19%) and Euglenophyceae (21%) respectively. Hossain *et al.*, (2017) studied diversity of plankton communities in the River Meghna. He reported Chlorophyceae with 16 genera, Dinophyceae with 2 genera, Bacillariophyceae with 13 genera, Cyanophyceae with 7 genera, Myxophyceae with 5 genera, Euglenophyceae with 1 genus and Xanthophyceae with 2 genera.

Kumar *et al.*, 2018 reviewed the studies of Phytoplankton in Lake Water of India. Phytoplankton are microscopic creatures mainly algae contain chlorophyll and live near the surface of water where there is sufficient light, producing their own food and thus providing meals for countless other aquatic dwellers. They play important role in maintaining the equilibrium between living organisms and abiotic factors. The density and diversity of phytoplankton and their associations as biological indicators is significant in the assessment of water quality. Phytoplankton are good indicator of environmental changes and their variation provides a ground for monitoring and assessing the strategies of the river management.

Conclusion

The above account clearly suggests us to conclude that inspite of such a voluminous work done by a large number of scientists still, there are some gaps in terms of geographical or biological aspects. Considering Rajasthan, many river systems need extensive study and it may be safely expected to find out some new genera species and this information can be utilized to solve food scarcity problems in the world.

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Review Paper

A Review on the studies of Zooplankton in the lotic water of India

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Abstract: Zooplanktons are microscopic free floating animals which play a vital role in aquatic ecosystem zooplanktons are highly sensitive to environment variation, as a result change in abudance species diversity or community composition can provide important indication of environmental health.in the present paper an extensive review of the literature available on zooplanktons in lotic water of India have been made which is a long felt necessity in this field.
Keywords: Zooplankton, lotic water, environment .

INTRODUCTION

Lotic refers to flowing water that includes river, spring, streams etc. In lotic water flow is unidirectional and there is a state of continuous physical change and the biota is specialized to live with flow condition. Rivers are important system of biodiversity and are among the most productive ecosystems on the earth because of the favourable conditions that supports number of flora and fauna.

Planktons are diverse group of organism that live in the water column of large bodies of water that cannot swim against a current. The plankton study is very useful tool for the assessment of biotic potential and contributes to overall estimation of biotic nature and general economic potential of water bodies.

Zooplankton: Zooplankton plays an important role in aquatic ecosystem. They link the primary producers, phytoplankton with higher larger trophic level organisms. Zooplankton communities respond to a wide variety of disturbances including nutrient loading and also play a key role in the aquatic food chain. The zooplankton plays an integral role and serves as bioindicator and it is a well suited tool for understanding water pollution status. So this paper deals with the studies of zooplankton in lotic water of India.

Odum (1971) discussed zooplankton is also sensitive to their environment and a change in zooplanktons concentration can indicate a suitable environmental change. The diversity of species, amount of biomass and

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abundance of zooplanktons communities can be used to determine the health of an ecosystem.

Saldeek (1983) reported that among zooplanktons Crustaceans, Cladocerans and Copepods can be used as indicators of aquatic environment.

Allan and Dall (1991) reported zooplankton to be rich in essential amino acid and fatty acids docosahexaenoic acid and eicosaptaenoic acid. Guy (1992) studied ecology of the fish pond ecosystem with special reference to Africa. He discussed zooplanktons provides fish with nutrients since fish require proteins, fats, carbohydrates, mineral salts and water in the right proportion. Zooplanktons study is of necessity in fisheries, aquaculture and paleolimnological research. Bisht (1993) Reported maximum zooplanktons diversity in the month of September and minimum in the month of January. Dobriyan *et al*., (1993) observed that the highest planktonic diversity was in the winter months when the water temperature is low, water current is low and the water is clear without turbidity.

Rosenberg and Resh (1993) discussed bio monitoring is the systematic use of living organisms or their responses to determine the quality of the environment. Brett *et al* (1994) investigated fresh water diversity of California and observed the species dependent effect of zoopanktons on the phytoplanktonic ecosystem and concluded that the presence of predaceous cladocerans and copepods have a direct effect on the presence of a several algae species, dissolved nutrients and the ciliate microzooplanktons. Bonner *et al* (1997) stated that most of the zooplanktons prefer either the steady or the low water current habitat. During monsoon season very less zooplanktons were observed because of high turbidity and fast water current.

Kobayash *et. al.*, (1998) reported the zooplankton density was negatively correlated with turbidity, conductivity, temperature and amount of phosphorus present.

In recent studies, biodiversity of zooplankton of nine different water bodies of South Rajasthan is studied by Sharma *et al.*, (2002) total 144 zooplanktonic forms were reported belonging to 3 phyla, 27 families, 64 genera and 105 species. Protozoa, Rotifera, Copepoda, Cladocera and ostracoda were represented by 13, 39, 22 and 6 forms respectively. Biodiversity in the zooplankton has been calculated in the Menhinick's index and values have been discussed in relation to physico-chemical characteristics and primary productivity. Datta *et al.*,(2004) investigated fresh water diversity of Jammu and collected 51 species of zooplanktons belonging to 35 species of Protozoa, 8 species and 2 larvae of Crustaceae, 5 species of Rotifera, 1 species of Porifera, 1 species of Platyhelminthes and 1 species of Annelida. Zafar and Sultana., (2005) studied the river Ganga at Kanpur reported the zooplanktons and macroinvertebrate diversity and observed that the quality of the water was responsible for quantitative and qualitative variations in zooplanktons. Mathivanan *et al.*, (2007) studied plankton of River Cauvery water (Tamil Nadu) The qualitative and quantitative evaluation of the variation in river water showed high quantity of zooplankton population throughout the study period and rotifers formed dominated group over other groups organism. This study revealed that the water of River Cauvery is highly polluted by direct contamination of sewage and other industrial effluents.. Utah *et. al.*, (2008) studied Biosurvey of planktons as indicators of water quality in River Calabar, Nigeria. They reported zooplanktons belonging to Copepods,

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Protozoa, Polychaetalarvae, Cyclopodia, Cladocera, Arthrotoda, Ostracoda, Rotifera, Malacostraca and Foraminiferida. The Copepods were the most abundant group. Vanjare, *et al.*, (2010) studied zooplankton from a river Mula, Pune, Maharashtra. Rotifera and Cladocera are free living zooplankton elements known to dominate freshwater habitats. 18 Rotifers and 10 Cladocerans were recorded during this study. This study showed an attempt to monitor a polluted habitat for zooplankton.

