International Journal of General Medicine and Pharmacy (IJGMP)
ISSN (P): 2319–3999; ISSN (E): 2319–4006
Vol. 11, Issue 2, Jul–Dec 2022; 1–22

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

"STUDY ON THE DENSITY OF PHYTOPLANKTON'S AND ZOOPLANKTONS' OF BICHHIYA RIVER WATER"

***Priyanka Bharti*[1] *& Sandhya Sharma*[2]**

[1]*Research Scholar, Govt. Model Science College, Rewa, Madhya Pradesh, India*

[2]*Assistant Professor, Govt. College Patharia, Madhya Pradesh, India*

ABSTRACT

Present study is centralize on Bichhiya River at Rewa which is one of the main tributaries of Beehar River The aim of this study was to ascertain the impact of several Biological parameters on water quality of Bichiya River and to assess further its nature in terms of microbial growth. Effective microbes can completely degrade and oxidizes toxic organic compounds; are characterized by low cost and offer the possibility of in-situ treatment. the water have been analyzed at the sampling site itself., Dissolved oxygen, COD, BOD, phytoplankton and Zooplankton are studied from the water sample in accordance with the procedures described in standard methods for the examination of water.

KEYWORDS: *Bichhiya River, Biological Parameters, Water Pollution, Phytoplankton and Zooplankton*

Article History

Received: *24 Jun 2022* **|** ***Revised:*** *27 Jun 2022* **|** ***Accepted:*** *15 Jul 2022*

INTRODUCTION

Freshwater resources are used for various purposes like, agriculture, industrial, household, recreational, environmental activities, etc. In fact the fresh water resources are very precious for the life on our planet. The water quality of rivers may vary with the seasons and geographical areas. During present time, most of rivers of world receive million liters of sewage, domestic waste, industrial and agricultural effluents containing from simple nutrients to highly toxic substances which are the most significant causes of pollution of aquatic ecosystem. Water resources in India have reached a point of crisis due to unplanned urbanization and industrialization. The increasing anthropogenic activities in recent years in aquatic ecosystem and their catchment areas have contributed to a large extent to deterioration of water quality. The number of dams, reservoirs, tanks, etc, has significantly increased in last few years. The development of fisheries in these fresh water resources needs to be increase through the scientific development. The quality of water should be checked at regular intervals to prevent deterioration of water quality and to maintain aquatic biota.

Water pollution is generally indicated by the presence of harmful and harmless microbes. Microbial examination of water is a direct measurement of deleterious effects of pollution. Most probable number is the most common microbial parameter for the sanitary analysis of water. The test is used to detect coliforms, a group comprising of all the aerobic and facultative anaerobic, Gram negative, non-spore forming and rod-shaped bacteria. These inhabit the intestines of all warm-blooded animals. The discharge of waste water from municipal sewers containing human faecal matter is hazardous to human health. Faecal contamination was routinely detected by microbiological analysis (Nogueira et al., 2003). The aim of

this study was to ascertain the impact of several physico-chemical parameters on water quality of Bichiya River and to assess further its nature in terms of microbial growth. Assessment of water quality is done to analyses the physical, chemical and biological characteristics of water (Kazi et al., 2009). Micro biota (typically, heterotrophic bacteria and fungi) use to degrade or transform hazardous contaminants to materials such as carbon dioxide, water, inorganic salts, microbial biomass, and other by - products that may be less hazardous than the parent materials. On the other hand, the bioremediation was advanced rapidly from 1990. Bioremediation is considered as one of many advantages, such as reduced cost, low environmental influence, no secondary pollution or pollutant movement, reducing pollutant concentration by the maximum extent, available for the sites where regular pollution treatment technology is difficult to be applied (Mingjun et al., 2009). Microorganism's enzymatic ally attacks the pollutants and converts them to harmless products and uses the contaminants as nutrient or energy sources. Bioremediation activity through microbe is stimulated by supplementing nutrients (nitrogen and phosphorus), electron acceptors (oxygen), and substrates (methane, phenol, and toluene), or by introducing microorganisms with desired catalytic capabilities.

Organic pollutants from industrial waste water from pulp and paper mills, textiles and leather factories, steel foundries and petrochemical refineries are a major cause of illness in parts of the world where regulations do not necessarily protect the people from such industrial outflows. The EM approach to water purification could help in preventing diseases and poisoning for potentially millions of people. Use of EM is considered to be economical, energy efficient and environmental friendly with minimal disposal problems. Effective microbes can completely degrade and oxidizes toxic organic compounds; are characterized by low cost and offer the possibility of *in-situ* treatment.

Effective monitoring of physicochemical and microbiological parameters can prevent river water pollution (Chandra et al. 2006), and this type of initiative has a special significance to protect human health from water pollution (APHA 1981). Indicator bacteria, such as total coliform (TC) and fecal coli forms (FC), are useful for the assessment of fecal pollution (APHA 1995). Detailed knowledge of fecal pollution in aquatic environments is crucial for maintaining healthy water body for recreational and economic purposes (Farnleitner et al. 2001). Concentrations of heterotrophic bacteria and *Vibrio cholera* can be a threat together with increasing water temperatures and decomposition of organic in Bichhiya River at Rewa. That can cause cholera disease through the faster growth rate of this pathogen in aquatic environments (Koelle et al. 2005).

Study Site

Present study is going to centralize on Bichhiya river Rewa which is one of the main tributaries of Beehar River. Its location in Rewa district is 24°10' latitude North and 81°15' longitude East. The river tehsil village of Gurh Tehsil and joins the Beehar river at Rajghat behind Rewa fort. At the upstream of the Bichhiya River, municipal water treatment station is situated. During their flow in township, industrial, domestic and municipal discharges merge into it at different points. The water of the river is used by urban and peripheral rural population directly at many stations for domestic and agriculture uses.

The climate of this area is seasonal. Three seasons namely rainy, winter and summer are recognized in a year. The average rainfall of this region was recorded 1012 mm/year. A minimum 2°C and maximum 46°C air temperature were recorded in some days of January and May respectively. The relative humidity fluctuated between 42.0 to 84.0% at 0830 hrs during study period.

Sampling Site

Four sampling stations namely A, B, C and D were selected for the physico-chemical and biological analysis during study period. The samples of water were collected at monthly interval between 8 AM to 11 AM.

METHODOLOGY

Water samples were taken from the different selected sampling stations from the January 2018 to December 2019. Samples were taken in the middle hours of the day. Some physical parameters of the water have been analyzed at the sampling site itself. For analysis of other physic-chemical and biological characteristics such as pH, Alkalinity. Turbidity, Conductivity, Dissolved oxygen, COD, BOD, phytoplankton and Zooplankton were analysis in the laboratory.

Physico-chemical of the water samples were done in accordance with the procedures described in standard methods for the examination of water and waste water (APHA, 1985), practical methods in water ecology and environmental sciences (Trivedi et al., 1987).Water quality in warm water fish pond (Boyd, 1981) and Work Book on Limnology (Adoni et al., 1985).

OBSERVATION

Water Temperature

The atmospheric temperature was observed always to be higher than water temperature. The air temperature was recorded between 12.6°C to 42.1°C during January 2018 and December 2019. The mean values of water temperature were recorded between 19.35 to 29.43°C during first year and between 19.78±28.65°C during second year of study period. The mean ±SD values of water temperature were noted as 25.89±3.46°C and 25.83±3.10°C during first and second years of study period respectively. During the present study, the range of water temperature was recorded between 19.05°C (January) to 32.60°C (May) and 19.80°C (January) to 32.90°C (May) during first and second years of study period respectively. The minimum temperature was observed in winter season and maximum in summer season.