Khanna *et al.*, (2012) studied the analysis of water samples for plankton diversity of river Ganga, In this study of river Ganga, among the zooplankton, Protozoa, Rotifera, Cladocera, Copepoda, Ostracods constitute the main component. Jos *et al.*, (2012) studied seasonal fluctuations in diversity of Zooplanktons of Achencovil River, Kerala. This study showed zooplankton community comprised of 28 species belonging to Cladocera 11species, Copepoda 9 species and Rotifera 8 species.This study also revealed that different groups of zooplankton have their own peak periods of density, which is affected by local environmental conditions Sharma *et al.*, (2012) studied fresh water Cladocera of South Rajasthan, India. This study shows cladocera are an important component of the crustacean zooplankton. Zooplankton samples from 77 different water bodies of South Rajasthan were analyzed to investigate the cladocera inhabiting these water bodies. During this study 54 species of cladocerans were reported, belonging to 6 families i.e. the Sididae, Daphinidae, Moinindae, Bosminidae, Macrothricidae and chydoridae. It was noticed that rich nutrients, the presence of weeds and shallow waters favoured rich diversities of cladocerans Sudha Summarwar (2012) investigated the plankton diversity in Thadoli area of Bisalpur reservoir.During this study the most pollution tolerant species of Oscillatoria, Euglena and Navicula were recorded. Rotifers of genus Brachionus and keratella are abundant in water of the reservoir. Their occurence in eutrophic water is well documental. Tidame and Shinde (2012) studied the zooplankton diversity of Nasik District. Different Zooplanktons were noticed during the study period, amongst them rotifers are more dominant. Total 17 genera were recorded from rotifers and genus Brachionus in abundant and more common to both the ponds. In Amrutkund 21 species of rotifers were recorded belonging to 15 genera while in pond Ramkund 23 species to 14 genera. The maximum diversity of rotifers was observed in the monsoon season in both Amritkund and Ramkund Pond. Dubey *et. al.*, (2012) Limnological studies on khop niwari tank with special reference to phytoplanktons.

Kohle *et al.*, (2013) studied qualitative and quantitative evaluation of the variation in Godavari River Nasik district. Rotifers formed dominated group over other group of organism. This study revealed that the water of river Godavari is contaminated of sewage and other industrial effluents. Komala *et al.*, (2013) studied plankton diversity and abundance of Arkavathi River before and after pollution. Plankton diversity and abundance varied during different seasons, both at non-polluted and polluted sites. A total of 27 species of Zooplanktons were recorded belonging to Protozoa 6 species, Rotifera 8 species, Crustacea 8 species and Insecta 5 species.Nutrient enrichment of the river due to silk industries effluents has altered the structure of plankton community.

Negi and Mamgain,. (2013) studied zooplanktons diversity of Tons river of Uttarkhand. They reported 23 genera of zooplanktons belonging to 7 major groups viz. Ciliophore, Cladocera, Copepod,

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Porifera, Rotifera, Ostracod and Zooflagellate. Singh, (2013) studied biodiversity of river Gomti is heavily affected by pollution. Planktons are important biological parameters to access the pollution level. This study shows biological productivity as ecological indicator to identify the ecological quality of river Gomti. . The zooplankton community comprised Protozoa 5 species, Rotifera 3 species, Cladocera 2 species and Copepoda 1 species. The zooplankton population was observed maximum during monsoon season but it was low in summer season.

Umadevi (2013) studied the abundance, composition and distribution of zooplankton in relation to water quality parameters in Kamnja River in Karnataka. 36 species of zooplankton were identified as a total, which included 14 species of Rotifera 11 species of Cladocera 8 species of Copepoda and 3 species of Ostracoda. Watkar and Barbate (2013) studied zooplankton diversity of River Kolar, Saoner, District. Nagpur, Maharashtra. This study revealed 28 species of zooplankton belonging to five major group Janmoni *et al.*, (2014) studied zooplankton diversity of the two rivers Kaliani and Dhansiri receiving oil refinery effluent from NRL. A total of 11 genera of zooplankton belonging to 5 groups. Cladocera, Copepoda, Ostracoda, Protozoa and Rotifera. This study revealed seasonal variations of zooplankton abundance were pre monsoon (29%) Post Monsoon (25%), winter 25% and monsoon (21%). Sarwade and Kamble (2014) studied Quantitative assessment of plankton of the river Krishna, District, Sangli, Maharashtra. Diversity of Zooplankton included, Cladocera, Rotifera, Protozoa, Nematoda, Aostraca, Schizopyrenide and copepoda as major groups, with 25 genera. Rotiferans were found dominant with 9 species.. Protozoans were second dominant group with 8 diversified species.Cladocerans included 2 species. Nematoda, Aostraca and Schizopyrenida each showed 1 type of species.Copepoda showed 3 types of species.. Dede and Deshmukh (2015) studied the zooplankton composition and seasonal variation in Bhima river near Ramwadi Village, Sholapur District. A total of 21 species were found in this river. These belongs to Cladocera, rotifer, Copepoda and Ostracoda. Among these 9 species belongs to Rotifera, 5 species belongs to Copepoda, 5species belongs to Cladocera, 3 species belongs to Ostracoda.Rotifera was found dominant group. The study of season wise zooplankton analysis showed an average abundance of species in winter season, lower in monsoon season and maximum occurrence in summer season, due to different environmental condition of water bodies. Eyo and Paul, (2015) studied great KWA River, Nigeria. They astimeted a total of 23 species of zooplanktons belonging to 5 taxonomic groups viz. Rotifera, Arthropoda, Palaemonidae, Ciliophora and Annelida. Rotifera was the most abundant group and Annelida was least represented groups.