Transparency (Light Penetration)

Transparency was measured with the help of Secchi disc. The maximum transparency was observed in the month of November and minimum in the month of July. During present study, the mean values of transparency varied between 28.50 to 72.80 cm during 2018 and between 29.60 to 74.00 cm during 2019. The minimum transparency was observed in the month of July (rainy season) and maximum in the month of November (winter season) in Bichhiya River Rewa (M.P.). The mean ±SD values of transparency were recorded as 55.78±15.41 cm and 55.65±14.79 cm during first and second years of study period respectively. Transparency was more or less constant and high during winter season and showing decreasing trend in rainy season.

pH (Hydrogen ion Concentration)

pH was determined with the help of pH meter. The Bichhiya river water was observed slightly alkaline in nature. The mean values of river water varied between 7.20 to 8.80 and 7.30 to 8.70 with a mean ±SD values of 7.81±0.41and 7.83±0.38 during first and second years of study period respectively. The minimum pH was observed in the month of July and maximum in the month of May during both study years.

Dissolved Oxygen (mg/l)

Dissolved oxygen was observed to be maximum during winter season and minimum in summer months. During present study, dissolved oxygen minimum and maximum values of fluctuated between 5.20 to 7.80 mg/l and 5.30 to 7.80 mg/l at different stations during first and second years of study time. The minimum values of dissolved oxygen were recorded in the month of May and maximum in the month of January during study period. Dissolved oxygen was observed with a mean ±SD value of 6.41±0.72 mg/l during first year between [160] with a mean ±SD value of 6.48±0.70 mg/l during second year of study period.

Electrical Conductivity (µmhos/cm)

Conductivity is a measure of its ability to carry an electric current. It is also an indicator of ionic composition of water. The rainfall and biodiversity changes the ionic composition of water. The minimum and maximum values of electrical conductivity varied between 128.00 µmhos/cm to 220.00 µmhos /cm during the year 2018 and between 225.00 µmhos/cm to 234.00 µmhos /cm during the year 2019 of study period. Conductivity was observed with a mean ±SD value of 170.39±24.60 mg/l during first year between with a mean ±SD value of 170.95±25.96 mg/l during second year of study period. The minimum values of conductivity were recorded in the month of April and maximum in the month of September during study period.

Biological Oxygen Demand (B.O.D.) (mg/l)

BOD values were recorded higher during rainy months and lower during summer season. The mean values of BOD varied between 4.30 to 8.75 mg/l during first year and between 4.25 to 8.58 during second year of study period. The mean ±SD values of BOD were observed 5.40±1.21 mg/l and 5.20±1.20 mg/l during first and second years of study period respectively.

Chemical Oxygen Demand (mg/l)

COD is used to measure the pollution strength of domestic and industrial wastes. The mean values of COD have been found to fluctuate between 18.30 to 39.60 mg/l during 2018 and between 18.40 to 39.50 mg/l during 2019; with a mean ±SD values of 28.30±5.49 mg/l and 28.30±5.36 mg/l during first and second years of study period respectively. The minimum values of COD were recorded in the month of January and maximum in the month of July during study period.

1. Winter Season (Nov 2018 to February 2018 and November 2019 to February 2019

December 2019 are represented in (Table No.-1)

Chlorophyceae

The mean density of Chlorophyceae were recorded between 5.95 org/l to 49.50 org/l and between 7.15 org/l to 50.70 og/l during winter season of first and second years of study period respectively. The minimum density was recorded for *Genicularia sp.* and maximum for *Cosmarium sp.* during both study years. Some members of this group also showed better density as *Chlorella sp.* (38.75 org/l), *Botryococcus sp.* (34.28 org/l) and *Chara sp*. (31.35 org/l) during first year and again *Chlorella sp*. (39.95 org/l), *Botryococcus sp*. (35.48 org/l) and *Chara sp*. (32.55 org/l) during second year of study period. The total minimum and maximum density of Chlorophyceae fluctuated between 343.5 org/l (station B) to 347.8 org/l (station A) with an average total density of 346.31 org/l during first year and between 361.5 org/l (station B) to 367.90 org/l (station C) with an average total density of 364.31 org/l during second year of study period.

Cyanophyceae

Among the 11 species of Cyanophyceae, the minimum average density was recorded for *Oscillatoria sp.* (11.30 org/l) and maximum average density for Coelosphaerium *sp.* (36.63 org/l) org/l during first year. During second year of study period, the average minimum and maximum density fluctuated between 12.50 org/l (*Oscillatoria sp*.) to 37.83 org/l (*Coelosphaerium sp*.). The appreciable density of this group was observed for *Microcystis sp*. (34.33 org/l and 35.53 org/l) followed by *Anacystis sp*. (27.63 org/l and 28.83 org/l) and *Spirulina* sp. and *Rivularia sp*. (26.68 org/l and 28.18 org/l) during first and second years of study period respectively. The total density of this group was recorded as 252.5 org/l for station A, 245.3 org/l for station B, 241.4 org/l for station C and 244. org/l for station D with an average density of 246.05 org/l during first year and 266.0 org/l, 258.8 org/l, 254.9 org/l and 258.4 org/l at stations A, B, C and D respectively with an average density of 259.55 org/l during winter season of year 2019 of study period.

Bacillariophyceae

The minimum and maximum density of Bacillariophyceae varied between 15.10 org/l (*Cyclotella sp*.) to 69.65 org/l (*Navicula indica*) during first year and between 16.30 org/l (*Cyclotella sp.*) to 70.85 org/l (*Navicula indica*) during second year of study period. Some other members of this group also showed appreciable density as *Navicula pulpa* (32.58 org/l and 33.78 org/l) followed by *Gyrosigma sp.* (23.70 org/l and 24.90 org/l) and *Cyclobella affinis* (21.83 org/l and 23.03 org/l) during first and second year of study period respectively. The total density of this group was recorded as 291.60 org/l, 305.5 org/l, 285.4 org/l and 298.9 org/l at stations A, B, C and D respectively with an average density of 295.37 org/l during first year of study period. During the year 2019 of study period, the total density of this group was recorded as 304.8 org/l at station A, 318.7 org/l at station B, 298.6 org/l at station C and 312.1 org/l at station D with an average density of 308.57 org/l.

Euglenophyceae

Among the two members of Euglenophyceae, the minimum density was recorded for *Phacus sp*. (20.53 org/l and 21.73 org/l) and maximum for *Euglena sp*. (21.70 org/l and 22.90 org/l) during first and second years of study period respectively. The total density of this group fluctuated between 36.8 org/l (station A) to 53.68 org/l (station D) with an average density of 42.22 org/l during first year and between 36.7 org/l (station B) to 53.68 org/l (station D) with an average density of 42.22 org/l during first year and between 39.1 org/l (station B) to 56.08 org/l (station D) with an average density of 44.63 org/l during winter season of second year of study period.

2. Summer Season (March 2018 to June 2018 and March 2019 to June 2019)

The density of phytoplankton observed during summer season of both study years are represented in

Chlorophyceae

The average density between different members of Chlorophyceae varied between 14.98 org/l to 43.80 org/l during of first year and between 16.48 org/l to 45.30 org/l during second year of study period. The minimum density was recorded for *Coelastrum micoporum* and maximum for *Botryococcus sp.* during both study years. Some members of this group also showed better density as *Chlamydomonas sp*. (33.45 org/l and 34.95 org/l) followed by *Scenedesmus armatus* (32.53 org/l and 34.03 org/l) and Crucigenia sp. (30.83 org/l and 32.33 org/l) during first and second years of study period respectively. The total density of this group was recorded as 381.2 org/l at station A, 382.9 org/l at station B, 384.2 org/l at station C and 382.2

org/l at station D with an average density of 382.66 org/l during first year and 403.7 org/l, 405.4 org/l, 406.7 org/l and 404.7 org/l at station A, B, C and D respectively with an average density of 405.16 org/l during second year of study period.

Cyanophyceae

Merismopedia sp. showed dominance among the members of Cyanophyceae with an average density of 29.75 org/l and 31.25 org/l during first and second years respectively. The minimum density of this group was recorded for *Gleocapsa sp.* (12.38 org/l and 13.88 org/l) during summer season of first and second years of study period respectively. The appreciable density was also recorded for *Nostoc sp.* (29.25 org/l and 30.75 org/l) followed by *Aplanocapsa sp*. (28.70 org/l and 30.20 org/l) and *Anacystis sp.* (25.45 org/l and 26.95 org/l) during both study years. The total density of this group varied between 211.5 org/l (station C) to 220.1 org/l (station A) with an average density of 216.29 org/l during first year and between 228.0 org/l (station C) to 236.6 org/l (station A) with an average density of 232.79 org/l during second year of study period.

Bacillariophyceae

Among the members of Bacillariophyceae, the maximum density was recorded for *Amphora sp.* (29.60 org/l and 31.10 org/l) and minimum density for *Diatoma elongatum* (9.53 org/l and 11.03 org/l) during first and second years of study period respectively. The appreciable density was recorded for *Fragillaria sp*. (22.75 org/l and 24.25 org/l) followed by *Gomphonema sp.* (18.60 org/l and 20.10 org/l) and Navicula indica (18.58 org/l and 20.08 org/l) during both study years. The total density of this group fluctuated between 197.5 org/l (station D) to 207.0 org/l (station B) with an average density of 202.74 org/l during first year and between 215.5 org/l (station D) to 225.0 org/l (station B) with an average density of 220.74 org/l during second year of study period.

Euglenophycae

Among the members of Euglenophyceae, the minimum density was recorded for *Phacus sp.* (16.85 org/l and 18.35 org/l) and maximum for *Euglena sp*. (18.53 org/l and 20.03 org/l) during first and second years of study period respectively. The total density of this group varied between 34.8 org/l (station D) to 35.8 org/l (station A) with an average density of 35.38 org/l during first year and between 37.8 org/l (station D) to 38.8 org/l (station A) with an average density of 38.38 org/l during second year of study period.

Table 1: Phytoplankton Genera Encountered at Different Sampling Stations of Bichhiya River Water

S.N o.	Phytoplankton genera	Station A	Station B	Station C	Station D
Group-Chlorophyceae					
1	Chlamydomonas sp.	+	+	+	+
2	Chlorella sp	+	+	-	+
3	Chara sp.	+	+	+	+
4	Coelastru m microporum,	+	+	+	+
5	Cosmariu m sp.	+	+	+	-
6	Crucigeni a sp.	+	+	+	+
7	Hormidiu m sp.	+	+	-	+
8	Oedogoni um sp.	+	+	+	+
9	Pediastru m simplex	+	+	+	+
10	Scenedes mus armatus	+	+	+	-

Table 1: Phytoplankton Genera Encountered at Different Sampling Stations of Bichhiya River Water

S.N o.	Phytoplankton genera	Station A	Station B	Station C	Station D
11	Spirogyr a sp.	+	+	+	+
12	Staurastr um sp.	+	+	-	+
13	Volvox sp	+	+	+	+
14	Ulothrix s p.	+	+	+	+
15	Zygnema sp.	+	+	+	-
Group-Cyanophyceae					
1	Aphanothece sp.	+	+	+	+
2	Arthrospira sp.	+	+	-	+
3	Anabaena spiro ides	+	+	+	+
4	Aplanocapsa sp.	+	+	+	+
5	Gleocapsa sp.	+	+	+	-
6	Gloeotrichia s p.	+	+	+	+
7	Merismopedia sp.	+	+	-	+
8	Microcystis sp.	+	+	+	+
9	Lyngbya sp.	+	+	+	+
10	Nostoc sp.	+	+	+	-
11	Scytonema sp.	+	+	+	+
Group-Bacillariophyceae					
1	Cyclotella sp.	+	+	+	+
2	Cocconeis sp.	+	+	-	+
3	Cymbella affinis	+	+	+	+
4	Diatoma elongatum	+	+	+	+
5	Fragillaria sp.	+	+	+	-
6	Melosira sp.	+	+	+	+
7	Navicula indica.	+	+	-	+
8	Navicula pulpa	+	+	+	+
9	Nitzschia sp.	+	+	+	+
10	Surirella sp.	+	+	+	-
11	Synedra capitata.	+	+	+	+
12	Tabellaria sp.	+	+	-	+
Group-Euglenophycea					
1	*Euglena sp.*	+	+	+	+
2	*Phacus sp.*	+	+	-	+

Table 2: the Number and Percentage Composition of Phytoplankton Species are Given below

S.No.	Groups	Number of Species	Percentage
1	Chlorophyceae	15	**37.50**
2	Cyanophyceae	11	**27.50**
3	Bacillariophyceae	12	**30.00**
4	Euglenophyceae	02	**05.00**
	Total	**40**	**100.0**

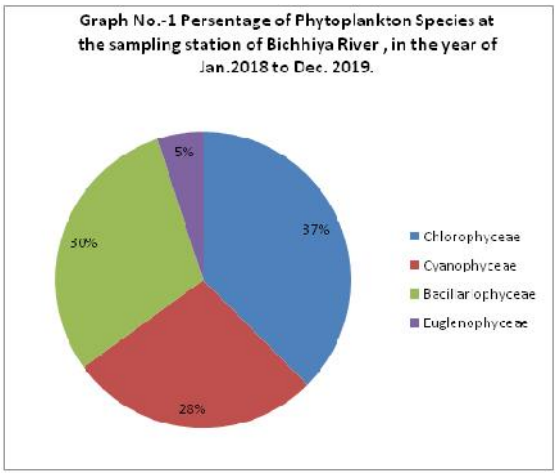

Figure 1.

Zooplankton

The zooplankton consists of diverse assemblage of major taxonomic groups. Many of these forms have different environmental and physiological assemblage. The number type and distribution of these organisms present in any aquatic habitat provide a clue on the environmental condition prevailing in that particular habitat. The occurrence and abundance of zooplankton in the water body depends on its productivity which in turn is influenced by the physico-chemical parameters and level of nutrients. The zooplankton is an important group of micro-organisms which indicates the trophic status of water body. Some of them are also acting as bio-indicator of organic and inorganic pollution of water body.

The seasonal density of zooplankton observed during different seasons of two years of study period (January 2018 to December 2019) are represented in (Tables No.-5.27). The average density of each species of zooplankton was determined for winter, summer and rainy seasons of Bichhiya river, Rewa (M.P.). In total 38 species of zooplankton were identified during present study. Out of 38 species of zooplankton 8 species belonged to Protozoa, 14 species to Rotifera, 5 species to Copepoda, 10 species to Cladocera and 1 species to Ostracoda as given Below:

Group -Protozoa

Amoeba sp., Arcella sp., Chilodonella sp., Diffusia sp., Epistylis sp., Euglena sp., Euglepha sp., Paramecium sp.

Group - Rotifera

Asplanchna brightwelli,Asplanchna sp., Brachionus angularis, Brachionus bidentata, Brachionus caudatus , Brachionus patulus, Brachionus quadridentatus , Brachionus rubens, Filinia longiseta , Filinia terminalis, Keratella tropica, Lecane aculiata, Monostyla sp., Trichocerca similis.

Group - Copepoda

Cyclops sp., Diaptomus sp., Gammarus sp., Mesocyclops sp., Nauplii.

Group - Cladocera

Alona affinis, Alonella sp., Biapertura affinis, Bosmina sp., Ceriodaphnia sp. ,Daphnia carinata , Daphnia sp., Moina sp., Monodaphnia sp., Sida sp.

Group - Ostracoda

Cypris sp.

Table 3: The Number and Percentage Contribution of Different Groups of Zooplankton are as Follows

S. No.	Groups	Number of Species	Percentage
1	Protozoa	8	21.05
2	Rotifera	14	36.84
3	Copepoda	5	13.16
4	Cladocera	10	26.32
5	Ostracoda	1	2.63
	Total	**38**	**100.00**

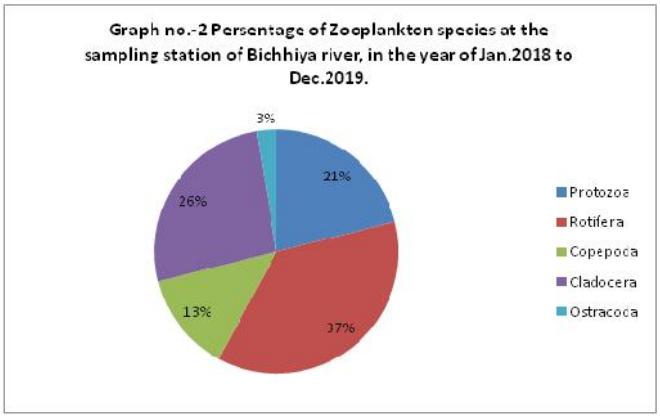

Figure 2.