Kumar and Khare (2015) studied diversity of plankton and their seasonal variations of density in the Yamuna River at Kalpi This study revealed that zooplankton were belong to 22 species of genera, Cladocera 5 species of 5 genera, Copepoda 2 species of 2 genera.Among recorded zooplankton Rotifera population was dominant during entire study span. Bislab and Kar (2016) studied Diversity of zooplankton in river Siang of Arunachal Pradesh, India. They estimated 24 different genera of zooplanktons among which Protozoa were represented by 5 genera, Rotifera by 7 genera, Cladocera by 5 genera, Ostracoda by 1 genus, and Copepoda by 5 genera. Bishnoi and Sharma (2016) studied Planktonic variations in a lotic water body of shri

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Ganganagar district, (Rajasthan) The zooplankton of gang canal comprises of 6 genera out of which 3 belong to the Rotifera, 2 to Cladocera and 1 to Protozoa. The zooplankton assemblage of the Gangcanal is contributed primarily by Cladocerans and Protozoans Rai *et al.*, (2016) Studied plankton composition, seasonal variation and diversity indices in river Narmada at Jabalpur region. Plankton diversity is one of the most important ecological parameters in water quality. The zooplankton comprises of Phylum Rotifera, Cladocera, Copepoda and Protozoa A total of 23 species of zooplanktons were recorded belonging to Rotifera 7 species, Cladocera 4 species, Copepoda 5 species and Protozoa 7 species. Chanchala *et al.*, (2017) studied zooplankton diveresty of river temari at Jabalpur district.They reported total 34 species of zooplanktons belonging to 6 species of Protozoa , 11 species of Rotifera, 6 species of Copepoda, 2 species of Ostracoda and 9 species of Cladocera. Robiul *et al.*, (2017) studied diversity indices of plankton communities in the river meghna of Bangladesh. Their study revealed zooplankton of Rotifer, Copepods, Cladocera, and Ostracoda as major groups. The highest number of genera was found in the family Copepoda and Cladocera

Conclusion: Above review of the literature on zooplankton showed that the Indian as well as foreign researches have made zooplanktons a subject for their studies and published both the good amount of research papers and books .The above description shows clearly that almost every part of the country has got perennial rivers and diversity of zooplanktons has been reported both taxonomically and ecologically. Even though the subject has been studied extensively yet many rivers and their accessory river are simply remain unstudied. This paper revels some of such pockets which should be studied and analyzed urgently.

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REVIEW ARTICLE

A CRICITAL EVALUATION OF LITERATURE ON ZOOPLANKTON RESEARCH IN INDIA

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ABSTRACT

Zooplankton is defined as drifting, ecologically important organisms that are an integral component of the food chain and also evaluate the ecological status of water bodies. Ecologically zooplankton are one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter. Zooplankton population is very useful indicator for biological, physical and chemical process of aquatic system because they are strongly affected by environmental conditions and respond quickly to changes in water quality. The most important types of zooplankton include the radiolarians, foraminiferans, dinoflagellates, cnidarians, crustaceans (including larvae), molluscs, polychaete larvae and chordates. Zooplankton are the intermediate link between phytoplankton and fish. Hence, diversity and seasonal variation studies of zooplankton are of great importance in water bodies. The present paper deals with the review of available published literature during the present century and that cover the diverse mention areas of zooplankton biology. The literature reviewed clearly suggests us to conclude that in spite of such a voluminous work done by many scientists, still there are some gaps in terms of geographical or biological aspects. Considering Rajasthan and Hadoti region specifically, many river systems need extensive study and it may be safely expected to find out some new genera species and this information can be utilized to solve food scarcity problems in the world.

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INTRODUCTION

Sivakumar *et al.* (2001) made qualitative and quantitative analysis of copepods and cladocerans of the freshwater bodies in and around Dharmapuri district of Tamil Nadu. They recorded four copepod species and seven cladoceran species. They also observed the higher population density of copepods and cladocerans in winter season than in the summer season. Das (2002) studied the dynamics of net primary production and zooplankton diversity in brackish water shrimp culture pond in southern part of Ganjam district, Orissa. Significant negative correlation was noticed between net primary production and zooplankton population. Copepods and rotifers were found to be the dominant groups among zooplankton. The zooplankton population varied with different seasons of the year with rainy and summer seasons showing the maximal density in zooplankton population. Ansia Anjana (2003) studied Physico-Chemical Profile and Plankton Diversity of Rankal Lake, Chhatarpur, M.P. The zooplankton was represented by 18 genera covering different groups. Saha (2004) studied Zooplankton diversity in five major coalfield areas in Jharkhand and revealed seventy species of zooplankton. Cladocerans and rotifers were dominant groups (nine species each) followed by seven species of copepoda and one species of ostracoda. The evenness (J) showed insignificant relationship with species diversity index (H'), while species richness (S) showed negative relationship with species diversity index values. The overall diversity of plankton was less due to high alkalinity of water which results due to fly ash deposition. Jha and Sulthana (2005) investigated the density of zooplankton in the River Ganga at Kanpur, India. They observed that the density of zooplankton was found to be high during summer and minimum in the monsoon season. Jayabhaye and Madlapure (2006) studied the zooplankton diversity in Parola Dam, Hingoli, Maharashtra and reported 29 zooplankton species, out of which 14 species belong to rotifera, five species belong to copepoda, three species belong to ostracoda and six species to cladocera. Mathivanan *et al.* (2007) studied plankton of river Cauvery water (Tamil Nadu). The qualitative and quantitative evaluation of the variation in river water showed high quantity of zooplankton population throughout the study period and rotifers formed dominated group over other group's organisms. This study revealed that the water of River Cauvery is highly polluted by direct contamination of sewage and other industrial effluents. Gaikwad *et al.* (2008) studied the diversity of zooplankton in the water bodies of North Maharashtra region. They recorded a total of 39 species including six species of copepods, five

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species of cladocera and eight species of rotifers. Rajashekhar *et al.* (2009) Zooplankton diversity of three freshwater Lakes with respect to trophic status from Gulbarga district, North East Karnataka and identified a total of 39 species of zooplankton. Dube *et al.* (2010a) investigated on Community structure of zooplanktonic groups of Kishore Sagar Tank. In this investigation they recorded total 36 species of zooplankton which belong to 7 groups. Dube *et al.* (2010b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and a total 60 species of plankton (twenty four species of phytoplankton and thirty six species of zooplankton) were recorded. Sharma and Mankodi (2011) studied the diversity of various types of plankton like, phytoplankton and zooplankton in Narmada River.