Rotifera forms the main bulk of zooplankton comprising 36.84% of species composition followed by Cladocera (26.32%), Protozoa (21.05), Copepoda 13.16% and Ostracoda (2.63%) during study period.

Seasonal Density of Zooplankton

The seasonal density of different species of zooplankton observed during study period are represented in (Table No.-5.28 & 5.29).

Winter Season (Jan, Feb., Nov. and Dec. 2018 and 2019): Tables No.-5.28 & 5.29 showed the density of different species of zooplankton observed during winter season of two years of study period.

Protozoa

The minimum and maximum density of different members of Protozoa varied between 12.50 org/l to 16.50 org/l during first year and between 14.75 org/l to 19.75 org/l during second year of study period. The minimum density was recorded for *Euglena sp*. during both study years and maximum for *Paramecium sp.* during first year and *Diffusia sp.* during second year of study period. *Diffusia sp.*(16.00 org/l) and *Epistylis sp.* (15.50 org/l) during first year and *Euglepha sp*. (17.00 org/l) and *Paramecium sp*. (16.50 org/l) during second year of study period also showed appreciable density. The total density of this group fluctuated between 115 org/l (station E) to 119 org/l (station B) with an average density of 116.75 org/l during first year and between 128 org/l (station A) to 134 org/l (station C) with an average density of 131.00 org/l during winter season of second year of study period.

Rotifera

Among the 14 species of Rotifera, the minimum density was observed for *Lecane aculiata*(14.50 org/l) during first year and *Filinia terminalis* (13.00 org/l) during second year of study period. The maximum density was observed for *Brachionus quadridentatus*(23.50 org/l) and *Asplanchna sp.* (23.50 org/l) during first and second years of study period respectively. Some other species of this group also showed better density as *Brachionus patulus*(23.25 org/l), *Asplanchna sp.* (22.75 org/l) and *Asplanchna brightwelli* (22.50 org/l) during first year and *Asplanchna brightwelli* (23.00 org/l), *Monostyla sp.* (21.50 org/l) and *Lecane aculiata* (17.50 org/l) during second year of study period. The total density of this group was recorded as 295 org/l, 282 org/l, 265 org/l and 277 org/l at stations A, B, C and D respectively with an average density of 279.75 org/l during first year and 240 org/l at station A, 242 org/l at station B, 242 org/l at station C and 238 org/l at station D with an average density of 240.50 org/l during winter season of second year of study period.

Copepoda

The minimum and maximum density of Copepoda varied between 20.25 org/l to 35.50 org/l during first year and between 14.75 org/l to 32.25 during second year of study period. The minimum density was recorded for *Mesocyclops sp.* and maximum for Nauphi during both study years and maximum for *Nauplii* during both study years. The total density of this group fluctuated between 125 org/l (station D) to 136 org/l (station A) with an average density of 129.75 org/l during first year and between 103 org/l (stations A and C) to 108 org/l) station D with an average density of 105.25 org/l during second year of study period.

Cladocera

Among the ten members of Cladocera, the minimum and maximum density was recorded between 11.75 org/l to 22.75 org/l during first year and between 11.75 org/l to 19.50 org/l during second year of study period. The minimum density was recorded for *Sida sp.* during both study years and maximum for *Bosmina sp.* during first year and *Alona affinis* during second year of study period. The total density of this group varied between 156 org/l (station D) to 170 org/l (station A) with an average density of 163.75 org/l during first year and between 140 org/l (station D) to 148 org/l (station B) with an average density of 143.50 org/l during second year of study period.

Ostracoda

The density of single species of Ostracoda varied between 15 org/l (station D) to 24 org/l (station C) with an average density of 20.75 org/l during first year and 22 org/l (station D) to 26 org/l (station B) with an average density of 24.25 org/l during winter season of second year of study period.

Summer Season (March 2018 to June 2018 and March 2019 to June 2019)

The density of different members of zooplankton recorded during summer season are represented in Tables No.5.28 & 5.29.

Protozoa

Among the 8 species of Protozoa, the minimum density was observed for *Paramecium sp.*(13.50 org/l) during first year and *Amoeba sp.* (15.50 org/l) during second year of study period. The maximum density was recorded for *Euglena sp.*(17.25 org/l) during first year and *Epistylis sp.* (22.50 org/l) during second year of study period. *Euglepha sp.*(15.75 org/l)*Arcella sp.* (15.75 org/l) and *Epistylis sp.* (15.50 org/l) during first year and *Diffusia sp.* (21.50 org/l), *Euglena sp.*

(21.50 org/l) and *Chilodonella sp.* (19.75 org/l) also showed appreciable density. The total density of this group was observed as 128 org/l at station A, 118 org/l at station B, 125 org/l at station C and 116 org/l at station D with an average density of 121.75 org/l during first year and 146 org/l, 152 org/l, 157 org/l and 147 org/l at stations A, B, C and D respectively with a mean value of 150.50 org/l during second year of study period.

Rotifera

The minimum and maximum density among different members of Rotifera varied between 15.25 org/l to 22.75 org/l during first year and between 14.50 org/l to 22.25 org/l during second year of study period. The minimum density was recorded for *Filinia terminalis* and maximum for *Brachionus quadridentatus* during both study years. Some members of this group also showed better density as *Keratella tropica* (21.75 org/l), *Trichocerca similis*(21.00 org/l) and *Lecane aculiata* (20.25 org/l) during first year and *Lecane aculiata* (21.75 org/l), *Brachionus patulus* (21.75 org/l) and *Asplanchna sp*. (19.75 org/l) during second year of study period. The total density of this group varied between 249 org/l (station C) to 255 org/l (station B) with an average density of 252.25 org/l during first year and between 243 org/l (station A) to 256 org/l (station D) with an average density of 250.75 org/l during second year of study period.

Copepoda

Among the 5 species of Copepoda, the minimum density was recorded for *Diaptomus sp*. (14.25 org/l) and *Mesocyclops* sp. (20.75 org/l) and maximum for *Nauplii* (34.50 org/l and 33.00 org/l) during first and second years of study period respectively. *Cyclops* sp. also showed better density during both study years. The total density of this group fluctuated between 118 org/l (station A) to 126 org/l (station D) with an average density of 120.75 org/l during first year and between 120 org/l (station A) to 128 org/l (station D) with an average density of 124.75 org/l during second year of study period.

Cladocera

Among the members of Cladocera the minimum density was recorded for *Alonella sp.* (13.00 org/l) and *Biapertua affinis*(13.25 org/l) and maximum for *Ceriodaphia sp.* (24.50 org/l and 23.25 org/l during first and second years of study period respectively. *Alona affinis*(23.50 org/l) and *Daphinia sp*. (22.75 org/l) during first year and *Moina sp*. (22.50 org/l) and *Alona affinis* (22.00 org/l) during second year of study period also showed appreciable density. The total density of this group was observed as 197 org/l, 206 org/l, 208 org/l and 194 org/l at stations A, B, C and D respectively with an average density of 201.25 org/l during first year and 189 org/l at station A, 191 org/l at station B, 198 org/l at station C and 195 org/l at station D with an average density of 193.25 org/l during second year of study period.

Ostracoda

The single member of Ostracoda showed total density between 14 org/l (station A) to 27 org/l (station C) with an average density of 22.00 org/l during first year and between 12 org/l (station A) to 30 org/l (station C) with an average density of 22.50 org/l during summer season of second year of study period.

Rainy Season (July 2018 to Oct. 2018 and July 2019 to Oct. 2019): The density of different members of zooplankton observed during rainy season of both study years are represented in Tables No.-5.28 & 5.29.