The phytoplankton were represented by Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae, out of which generic diversity of Bacillariophyceae was more. Sharma *et al.* (2012) studied fresh water Cladocera of South Rajasthan, India. This study shows cladocera are an important component of the crustacean zooplankton. Zooplankton samples from 77 different water bodies of South Rajasthan were analyzed to investigate the cladocera inhabiting these water bodies. During this study 54 species of cladocerans were reported, belonging to 6 families i.e. the Sididae, Daphnidae, Moinidae, Bosminidae, Macrothricidae and Chydoridae. It was noticed that rich nutrients, the presence of weeds and shallow waters favoured rich diversities of cladocerans. Negi and Mamgain (2013) studied Zooplankton diversity of Tons River of Uttarakhand State India. A total of 23 genera of zooplankton belonging to 7 major groups viz. Ciliphora, Cladocera, Copepod, Protozoa, Rotifera, Ostracod and Zooflagellata.

Priyanka Malhotra (2014) studied the variations in zooplankton population in relation to industrial effluents. Various pollution indicating physicochemical parameters have been correlated with zooplankton indicating the effect of DO, BOD and pH on zooplanktonic population and diversity. Zooplankton occurs in all water bodies and is of fundamental importance in nutrient recycling and regenerated primary production. Due to short life span and wide distributions of many zooplankton, these act as "ecological indicators." Kumar and Khare (2015) studied the analysis of diversity of plankton (i.e., phytoplankton and zooplankton) and their seasonal variation of density in the Yamuna River at Kalpi, District Jalaun, U. P.. Registered zooplankton were belong to 22 species of 16 genera of different groups like as protozoa (3 species of 3 genera), Rotifera (12 species of 6 genera), Cladocera (5 species of 3 genera) and Copepoda (2 species of 2 genera). Rotifera Population was dominant during entire study span. Shukla and Solanki (2016) studied the zooplankton composition, variation and diversity indices in River Narmada at Jabalpur region. Zooplankton diversity is one of the most important ecological parameters in water quality assessment and good indicator of the changes in water quality. Zooplankton formed important quantitative component of net plankton of the four parts; Protozoa dominantly contributed to their abundance while Copepoda> Rotifera> Cladocera> Ostracoda were sub-dominant groups. Due to their large density, shorter life span, drifting nature, high group or species diversity, different tolerance to the stress and often respond quickly to environmental change and water quality, zooplankton are being used as indicator organisms for the physical, chemical and biological process in the aquatic ecosystem. P.V. Krishna and Hemanth Kumar (2017) studied Seasonal Variations of Zooplankton Community in Selected Ponds at Lake Kolleru Region of Andhra Pradesh, India. A total number 16 species recorded with 9 Rotifera, 3 Cladocera and 4 Copepods. In the rotifers the genus Brachionus is the dominant group. Ecologically zooplankton is one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter. Manickam *et al.* (2018) studied impact of seasonal changes on zooplankton biodiversity was conducted in the Ukkadam Lake (Lat 10° 59' N and Long 76° 57' E), at Coimbatore city, Tamil Nadu, India. The population density of various group of zooplankton was observed, and it was found to be following order Rotifera > Copepoda > Cladocera > Ostracoda. The high and low population densities were recorded in summer and early monsoon season respectively. This higher zooplankton population density in summer might be due to the temperature acceleration in the Ukkadam Lake. It indicates that the temperature has influence on the zooplankton diversity. Therefore, increased temperature due to global climate change might have influence on the zooplankton production. Kamlesh Meena and Prahlad Dube (2018) studied A critical review of zooplankton of Lentic Water Bodies in India. Zooplankton are the plankton consisting animals and the immature stages of larger animals. Due to their large densities they are being used as the indicator organisms of physical, chemical, and biological process of aquatic system.

Conclusion

On the basis of above review we can say that a lot of work done by scientists on the zooplankton. So many species and genera names were keep changing. Favourable conditions increase their number so they considered as a useful indicator for the health of aquatic system. Still, it is expected to search many more genera and species of zooplankton in India.

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RESEARCH ARTICLE

A REVIEW ON SEASONAL VARIATION OF PHYTOPLANKTON IN LOTIC WATER

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ABSTRACT

Phytoplankton are microscopic free floating animals which play a vital role in aquatic ecosystem. Phytoplankton are highly sensitive to environmental variation, as a result change in abundance, species diversity or community composition can provide important indication of environmental health. Phytoplankton diversity is controlled by seasonal variation. In the present paper an extensive review of the literature available on seasonal variation of Phytoplankton in lotic water of India have been made which is a long felt necessity in this field.

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INTRODUCTION

Lotic refers to flowing water, it includes river, spring, streams etc. In lotic water flow is unidirectional and there is a state of continuous physical change and the biota is specialized to live with flow condition. Rivers are important system of biodiversity and are among the most productive ecosystems on the earth because of the favourable conditions that supports number of flora and fauna (Gupta *et al.*, 2005). Phytoplankton are the minute organism and are effective tools in environment biomonitoring of aquatic ecosystem. Unplanned urbanization, rapid industrialization, indiscriminate use of artificial chemical in agriculture causing aquatic pollution, which deteriorating quality and depletion of aquatic biota (Yeole and Patil, 2005).
In all kinds of aquatic eco-systems phytoplankton act as a good bio-indicator to reflect the quantity of water and is the important primary producers and control the dynamic of productivity. Phytoplankton forms the very basic link in the food pyramid of all aquatic animals (Rajagopal *et al.*, 2010).
Phytoplankton diversity is controlled by seasonal changes as well as by the rate at which plant nutrients are supplied. Nitrogen, Phosphorus and Silica are three main nutrients needed for the phytoplankton to grow at different times and in different ratio (Pillaiyta, 2005).

Planktonic population on which whole aquatic life depends is directly or indirectly governed by many biological conditions and tolerances of organisms to variations in one or more of these conditions. Very limited information is available on the Phytoplankton status and seasonal variation of phytoplankton in lotic waters. Thus the present paper deals with the review of seasonal Phytoplankton diversity.

Review

Venkateswarlu (1969) observed maximum population of chlorophyceae during winter in Moosi River, Hyderabad. Singh (1990) reported that Plankton population showed bimodal, pattern of fluctuation with one peak in pre winter and other in summer. The assessment of water quality using phytoplankton diversity and their association as biological indicators has been carried out by many workers (Chaturvedi *et al.*, 1999). Different species of plankton vary in different seasons due to the changes in Physico-chemical nature of water. The phytoplankton community shows high diversity with the seasonal fluctuation which indicates the diversity in ecological niches. Species richness was high in summer and winter and it was minimum during monsoon (Khanna *et al.*, 2012). Similar study was made by Carter *et al.*, (1980), Chakraborty *et al.*, (1959). Baghela (2006) observed the dominance of Chlorophyceae in Oligotrophic Lake Jawai Dam. McHugh (2005) reported Bacillariophyceae as dominant life forms in phytoplankton and largest group of biomass producer on earth. The total quantity of plankton present in waters may

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undergo marked and rapid variation, so that in the course of a year a number of pulses may succeed after each other. (Hutchinson and Bowen 1947) Seasonal variation of algal forms in lakes and rivers is presented by many researchers (Kaur et al., 2001, Jeroudha 2002, Tiwari and Chouhan 2006.) Dube et al., 2002b studied ecobiology of seasonal water bodies in south eastern plateau of Rajasthan. Assessment of physico-chemical and biological parameters serves a good index in providing particular status to a water body. Recently Phytoplankton of fresh water rivers have been studied in detail (Annalakshmi and Amsath 2012, Mishra et al., 2002, Jafari and Gunale 2006). Diatom diversity is the best indicator of altered water quality (Sczczepocka and Szulc 2009). Thirugnanamoorthi and Selvaraju (2009) has reported the maximum density of Cyanophyceae members during summer and minimum during winter and rainy seasons. It was noticed that density of Phytoplanktons was maximum in summer, minimum in rainy season and intermediate in winter season. He reported abundant count of Bacillariophyceae in monsoon season which was lowered in premonsoon.

Dube et al., (2009a) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and twenty four species of phytoplankton were recorded. In warm climates, Cyanobacteria dominance is most pronounced during the summer months, which coincides with the period when the demand for recreational water is highest (Srivastava et al., 2010). Hasan et al., (2010) observed minimum density of Phytoplankton during monsoon and maximum during summer. Shinde et al., (2012) have noticed maximum number of Chlorophyceae in summer and minimum during monsoon season. He recorded maximum genera of Euglenophyceae and Bacillariophyceae during summer and minimum during monsoon. Alam (2013) reported 30 species of different groups of Phytoplanktons from the Yamuna River at Kalpi. Population of Chlorophyceae were maximum during summer and minimum during monsoon season. Sarwade and Kamble (2013) stated Plankton diversity and seasonal variation in Krishna River, Maharashtra. He reported 5 groups of phytoplankton i.e. Cyanophyceae, Bacillariophyceae, ,Chlorophyceae, Hydrocharitaceae and Desmidiceae including 53 species . This study showed that planktonic population was maximum in post monsoon season as compared to premonsoon season. Panchali et al., (2013a) stated mathematical modeling of nutrient quantity of a fresh water pond, Kota, Rajasthan with special reference to seasonal variation of planktons.

Bhatnagar and Bhardwaj (2013) reviewed algal biodiversity status in Chambal River at Kota Barrage. They studied the presence of a total 65 algal species including Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. Class Cyanophyceae were dominant showing seasonal variation with maximum taxa in summer season and minimum in rainy season. Seasonal distribution of members of Bacillariophyceae followed maximum in winter and minimum in monsoon. This is in accordance with the observations made by Nautiyal (1996) and Pareek et al., (2011). Sharma et al., 2013 detailed on benthic fauna of Kishore Sagar reservoir, Kota, Rajasthan. Panchali et al., 2014 given mathematical model for phytoplankton growth. Kumar and Khare (2015) studied diversity and seasonal variation of Phytoplanktons in the Yamuna River at Kalpi. They reviewed 38 species of 25 genera of Phytoplanktons belonging to Chlorophyceae, Euglenophyceae, Bacillariophyceae and Cyanophyceae.

Belkhode and Sitre (2016) studied Phytoplankton diversity of Dham River in Wardha. He reported 36 different species of phytoplankton represented by 6 different classes chloro phyceae, Euglenophyceae, Desmidaceae, Cyano phyceae, Bacillariophyceae and Hydrocharitaceae. The density of phytoplankton is abundant in summers due to prevailing and suitable water conditions in Dham river. Solanki and Shukla (2016) studied Phytoplankton diversity and their seasonal variation in Narmada River Valley of Jabalpur Region. He identified 30 algal taxa belonging to 16 genera including Chlorophyceae, Euglenophyceae, Bacillariophyceae, Trebouxiophyceae, Ulvophyceae, Zygnematophyceae and Cyanophyceae. The maximum phytoplankton population found in post monsoon. In monsoon season the population was low. Species of Chlorophyceae were maximum in early summer and the species of Cyanophyceae were highest in late summer. Few species of Euglenophyceae were observed in early winters and Bacillariophyceae were dominated during late winter (Mathur 1990). Meena and Dube 2017 studied important role of microorganisms in dealing Environment Problem.

Conclusion

Concluding the above account we can state that Phytoplanktons are popular organisms found in fresh water resources.They are important part of aquatic food chain and food webs and proven to be very good indicators about the water quality. In the above account it has been observed that studies were reported regarding their diversity and seasonal variation. Thus seasonal variation of phytoplanktons study is a very important tool in limnology.

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Review Paper

A Critical Review on the Studies of Phytoplanktons in Lotic Water of India

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Abstract
Phytoplanktons are microscopic free floating animals which play a vital role in aquatic ecosystem. They are highly sensitive to environmental variation, as a result change in abundance, species diversity or community composition can provide important indication of environmental health. In the present paper an extensive review of the literature available on Phytoplanktons in lotic water of India have been made which is a long felt necessity in this field.