Protozoa

The minimum and maximum density of Protzoa varied between 6.75 org/l (*Paramecium sp.*) to 15.75 org/l (*Diffusia sp.*) during first year and between 8.25 org/l (*Paramecium sp.*) to 14.75 org/l (*Diffusia sp.*) during second year of study period. *Chilodonella sp.* and *Arcella sp.* also showed better density during both study years. The total density of this group varied between 90 org/l (station D) to 102 org/l (station B) with an average density of 97.25 org/l during first year and between 88 org/l (station A) to 103 org/l (station B) with an average density of 94.25 org/l during second year of study period.

Rotifera

Among the members of Rotifera, *Brachionus quadridentatus* exhibited the higher density of 18.00 org/l and 17.50 org/l and lower density was recorded for *Lecane aculiata* (9.25 org/l) and (11.00 org/l) during first and second years of study period respectively. Some members of this group aso showed better density as *Brachionus patulus* (16.75 org/l), *Asplanchna brightwelli* (16.25 org/l) and *Asplanchna sp.* (15.25 org/l) during first year and *Brachionus caudatus* (17.25 org/l), *Monostyla sp.* (17.25 org/l) and *Asplanchna sp.* (16.25 org/l) during second year of study period. The total density of this group was recorded as 172 org/l, 205 org/l, 191 org/l, and 187 org/l at stations A, B, C and D with an average density of 197.75 org/l during first year and 209 org/l at station A, 215 org/l at station B, 204 org/l at station C and 205 org/l at station D with an average density of 208.25 org/l during second year of study period.

Copepoda

Among the 5 members of Copepoda, the minimum density was recorded for *Mesocyclops sp.*(17.00 org/l) and maximum for *Cyclops sp.* (27.50 org/l) during first year of study period. During second year, the minimum density was recorded for *Cyclops sp.*(13.50 org/l) and maximum for *Nauplii* (31.50 org/l). The total density of this group fluctuated between 127 org/l (station A) 124 org/l (station B), 118 org/l at station C and 114 org/l at station D with an average density of 120.75 org/l during first year and between 88 org/l (station D) to 96 org/l (station B) with an average density of 91.00 org/l during second year of study period.

Cladocera

Among the 10 species of Cladocera, the minimum density was recorded for *Monodaphnia sp. (10.75 org/l)*and *Sida* sp. (9.75 org/l) and maximum for *Daphnia carinata* (16.25 org/l) and *Daphnia sp.* (17.50 org/l) during first and second years of study period respectively. *Bosmina sp.* (15.75 org/l), *Ceriodaphnia sp.* (15.25 org/l) and *Daphnia sp.* (14.50 org/l) during first year and *Ceriodaphnia sp.* (16.75 org/l) and *Bosmina sp.* (16.25 org/l) during second year also showed appreciable density. The total density of this group was observed as 130 org/l at station A, 137 org/l at station B, 132 org/l at station C and 127 org/l at station D with an average density of 131.50 org/l during first year and as 140.0 org/l, 156.0 org/l, 140.0 org/l and 139.0 org/l with an average density of 141.25 org/l during second year of study period.

Ostracoda

Among Ostracoda, the single member *Cypris* sp. showed density between 15 org/l (station D) to 26 org/l (station B) with an average density of 22.25 org/l during first year and between 12 org/l (station D) to 24 org/l (station B) with an average density of 18.25 org/l during second year of study period.

Total Seasonal Density of Zooplankton

The total seasonal densities of zooplankton observed during study period are represented in Table No.-5.28. Result revealed that higher density of zooplankton was recorded during summer season (718.00 org/l and 741.75 org/l) followed by winter season (710.75 org/l and 644.50 org/l) and rainy season (580.50 org/l and 553.00 org/l) during first and second years of study period respectively.

Table 4: Total Mean Seasonal Density (Org/L) of Zooplankton Observed at Four Stations of Bichhiya River Water, (January 2018 to December 2019)

Years	Seasons	Station A	Station B	Station C	Station D	Average
January 2018 to December 2018	Winter	739	715	701	688	710.75
	Summer	708	725	728	711	718.00
	Rainy	547	594	560	533	558.50
January 2019 to December 2019	Winter	637	655	648	638	644.50
	Summer	710	744	764	749	741.75
	Rainy	541	584	551	536	553.00

RESULT AND DISCUSSION

Biological Characteristics of the Bichhiya River

Plankton according to their quality may be classified into phytoplankton and zooplankton. The distribution and composition of plank tonic species are considered as remarkable measures to determine the status of pollution in water and vary considerably from one water body to another. Diversity, distribution abundance and variation in the biotic factors provide information of energy turnover in the aquatic system.

Phytoplankton

The detailed taxonomic survey was carried out from January 2018 to December 2019 in Bichhiya River of Rewa and average density of all phytoplankton species was recorded for winter, summer and rainy season. Adiniji (1977) noticed that population density of phytoplankton is controlled by the amount of nutrient notably phosphate and nitrate in water. During present study, 40 species of phytoplankton were recorded, belonging to class Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. Of these, 15 species belonged to Chlorophyceae, 11 species to Cyanophyceae, 12 species to Bacillariophyceae and 2 species to Euglenophyceae. Maximum density of phytoplankton was recorded in winter season followed summer season and rainy season. Laskar and Gupta (2009) reported minimum density of phytoplankton during monsoon season and maximum during summer season in Chatla lake, Assam. The seasonal changes in the species composition, distribution and density are due to the changing environmental conditions. Baba and Pandit (2014) reported that phytoplankton depicted bimodal growth curve with peaks in spring and autumn which may be as a result of regeneration and availability of minerals as a result of decomposition of organic matter in sediments. The seasonality of phytoplankton is also attributed to the moderate water temperature conditions besides the release and availability of plant nutrients during these periods. Among the members of Chlorophyceae, *Cosmarium sp.*, *Chlorella sp.*, *Botryococcus sp.* and *Chara sp.* showed better density in comparison to other members of the group. Among Cyanophyceae, *Coelospharenum sp.* showed its dominance. The appreciable density was also recorded for *Microsystis sp.*, *Anacystis sp.* and *Rivularia sp.*. Among the members of Bacilariophyceae, the maximum density was recorded for *Navicula indica* during study period. The appreciable density was also recorded for *Navicula pulpa*, *Gyrosigma sp.* and *Cyclotella affinis*. Among the two

species of Euglenophyceae, the maximum density was recorded for *Euglena sp*. during both study years. The maximum average total seasonal density of phytoplankton was recorded during winter season (929.87 org/l and 977.05 org/l) followed by summer season (837.07 org/l and 897.07 org/l) and rainy season (684.75 org/l and 732.75 org/l) during first and second years of study period respectively. Chlorophyceae showed their dominance over the other groups of phytoplankton. Next in order was Cyanophyceae followed by Bacillariophyceae and Euglenophyceae. Trivedi et al. (1990) reported that as pollution increased in water Chlorophyceae is replaced by Bacillariophyceae and Cyanophyceae. Thus the water of Bichhiya River cannot be considered as polluted because Chlorophyceae showed its dominance during both study years. Chakrawarty et al. (1959) reported that Chlorophycean members showed a slight decrease in their growth with increase in pH, calcium, chloride and total suspended solids. Bacillariophyceae showed maximum growth with increasing pH, temperature, phosphate, chloride and total suspended solids (Pearsal, 1932, Patric, 1948, Zafar, 1967, Hegde, 1983). Adiniji (1978) observed that temperature, dissolved oxygen, food and avoidance of being preyed upon govern the abundance and distribution of phytoplankton. Smith (1942) also reported that light, temperature and free carbon dioxide were the controlling factors for the growth of algae. Verma and Shukla (1970) reported that no individual factor physical or chemical was singularly responsible for the seasonal fluctuation of phytoplankton. Zafar (1964a) reported that higher values of dissolved oxygen (6.8 to 9.3 mg/l) was correlated with peak population of Chlorophyceae. Sreenivasan (1965) observed maximum production of phytoplankton in April in Amaravaty reservoir. Khan and Siddiqui (1971) also reported high gross primary productivity from March to May. Kannan and Job (1980) observed that primary production was high between April and July in Sathiar reservoir. Vyas and Kumar (1968) reported both positive and inverse relationship between phytoplankton and dissolved oxygen. Pailwan et al. (2008) reported the phytoplankton population exhibits bimodal peak, one in winter and other in summer season with infrequent occurrence of Dinophyceae and Euglenophyceae. In present study also phytoplankton showed better density in winter and summer season. Abdar (2013) reported that richness in nitrogen and orthophosphates were favorable for growth of phytoplankton. He also reported that among Cyanophyceae, *Microcystis sp.*, *Oscillatoria sp.* and *Anabaena sp.* were present throughout the year. *Microcystis sp.* was dominant in the season. Phytoplanktons are the primary producers as they trap solar energy and produces organic molecules by consuming CO2. Phytoplankton are not only primary producers but also brings out biogenic oxygenation of the water during day time (Welch, 1952, Wetzel, 1975, 1983).