Key Words: Diversity, Pollution, Phytoplanktons, Lotic water, Environment.

Introduction

Lotic refers to flowing water, it includes river, spring, streams etc. In lotic water flow is unidirectional and there is a state of continuous physical change and the biota is specialized to live with flow condition. Rivers are important system of biodiversity and are among the most productive ecosystems on the earth because of the favourable conditions that supports number of flora and fauna (Gupta *et al.*, 2005). Planktons are diverse group of organism with feeble lcomotors that live in the water column of water bodies that cannot swim against a current (Dube 2005). The study of plankton is very useful tool for the assessment of biotic potential and contributes to overall estimation of biotic nature and general economic potential of water bodies (Pawar *et al.*, 2006).

Phytoplanktons

These are microscopic creatures mainly algae contain chlorophyll and live near the surface of water where there is sufficient light, producing their own food and thus providing meals for countless other aquatic dwellers. They play important role in maintaining the equilibrium between living organism and abiotic factors. The density and diversity of phytoplanktons and their association as biological indicator is significant in the assessment of water quality. Phytoplanktons are good indicator of environmental changes and their variation provides a ground for monitoring and assessing the strategies of the river management.

Review

Margalef (1968) suggested that phytoplanktons population in fertile water is more diverse than those in infertile water. Odum (1971) stated that phytoplanktons are the primary producers for the entire aquatic body and comprises the major portion in the ecological pyramids. Reddy and Venkateswarlu (1986) investigated impact of pulp and paper mill on the abudance of algae in the River Tungabhadra. They observed that in the effluent channel algae were present in very low numbers. After the effluent were discharged in the river, blue green algae made their appearance in good number. Nandan and Patel (1984) has showed the algal genera, *Euglena, Oscillatoria, Scenedesmus, Navicula, Nitzschia and Microcystis* are the species found in originally polluted waters. Narendra *et al.*, (1990) revealed that due to the pollution, phytoplanktons population is affected and leading to drastic change in the food chain of the fresh water environment. Mukherjee and Pankajakshi (1995) assessed the impact of detergents on plankton in freshwaters. They observed that *Microcystis* was tolerant species to the toxic effects of detergents. Sarojini (1996) observed that high turbidity, pH, bicarbonate, orthophosphate, alkalinity, chloride may be responsible for the Cyanophycean growth and bloom.

Sunder (1996) assessed the planktonic community of Kumaon Himalayan River Gaula. They investigated that the diatoms formed the major group among the total phytoplanktons. Kalavati *et al.*, (1997) studied phytoplanktons occupy the functional and basic significance in the overall food web. Mishra and Tripathi (2002) showed that phytoplanktons are ecologically significant as they form the basic link in the food chain of all aquatic animals. Hambright and Zohary (2000) revealed that phytoplanktons are one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change.

Begam and Khan (2002) checked the impact of the pollution of River Burhi Gandak on plankton, Bihar. They noticed a decrease in water temperature while dissolve oxygen concentration and number of phytoplanktons was dropped in summer. Dube(2005) has studied physicochemical characteristics of semi-permanent pond at Baran Rajasthan, India. The plankton study is very useful tool for the assessment of biotic potential and contributes to overall estimation of basic nature and general economic potential of water body. (Pawar *et al.*, 2006)

Joshi (2005) observed the phytoplanktons population in the River Sutlej of western Himalayas, was changes with the floods. He stated that the dilution effect of floods not only reduced the plankton-density but also lowered the organic carbon productivity.

Mathivanan *et al.*, (2007) studied plankton of River Cauvery water (Tamil Nadu), the qualitative and quantitative evaluation of the variation in river water showed high quantity of phytoplanktons belonging to Chlorophyceae, Bacillariophyceae, Myxophyceae and Euglinae. This study revealed that the water of River Cauvery is highly polluted by direct contamination of sewage and other ndustrial effluents.

Desai *et al.*, (2008) studied Phytoplanktons diversity in Sharavati River basin, Central Western Ghats. During this study total of 216 pecies of 59 genera belonging to Bacillariophyceae, Desmidials, Chlorococcales, Cynophyceae, Dinophyceae, Euglenophyceae and Chrysophyceae were recorded. Various pollution indices showed the oligotrophic nature of the reservoir waters with slight organic ollution in stream waters.

Mishra *et al.*, (2008) studied that in fresh water ecosystems primary productivity by phytoplanktons involves trapping of radiant nergy and its transformation into high potential biochemical energy by photosynthesis, using inorganic materials of low potential nergy.

hekhar *et al.*, (2008) studied water quality status of River Bhadra receiving Mysore paper mill and iron and steel mill effluent. A total 45 species of phytoplanktons belonging to 5 classes were recorded. This study showed phytoplanktons diversity. It did not show the me type of water quality. This study showed the need of phytoplanktons community as index of water quality polluted by industrial fluents at the downstream of the Bhadra River.

ube *et al.*, (2010b) have studied the occurrence and seasonal variation of the plankton in Kishore Sagar Tank, Kota, Rajasthan and enty four species of phytoplankton were recorded.

nalakshmi and Amsath (2012) studied phytoplanktons diversity of River Cauvery. He reported 68 species of phytoplanktons mprising Cholrophyceae 33.82%, Bacilleriophyceae 27.94%, Cyanophyceae 32.35% and Euglenophyceae 5.88%.

rdous *et al.*, (2012) studied phytoplanktons diversity in River BuriGanga. He estimated 27 genera of phytoplanktonss belonging to e families viz. Cyanophyceae, Bacillariophyceae Chlorophyceae, Euglenophyceae and Cryptophyceae.

anna *et al.*, (2012) studied the analysis of water samples for plankton diversity of river Ganga, In this study of River Ganga, the ytoplanktons diatoms were dominated and class Blue green algae was found.

yam *et al.*, (2012) studied water chemistry and phytoplanktonic variation of Kalisil River, district Karuli. This study revealed ctuations in the various physico-chemical properties of water in different seasons. A total of 36 algal genera with 60 species onging to four class have been accounted viz Chlorophyceae(23species) , Cyanophyceae(20species) Bacillariophyceae (13 cies) and Euglenophyceae(13 species).

ha Summarwar (2012) investigates the plankton diversity in Thadoli area of Bisalpur reservoir. During this study the most lution tolerant species of *Oscillatoria,Euglena* and *Navicula* were recorded. Only 4 groups of Phytoplanktons belonging to orophyceae (22 species), Euglenophyceae (7 species) ,Bacillariophyceae(7 species) and Cyanophyceae (12 species) were orded.

tnagar and Bhardwaj (2013) studied the seasonal algal diversity and the physico-chemical properties of water of Chambal River. s study shows the presence of a total of 65 algal species. Some algal forms are good indicators of water pollution and their sence show signs of water pollution.The algal forms consisted of a total of 65 taxa belonging to Chlorophyceae(32 cies),Cyanophyceae(18 species), Bacillariophyceae (12 species), and Euglenophyceae (3 species). Negi and Rajput (2013) studied toplanktons Community Structure in Ganga River at Bijnor. They reported 43 genera of phytoplanktons belonging to 5 groups viz. orophyceae 16 genera, Bacillariophyceae 12 genera, Cyanophyceae 10 genera, Euglenophyceae 4 genera and Xanthophyceae 1 nera. Chlorphyceae exhibited maximum abduance and genera diversity and Xanthophyceae exhibited minimum abudance and genere diversity.

Komala *et al*., (2013) studied plankton diversity and abundance of Arkavathi River. It was assessed before and after pollution. Plankton diversity and abundance varied during different seasons, both at non-polluted and polluted sites. A total of 71 species of phytoplanktons were recorded belonging to Myxophyceae(36 species), Bacillariophyceae(13 species), Euglenophyceae (5 species), Chlorococcales (6 species) and Desmidiceae (11 species). Singh, P (2013) studied biodiversity of River Gomti which is heavily affected by pollution. Planktons are important biological parameters to access the pollution level. This study shows biological productivity as ecological indicator to identify the ecological quality of River Gomti. The phytoplanktons density fluctuated maximum during monsoon season and minimum during winter season. Phytoplanktons consists of the members of Chlorophyceae (7 species), Bacillariophyceae (5 species),Cyanophyceae (4 species) and Euglenophyceae (1 species).

Subhashree and Patra (2013) studied phytoplanktons of River Mahanadi of Odisha. This study revealed that diversity of species Chlorophyceae 53.45% whereas Cyanophyceae 20.78% and Bacillariophyceae 25.77% were composed.

Mukati *et al*., (2014) studied phytoplankton-ecology in Narmada River of West Nimar, MP, and India. Ten species of phytoplanktons have been collected from various freshwater habitats in the West Nimar. This study revealed Cyanophyceae has a dominant class. Phytoplanktons belonging to Cyanophyceae (4 species), Charophyceae (3 species), Trebouxiophyceae(1), Ulvophyceae(1), Zygnematophyceae(1) were reported from River Narmada.

Ekpo *et al*., (2015) studied plankton abduance and diversity in great KWA, River, Nigeria. He revealed a total of 26 species and 574 phytoplanktons individuals belonging to 4 families.The family represented were Bacillariophyceae 49.83%, Chlorophyceae 21.25%, Chrysophyceae 16.55% and Cyanophyceae 12.37%. Hossain *et al*., (2017) studied diversity of plankton communities in the River Meghna. He reported Chlorophyceae with 16 genera, Dinophyceae with 2 genera, Bacillariophyceae with 13 genera, Cyanophyceae with 2 genera, Myxophyceae with 5 genera, Englenophyceae with 1 genera and Xanthophyceae with 2 genera.

Conclusion

Concluding the above account we can state that Phytoplanktons are popular organisms found in fresh water resources.They are important part of aquatic food chain and food webs and proves to be very good indicators about the water quality.In the above account it has been observed that studies were reported regarding their diversity impact of pollution and toxic materials.Thus phytoplanktons study is a very important tool in limnology.

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Annexure-2

Seminar Attended

LIST OF CONFERENCES/ SEMINARS/ WORKSHOPS ATTENDED

1. ESW VII Annual National Research Conference on "Climate Change and Global Health Management" February 01-02, 2020 Organised by ESW Society, Khajuraho (M. P.) in Collaboration with Shri Krishna University, Chhatarpur and Society of Life Sciences, Satna.

2. National Conference on "Recent Trends in Environmental Sustainability and Green Practices" November 15-16, 2019 Organized by Department of Botany, Government College, Bundi (Rajasthan) in Collaboration with the Society of Life Sciences Satna (M. P.).

3. The International Conference on "Environmental Stresses and Ecological Challenges" February 24-26, 2019 Organized by Shri Krishna University, Chhatarpur, Madhya Pradesh, India.

4. National Seminar on "Folk History Tradition and Historical Sources in India with Special Reference to Genealogical Studies" April 14-15, 2018 Organized by School of Heritage, Genealogy Research, Kota University, Kota with the Support of Indian Council of History and Research, New Delhi.

5. National Seminar on "Science, Spirituality and Vivekananda" September 19-20, 2017 Organized by Swami Vivekananda Shodhpeeth, Kota University, Kota.

6. A Workshop on "Academic Ethics and Integrity" July 27, 2017 Organized by the Internal Quality Assurance Cell, University of Kota.

Reg. No. SC2707/2K M.P. Govt. Firms & Society Act [illegible] by NITI Aayog, Government of India.

Environment & Social Welfare Society
Khajuraho, India

Organized

ESW VII

ANNUAL NATIONAL RESEARCH CONFERENCE 2K20

"Climate Change and Global Health Management"

In association with
The National Academy of Sciences India, Bhopal Chapter (M.P.)
Zoological Survey of India, Ministry of Environment, Forest and Climate Change
Govt. of India.
Godavari Academy of Science and Technology, Chhatarpur (M.P.)