Zooplankton

The occurrence, distribution and diversity of zooplankton is related with the physico-chemical condition of water. Temperature is the most important factor which determines the distribution of zooplankton. During present study, in total 38 species of zooplankton were identified representing 8 species to Protozoa, 14 species to Rotifera, 5 species to Copepoda, 10 species to Cladocera and one species to Ostracoda. Rotifera forms the main bulk of zooplankton comprising 36.84% followed by Cladocera (26.32%), Protozoa (21.05%), Copepoda (13.16%) and Ostracoda (2.63%) during study period. Among zooplankton *Paramecium sp.* and *Diffusia sp.* (Protozoa), *Brachionus quadridentatus, B. angularis, B. patulus, Asplanchna sp.* (Rotifera), *Nauplii* (Copepoda), *Bosmina sp.* and *Alona affinis* (Cladocera) and *Cyrpis* (Ostracoda) showed dominance in the dam during study period. The maximum density of zooplankton was recorded during summer season followed by winter and rainy season during study period. Rotifera showed maximum annual density followed by Cladocera, Copepoda, Protozoa and Ostracoda during first year and Rotifera, Cladocera, Protozoa, Copepoda and Ostracoda during second year of study period. Arora (1966) reported that *Rotaria rotatoria* was found only in polluted water. Tiwary and Sharma (1977) related the appearance of *Lecane, Keratella tropica* and *Platyas patulus* with semi

polluted and polluted water. Arora (1966) recorded these species from Jamuna and Sakardara tanks at Nagpur which he classified as medium polluted tanks. During present study, only *Keratella tropica* and *Lecane aculiata* were recorded. Adoni (1975) reported that density of rotifers and their species diversity is increased in higher eutrophic waters. Adiniji and Ovie (1982) reported the abudance of zooplankton at surface water where dissolved oxygen was high but the abundance of zooplankton reduced with the reduction of oxygen in water. Wetzel (1983) observed that the primary following fertilization usually results in greater zooplankton abundance. The high population density of the rotifers could be attributed to their parthenogenesis reproductive patterns and short developmental rate under favorable conditions (Wetzel, 2001). The dominance of rotifers was due to its preference for warm waters as highlighted by Dumont (1983) and Segers (2003). Matsumura Tundisi (1999) reported the dominance of *Brachionus* is indication of eutrophic water. Alkaline pH was also found to favour zooplankton growth. Byars (1960) had also reported that zooplankton prefer alkaline water. Khaire (2012) reported that dissolved oxygen is most vital parameter which influences the plankton population. It showed significant positive correlation (r=0.9361) with zooplankton population. Similar results were reported by Salaskar and Yeragi (2003) and Surve et al. (2004). Khaire (2012) reported negative correlation with alkalinity (r=-0.9260), total hardness (r=-0.1692) and Chlorides (r=-0.6292). Surve et al. (2004) observed positive correlation between zooplankton and alkalinity supports our observation Khalokar (2014) reported high predation also leads to the low specific diversity of zooplankton and evidence by low value of concentration dominance, as also reported by Verma and Shukla (1970). Cladocerans forms an important component of zooplanktons and forms the most dominant group of fish food organisms. During present study, zooplankton community composition of the river also showed to be productive in nature and support a diverse species. The zooplankton assemblage was strongly influenced by the physico-chemical factors of the water temperature, food abundance, nutrients were some of the important factors that could limit zooplankton community. Maintenance of good water quality will enhance the zooplankton community and this will be a great advantage for fish production in the river.

Total Phytoplanktons & Zooplanktons

Monthly sampling of phytoplankton and zooplankton were documented at 4 Sampling stations of Bichhiya River Rewa (M.P.) for January 2018 to December 2019.

Phytoplankton

Maximum density of phytoplankton was recorded in winter season followed summer season and rainy season. During present study, 40 species of phytoplankton were recorded, belonging to class Chlorophyceae, Cyanophyceae, Bacillariophyceae and Euglenophyceae. Of these, 15 species belonged to Chlorophyceae, 11 species to Cyanophyceae, 12 species to Bacillariophyceae and 2 species to Euglenophyceae as given below :

Group-Chlorophyceae

Chlamydomonas sp., Chlorella sp, Chara sp. Coelastrum microporum, Cosmarium sp. Crucigenia sp., Hormidium sp., Oedogonium sp., Pediastrum simplex, Scenedesmus armatus, Spirogyra sp., Staurastrum sp., Volvox sp, Ulothrix s p. , Zygnema sp.

Group-Cyanophyceae

Aphanothece sp., Arthrospira sp., Anabaena spiroides, Aplanocapsa sp. Gleocapsa sp., Gloeotrichia sp., Merismopedia sp., Microcystis sp., Lyngbya sp., Nostoc sp., Scytonema sp.

Group-Bacillariophyceae

Cyclotella sp., Cocconeis sp., Cymbella affinis, Diatoma elongatum, Fragillaria sp., Melosira sp., Navicula indica, Navicula pulpa, Nitzschia sp, Surirella sp., Synedra capitata., Tabellaria sp.

Group-Euglenophycea

Euglena sp. & Phacus sp.

CONCLUSION

The results of the present study showed that the most of the physico-chemical parameters of the Bichhiya river well within the desirable limits of WHO and BIS standards. Increase in temperature of the river water reduces the dissolved oxygen which influences biological activities such as feeding habits and reproductive behavior in the fish and other aquatic organisms. Along with waste discharge many harmful chemicals such as detergents algaecides, pesticides used in plant operations also find their way into the river adding future to water pollution. The analysis for which should have also be done but to river of time. Lastly the large scale of water intake from the river for all above mentioned operations also has deleterious effects on the aquatic life affecting the aquatic ecological balance.

The presence of large number of macrophytes or free floating vegetation, common to tropical river generally block the water surface lower dissolved oxygen levels and also course nuisance for swimming. In essence the physico-chemical and Biotic community of the river reveals that it is tending, fast towards 'eutrophism' particularly at all sampling station. The quality of water is deteriorating day by day due to inflow of industrial, domestic sewage, municipal waste, agricultural runoff and effluents of organic waste of animal and human origin into the river. Deterioration of water quality and eutrophication are assuming alarming state in Bichhiya River, due to casual attitude of people concerned with development of urban population. Therefore, there is an urgent need of regular monitoring of water quality to govern the status and diverting the city sewage away from the river to preserve the flora and fauna of this ecosystem. If waste input is not checked then it will severely impair water dynamics and will cause eutrophication of the entire system. Overall, coordinated efforts of various stakeholders and proper community involvement are the primary needs to restore the ecological subsystem of the river and to make it useful for further social and economic exploration.