CERTIFICATE

It is certified that Ms./Mr./Dr. JYOTI SHARMA
Designation PhD Scholar Institute/College/University University of Kota (Rajasthan) participated in The ESW VII Annual National Research Conference organized by ESW Society, Khajuraho (M.P.) in Collaboration with Shri Krishna University, Chhatarpur and Society of Life Sciences, Satna on "Climate Change and Global Health Management" on 01 & 02 February, 2020 as Chairman/Co-chairman/Rapporteur/Delegate/ Invitee Guest and presented paper/poster entitle Seasonal Variation of Phytoplankton in Chandloi River, dis. Kota, Rajasthan.

We wish him/her all success in life.

Dr. Brajendra S. Gautam	Dr. Shivesh P. Singh	Dr. Ashwani K. Dubey
Chancellor	Secretary	President & Organizing Secretary
Shri Krishna University, Chhatarpur	Bhopal Chapter, NASI	ESW Society, Khajuraho

National Conference

on

Recent Trends in Environmental Sustainability and Green Practices

(RTESGP-2019)

November 15-16, 2019

CERTIFICATE

This is to certify that Prof. / Dr. / Ms. JYOTI SHARMA

of Govt. College, Kota

has participated in the National Conference organized by **Department of Botany, Government College, Bundi (Rajasthan)** in collaboration with **The Society of Life Sciences Satna (M.P.)** as a ~~Keynote Speaker~~ / ~~Chairperson~~ / ~~Invited Speaker~~ / Oral Paper Presenter / ~~Poster Presenter~~ / ~~Delegate.~~ The title of his / her research paper was Seasonal Variation of Rotifers in Chandloi River, District Kota Rajasthan

His / her particpation was highly appreciated.

Dilip K. Rathore	S.M. Meena	O.P. Sharma	Prahlad Dubey	J.K. Jain
Organizing Secretary	Co-Ordinator	Convener	Chairman	Patron

SHRI KRISHNA UNIVERSITY

CHHATARPUR - MP - INDIA

Certificate

This is to certify that Prof./Dr./Mr./Ms./Mrs. Jyoti Sharma

University/College/Institute University Of Kota (Rajasthan)

has participated in The International Conference on "Environmental Stresses and Ecological Challenges" from 24th to 26th February, 2019 organized by Shri Krishna University, Chhatarpur, Madhya Pradesh, India as Chairman/ Co-Chairman/ Rapporteur/ Invitee Guest/ Deligate and Presented Paper/ Poster entitled On the Impact of Tilapia in River Water.

Dr. B. S. Gautam
Chancellor/Chief Patron

Dr. Govind Singh
Vice- Chancellor/Patron

Prof. Ashwani Kumar Dubey
Organizing Secretary

स्कूल ऑफ हेरीटेज, वंशावली शोधपीठ, कोटा विश्वविद्यालय, कोटा

राष्ट्रीय संगोष्ठी

"भारत में लोक इतिहास परम्परा एवं ऐतिहासिक स्त्रोत - वंशावली लेखन अध्ययन के विशेष संदर्भ में"

वैशाख कृष्ण त्रियोदशी एवं चतुर्दशी (विक्रम संवत 2075)

14-15 अप्रैल, 2018, शनिवार एवं रविवार

(सौजन्य : भारतीय इतिहास एवं अनुसंधान परिषद्, नई दिल्ली)

प्रमाण-पत्र

प्रमाणित किया जाता है कि श्री/सुश्री/श्रीमती/डॉ. ज्योति शर्मा शोधार्थी

कोटा विश्व विद्यालय कोटा ने स्कूल ऑफ हेरीटेज, वंशावली शोधपीठ, कोटा विश्वविद्यालय, कोटा द्वारा आयोजित "भारत में लोक इतिहास परम्परा एवं ऐतिहासिक स्त्रोत-वंशावली लेखन अध्ययन के विशेष संदर्भ में" विषयक दो दिवसीय राष्ट्रीय संगोष्ठी में विषय विशेषज्ञ/ सत्राध्यक्ष / मुख्य अतिथि/आमंत्रित वक्ता/पत्र-प्रस्तोता ✓ के रूप में भाग लिया और A critical evolution of literature on Zooplankton Research in India शीर्षक से शोध पत्र प्रस्तुत किया।

के.आर. चौधरी
आयोजन सचिव, राष्ट्रीय संगोष्ठी - 2018

डॉ. एम. एल. साहू
समन्वयक, राष्ट्रीय संगोष्ठी - 2018

स्वामी विवेकानन्द शोधपीठ, कोटा विश्वविद्यालय, कोटा

राष्ट्रीय संगोष्ठी

"विज्ञान, आध्यात्म एवं विवेकानन्द"

(SSV-2017)

19 - 20 सितम्बर 2017

(चतुर्दशी - अमावस्या, कृष्ण पक्ष, अश्विन माह, विक्रम सम्वत् 2074)

आयोजक

सह आयोजक

प्रमाण-पत्र

प्रमाणित किया जाता है कि सुश्री/श्रीमती/श्री/डॉ./प्रो. Jyoti Sharma

संस्था University of Kota, Kota. ने

"विज्ञान, आध्यात्म एवं विवेकानन्द" विषय पर आयोजित दो दिवसीय राष्ट्रीय संगोष्ठी में आमंत्रित वक्ता/प्रतिनिधि/प्रतिभागी के रूप में दिनांक 19-20 सितम्बर 2017 को भाग लिया एवं शोध पत्र हेतु आमंत्रित व्याख्यान/मौखिक/पोस्टर द्वारा विषय .... पर प्रस्तुतीकरण किया।

डॉ. एन. एल. हेड़ा
आयोजन सचिव

डॉ. संदीप सिंह चौहान
कुलसचिव

डॉ. भवानी सिंह
संयोजक

A

WORKSHOP

ON

ACADEMIC ETHICS AND INTEGRITY

(JULY 27, 2017)

Internal Quality Assurance Cell

University of Kota

Kota, Rajasthan

CERTIFICATE

This is to certify that Dr. / Mr. /Ms.......Jyoti Sharma..........................

from.......University of Kota.........has participated / presented

a paper/ delivered invited talk entitled........–..in

the WORKSHOP ON *ACADEMIC ETHICS AND INTEGRITY* organized

by the Internal Quality Assurance Cell, University of Kota on July 27, 2017.

Member Secretary, IQAC

Director, IQAC