REFERENCES

1. *Abook, K.M. and Manuel, A.C. (1967): preliminary observation on the Upper Lake at Bhopal. Environ. H1th. 9:22.*
2. *Adoni A.D.(1985) Work Book on Limnology, Indian MAB Comm., Govt. of India . 216*
3. *Agrawal, S.K. (1983). Water quality of sewage drains entering Chambal river at Kota. Acta. Ecol., 5:29-29.*
4. *Ahmad, M. S. (1989). Physiology of polluted ponds of Dharbhanga.Ph.D. thesis, L.N. Mithila University, Dharbhanga.*
5. *Ambasht, R.S. (1990). Environment and pollution (An Ecological Approach). Ist ed., Students Friends and Co. Pub. Lanka Varanasi, India.*
6. *Anderson, J. R. (1982). Acquisition of cognitive skill. Psychological Review, 89, 369-406.*
7. *Anon. (1996). Committee to assess agro residues availability. INPAPER International 1(1): 13.*

8. *APHA (1975). standards methods for the Examination of water and waste water .American Public Health Association, Washington, D.C.*
9. *APHA (2005). Standard Methods for the Examination of Water and waste water. 19th Eds. American Public Health Association, Washington DC.*
10. *APHA, (1985). Standard method for Examination of water and wastewater American Public Health Association 16th Ed. APHA New York.*
11. *Araujo, J. C., Campos, a C., Correa, M. M., Silva, E. C., Matté, M. H., Matté, G. R., Von Sperling, M., et al. (2011). Anammox bacteria enrichment and characterization .*
12. *from municipal activated sludge. Water science and technology: a journal of the International Association on Water Pollution Research, 64(7), 1428–34.*
13. *Arora R(2012**).**Studies on Physieo-ehemieal parameters causing pollution of Ghod river, India, J. Environ. Res. Develop., **7**(1A), 441-443.*
14. *Arya, S, Kumar, V, Raikwar, M, Dhaka, A and Minakshi (2011). Physico-chemical Analysis of Selected Surface Water Samples of Laxmi Tal (Pond) in Jhansi City, UP, Bundelkhand Region, Central India Journal of Experimental Sciences 2(8): 01-06.*
15. *Asadi, S. S., Vuppala, P., & Anji, R. M. (2007). Remote sensing and GIS techniques for evaluation of groundwater quality in municipal corporation of Hyderabad (Zone-V), India. International Journal of Environmental Research and Public Health, 4(1), 45–52.*
16. *Aykulu. G. (1978). A quantitative study of the phytoplankton of the river Avon. Briston Br. Phykal. J., 13:1-102.*
17. *Bagde, U. S. and Verma, A. K.: 1985, 'Limnological studies of JNU lake. New Delhi, India', Proc. Natl. Symp. Pure and Appld. Limnl. **32**, 16–23.*
18. *Bagde, U.S. and Verma, A.K. (1985) Physico-chemical characteristics of water of J. N. U. Lake at New Delhi. Indian Journal of Ecology, 12, pp. 251-256.*
19. *Banejee U.S. and Gupta S., (2012).Monitoring and assessment of river pollutant : A study on river Damodar and river Barakar of India using faetor analysis, J. Environ. Res. Develop., **6**(3A), 638-644.*
20. *Barnabe, G. (1994). Aquaculture biology and ecology of cultured species. Ellis Horwood Ltd.*
21. *Barry, T.H. Paulballey, Rick Edwards kent H., Kim-James, Andrew Mcmahon, Charlesmeredith and Swadling, K. (1990). Effect of salinity on river stream and wetland ecosystem in Victoria, Australia. Water Res., 24(9):1103-1117. .*
22. *Bhanja, K. Mohanta and Ajoy Ku. Patra. (2000). Studies on the water quality index of river Sanamachnakandan at Keonjher Garh, Orissa, India. Poll. Res., 19(3):377-385.*
23. *Bhaskaran, T.R. (1959). Industrial waste survey and river pollution studies in Bihar and U.P. State. Bull. Cpheri., 1:55-62.*

24. *Bhatnagar, G.P. (1984). Limnology of Lower lake, Bhopa with reference to pollution Eutrophication.Tech. Rep. May 1979-April 1982 :MAB Programme, Deptt. Of Environ. Govt. of India,New Delhi, 1-77.*

25. *Bhatt, S.D. and Pathak, J.K. (1992). Assessment of water quality and aspects of pollution in a stretch of river Gomati (Kumaun) lesser Himalaya. J. Environ. Biol., 13(2):113-120.*

26. *Bhuiyan J.R. and Gupta S. (2007)- A comparative hydrobiological study of a few ponds of Barak Valley, Assam and their role as sustainable water resources. Journal of Environmental Biology October 2007, 28(4) 799-802.*

27. *Biswas K. (1942). The role of algae communities of the river Hughly in the drinking water of Calcutta. 150th Ann. Vol. Roy. Bot. Gdn., 189-206.*

28. *Bledsoe, B.P. and Shear, T.H. (2000). Vegetation along hydrologic and edaphic gradients in a north Carolina coastal plain creek bottom and implications for restoration. Wetlands, 20(1):126-147.*

29. *Blinn, D.W. and Bailey, P.C.E. (2001). Land-use influence on stream water quality and diatom communities in Victoria, Australia : A response to secondary salinization. Hydrobiologia, 466:231-244.*

30. *Blume, J.L. (1956). The ecology of river algae. Bot. Rev., 22(5):291-341.*

31. *Boyd, C.E. (1981). Water Quality in Warmwater Fish Ponds. Alabama Agricultural Experiment Station, Auburn University, Auburn, AL.*

32. *Brinley, F.J. (1942). Biological studies, Ohio river pollution survey-II. Plankton algae as indicators of the sanitary condition of a stream. Sewage Wks. J., 14:152-159.*

33. *Brooker, M.P. and Johnson, P.E. (1984). The behaviour of phosphate, nitrate, chloride and hardness in Twelve Welsh rivers. Water Res., 18(9):1155-1164.*

34. *Bubb, J. M., Rudd, T. & Lester, J. N. (1991) Distribution of heavy metals in the River Yare and its associated broads. I. Mecury and methyl mercury. Sci. Total Environ. 102: 147–168.*

35. *Burns, C.W., D.J. Forsyth, J.F. Haney, M.R. James, W. Lampert and R.D. Pridmore 1989. Coexistence and exclusion of zooplankton by Anabaena minutissima Var. attenuate in lake Rotongaio, New Zealand. Arch. Hydrobiol., 32: 63-82.*

36. *Butcher, R.W. (1949). Studies in the ecology of rivers VII and the algae of organically enriched waters. J. Ecol., 35:186-191. .*

37. *Chakrabarty, S and Sharma H.P. (2011). Heavy metal contamination of drinking water in Kamrup district, Assam, India. Environ. Monitor. and Assess. 179:479–486.*

38. *Chattopadhya, S.N., Tapan, R., Sharma, V.P., Arora, H.C. and Gupta R.K. (1984). A short term study on the pollution status of river Ganga in Kanpur region. Indian J. Environ. Hlth., 26(3):244-257.*

39. *Chaube UC (1988) Model study of water use and water balance in Betwa Basin. J Inst Eng Indian Civil Eng Div 69:169–173.*

40. *Claus D and Berkley R.C.W (1986). Genus Bacillus Cohn. In: Sneath PHA Eds. Bergey's Manual of Systematic Bacteriology, Sec 13(2), Baltimore, MD, USA. Williams & Wilkins Co. 1105-1139. .*

41. *Cuffney, T.F., Meador, M.R., Proter, S.D. and Gurtz, M.E. (2000). Responses of physical, chemical and biological indicators of water quality to a gradient of agricultural land-use in the Yaking river basin, Washington. Environ. Monitoring and assessment, 64:259-270.*
42. *Curds CR, Cockburn A (1970a). Protozoa in biological sewage treatment processes: A survey of the protozoan fauna of British fauna percolating filters and activated sludge plants. Water Res., 4: 225-236.*
43. *Danazumi, S and Bichi, M.H (2010). Industrial pollution and heavy metal profile of Challawariver in Nigeria, J of Appl. Sci. in Environ. Sani. 5: 23-29.*
44. *Darwall WRT, Vie JC (2005) Identifying important sites for conservation of freshwater biodiversity: extending the species-based approach. Fish Manag Ecol 12:287–293.*
45. *Das, S.M. and V.K. Sriastava (2003). Studies on plankton components.Proc. Nat. Acad. Sci. India, 29: 174-189.*
46. *Day F. S. (1951). The fishes of India. William and Sons Ltd., London.*
47. *De., P.K. (1939) – "Reservoir fishery management and development in Asia".*
48. *Deshpande NM (2002) Biodegradation of Dimethoate- a carbamate group of organophosphorus insecticides. Ph.D thesis in Microbiology, University of Pune.*
49. *Dhote, S. (2000) : Impact of anthropogenic activites on limnological characteristics of Bhoj Wetland. National Worshop on "Biodiversity and Conservatio of Aquatic Resources W/R to threatene Fish Mahseer." 26th & 27 Feb. 2000, P. 58.*
50. *Dudgeon D, Arthington AH, Gessner MO, Kawabata ZI, Knowler DJ, Leveque C, Naiman RJ, Prieur-Richard AH, Soto D, Stiassny MLJ, Sullivan CA (2006) Freshwater biodiversity: importance, threats, status and conservation challenges. Biol Rev 81:163–182.*
51. *Dumontet, S. and Scopa, A. (2001). The importance of pathogenic microorganisms in sewage and sewage sludge. J. Air Waste. Manage. Assoc. 5:848-860.*
52. *Duncan S.W. and D.W. Blinn (1999) – "Importance of physical variable on the seasonal dynamics of epilithic algae in a highly shaded canyon stream journal of physiology 25:455-461.*
53. *Dutta, N., Malhotra, J.C. and Bose, B.B. (1954). Hydrobiological and seasonal fluctuations of the plankton in the Hooghly estuary. Symp. On marine and fresh water plankton in the Indo Pacific. Pp. 1-13.*
54. *Dwivedi, B.K. and Pandey, G.C. (2002). Physico-chemical factors and algal diversity of two ponds (Girija Kund and Maqubara Pond), Faizabad, India. Pollution Research, 21(3):361-369.*
55. *Edmondson, (1974). Nutrients and phytoplankton in lake Washington. In Nutrients and eutrophication.The limiting nutrient controversy. Lickens, G.E.(ed) Sec. Symposiumlimnol. And OceanogSubha,r., 1:172-193.*
56. *Eshwarlal Sedamkar and Angadi, S.B. 2003. Physicochemical parameters of two freshwater bodies of Gulbarga-India with special reference to phytoplankton. Poll. Res., 22(3): 411-422.*
57. *Fandi G. K., I. Y. Qudsieh, S. A. Muyibi, M. Massadeh (2009)- Water Pollution Status Assessment of King Talal Dam, Jordan. Advances in Environmental Biology, 3(1): 92-100.*

58. *Fandi et al., 2009 K. Fandi, I. Qudsieh, S. Mubibi, M. Massadeh (2009)- Water pollution assessment of King Talal Dam Adv. Environ. Biol., 3 (1), pp. 92-100.*

59. *Fjerdingstad, E. (1950). The microflora of river Molleaa with special reference to the relation of benthal algal population. Folialimnologica Condinonca, 5:79-101.*

60. *Gaikwad, V.B. and Gunale, V.R. (2001). Water quality monitoring of Godavari river in and around Nahsik region, Pp. 1-20.*

61. *Galatowitsch, S.M., McAdams, T.V. (1994). Distribution and requirements of plants on the upper Mississippi river: Literature Review. Cooperative Fish and Wildlife Research Unit, Ames, IA.*

62. *Ganapati, S.V. (1943). The ecology of temple tank containing a permanent bloom of microcystis aeroginosa kuetzing, J. Bomb. Nati. Hist. Soc., 42(1):65-77.*

63. *Ganapati, S.V. (1972). Organic production in seven types of aquatic ecosystems in India. In: An emphasis on organic production (Ed: P.M. Golley), Athens J. Tropica. Ecology, Pp. 313-350.*

64. *Ganpati, S.V. (1956). Hydrobiological investigation of the Hope Reservior and of the Tamarapannani river at Tapanasal, Tirunelveli District,Madras state. TheInd. Geogr., D.31 : 1-20.*

65. *Gaur, V.K., Gupta, S.K., Pandey, S.D. Gopal, K., &Misra, V. (2005). Distribution of heavy metals in sediment and water of river Gomti. Environ. Monitor. and Assess. 102: 419–433.*

66. *George, M.G. (1976). Diurnal variations in two shallow ponds in Delhi, India. Hydrobiologia, 18(3):265-273.*

67. *Ghabzan, N.J., Gunale, V.R. and Pisal, B.R. (2005). Water pollution monitoring of Mulla and Pavanariver from Pune, India urban area. Asian J. Microbiol., Biotechnol. Environ. Sci., 7(4), 785-790.*

68. *Ghalib, H., Yaqub, M., & Al-Abadi, A. (2019). Hydrogeochemical modeling and isotopic assessment of the quaternary aquifer at Ali al-Garbi Area in Misaan Governorate, South of Iraq. In Advances in Sustainable and Environmental Hydrology, Hydrogeology, Hydrochemistry and Water Resources, 121–124. doi:10.1007/978-3-030-01572-5_30.*

69. *Giridharan L, Venugopal T, Jayaprakash M (2010) Identification and evaluation of hydrogeochemical processes on river Cooum, South India. Environ Monit Assess 162:277–289.*

70. *Glaser, P.H., Janssens, J.A. and Siegal, D.I. (1990). The response of vegetation to chemical and hydrological gradients in the Lost river peatland, Northern Minnesota. J. Ecol., 78:1021-1048.*

71. *Goel, P.K. and Autade, V.B. (1995). Ecological studies on the river Panchaganga at Kolhapur with emphasis on biological components. Recent Researches in Aquatic Environment. Gautam, A. Daya Publishing House, Pp. 43-44.*

72. *Goel, P.K. and Bhosale, M. (2001). Studies on the river Panchganga at Kolhapur with special reference to human impact on water quality. In: Current topics in environmental sciences (Eds: G. Tripati and G.C. Pandey), ABD publishers, Pp.120.*

73. *Joy, C.M., Balakrishnan, K.P. and Ammini Joseph. (1990). Effect of industrial discharges on the ecology of phytoplankton production in the river Periyar (India). Water Research, 24(6):787-796.*
74. *Kant Shashi. 1985. Algae as indicates of organic pollution proc. All India Applied Phycological Congress, Kanpur, 77-86.*
75. *Kant, S. and Anand, V.K. (1978). Interrelationships of phytoplankton and physical factors in Mansar lake Jammu (J & K). Ind. J. Ecol., 5(2):134-140*[\ooo;;po;;;
76. *Kumar, P. and Gupta, R.K. (2002). Growth characteristic of Potamogeton crispus and Elodea canadensis in polluted water. Poll. Res., 21(3):305-307.*
77. *Kumar, S.S. and Bhoopathi, C.A. (2007). In vitro study of microbially treated and untreated sago factory effluent on growth of Vignamungoand V. radiata. J. Ecotoxicol. Environ. Monit.,17(3), 263-268.*
78. *Kundangar, M. R and D.P. Zutshi (1985)-Environmental features and plankton communities of two Himalayan rural lakes, Proc. nat. Symp. Pure and Applied limnology edited by A.D. Adoni. Bull. Bot. Soc. Sagar., 32: 40-47.*
79. *Lackey, J.B. and Hupp, E.R. (1956). Plankton population in Indian's white river. J. Amer. Water Works Assn., 48:1024-1036.*
80. *Laffaille P, Acou A, Guillouet J, Legult A (2005) Temporal change in European eel, Anguilla anguilla, stock in a small catchment after installation of fish passes. Fish Manag Ecol 12:123–129.*
81. *Lakshminarayan J.S. (1965-a). Studies on the plytoplankton of river Gangas, Varanasi, India-I. The Physico characteristics of river Gangas. Hydrobiol., 25:119-137.*
82. *Leveque C, Balian EV, Martens K (2005) An assessment of animal species diversity in continental waters. Hydrobiologia 542:32–67.*