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Physico-chemical conditions and plankton diversity of Godavari River in Nashik City area of Maharashtra: A comparative assessment

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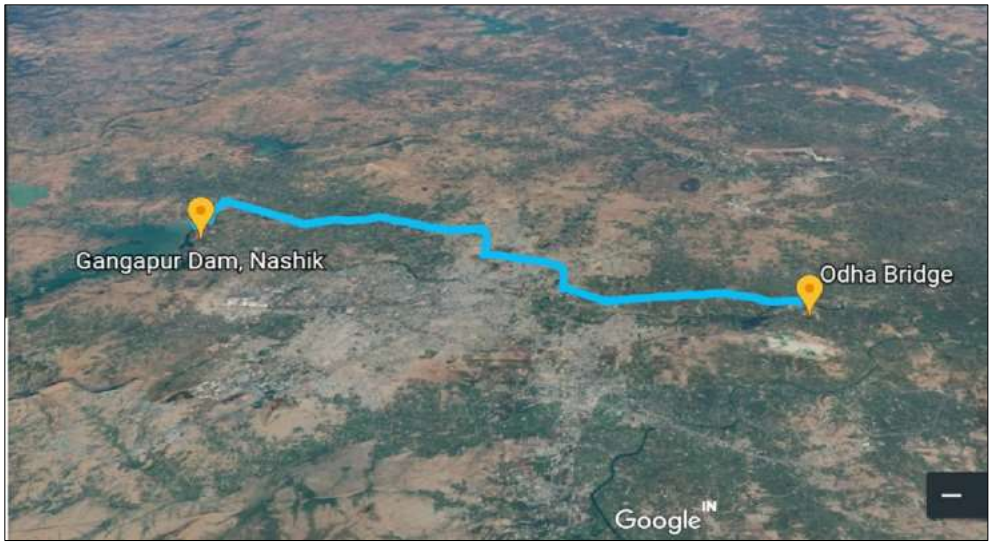
Abstract
The physico-chemical parameters play a vital role in growth and sustainability of planktonic diversity in river ecosystem. These parameters and plankton diversity index can be used to evaluate suitability of water for drinking and other purposes. The present work carried out comparative assessment of physico-chemical parameters and plankton diversity of Godavari river water in Nashik city area for a period of one year starting from April-2017 to March-2018. Samples of water were collected from carefully selected two sampling sites each month during this study duration. Analysis of samples were done for physico-chemical parameters and plankton diversity. The study revealed there is a direct effect on plankton population due to fluctuation in physio-chemical parameters during the selected period. The physico-chemical parameters, of both the sites on the river, were studied by measuring the degree of correlation with the plankton diversity. The study revealed that quality of Godavari river water is highly affected negatively due to industrial, agricultural and human activities. The plankton diversity index of river Godavari indicate that the river is badly polluted and the water quality have the direct effect on plankton diversity.

Keywords: correlation, plankton diversity, physico-chemical parameters, river godavari, water quality

1. Introduction
Water is referred as elixir of life. Life flourished in, on and around the water. Hence, river is considered as one of the greatest boons to the human beings. Most of the civilizations have prospered and prospering on the banks of the rivers. The river water finds multiple uses in every part of human life such as agriculture, domestic, industry, transportation, and recreational activities [36]. Beside these usages, it also have been used for washing, cleaning and disposal purposes since ages. A large amount of waste from agricultural activities, domestic sewage, and industries is deposited or released into rivers, which harms the water quality. Human activities have greatly changed the river ecosystems biologically, chemically and physically. The declination of river ecosystem has forced us to check rather monitor water quality of various rivers of our country to plan out possible restoration measures [8]. As we know that phytoplankton are good indicators of environmental changes, because their structure and metabolism changes quickly in response to environmental conditions [40]. Phytoplanktons are found at the base of the food chain in aquatic ecosystem [13]. They are also the primary producers in pelagic waters, so they condition the structure and density of their dependents as well as physico-chemical properties of water. They are found in abundance in the pelagic zone of oceans, rivers, lakes and ponds where light reaches easily. They are responsible for releasing large amount of organic matter, which dissolves and integrates into the biomass of different bacteria [11]. The secondary production, directly or indirectly, depends on them in aquatic ecosystems [10]. They also play an important role in cycling energy and recycling nutrients within their respective environments. So far, an extensive studies have been done on this topic by many researchers in India and abroad. These studies accentuated the fact that, greater losses will be there to aquatic ecosystem, in future, than to terrestrial ecosystems due to the loss of biodiversity and its effects.

The study purpose was to make a comparative assessment of Godavari River to know about the pollution status by analyzing the physico-chemical attributes and plankton diversity and recommend suggestive measures for conservation and sustainability of this river ecosystem.

2. Material and Methods
The study was carried out in the vicinity of Nashik city on Godavari River water. The two sites chosen were: Gangapur dam (S-1) and Odha village (S-2) from where the river passes. The study was done for the period April 2017 to March 2018. The samples were collected, on monthly basis, from both the sites, in sterilized bottles and analyzed in the laboratory for the selected physical and chemical parameters. The following image shows the path of the Godavari River from Gangapur dam to Odha village.



***Source*:** Google Earth

Fig 1: Sites: Gangapur Dam, Nashik and Odha Village

Temperature (^{0}C), Transparency (cm), pH, Dissolved Oxygen (mg/l) and TDS (mg/l) were analyzed at the respective sites and the other physico-chemical parameters such as: Turbidity (JTU), Electric conductivity (µmho/cm), Total Solids (mg/l), TSS (mg/l), Total Alkalinity (mg/l), Total Hardness (mg/l), BOD (mg/l), COD (mg/l), Calcium (mg/l), Magnesium (mg/l), Chloride (mg/l), Phosphate (mg/l), Nitrate (mg/l), Sodium (mg/l) and Potassium (mg/l) were analyzed in laboratory by following the standard methods given in APHA (2005). Temperature was measured using thermometer and Transparency was measured by using Secchi disc. Likewise, Turbidity was measured using Jackson Turbidity unit, Conductivity by Conductivity meter and pH by digital pH meter. Total Solids, TDS, TSS were measured by gravimetric analysis. BOD, COD, DO, Total Alkalinity, Total Hardness, Free CO_2, Calcium, Magnesium, and Chloride were analyzed by titration method. UV-VIS Spectrophotometer was used to analyze Nitrate and Phosphate. Whereas, Sodium and Potassium were analyzed by Flame photometer.

Plankton net (0.1mm mesh size) was used for plankton collection and the plankton were preserved in 4% formalin solution. The plankton count was made by Sedgewick rafter cell by observing them under the microscope.

Following formula was used for the same

$$No.\ of\ Species/l = \frac{C \times 1000mm3}{L \times D \times W \times S}$$

Here,
C= No. of organisms counted
L= Length of each stripe (mm)
D= Depth of each stripe (mm)
W= Width of each stripe (mm)
S= No. of stripes

Statistical analysis was done for the qualitative analysis of the plankton samples. Standard deviation and Karl Pearson's correlation coefficient (r value) were done to find the relation between various physico-chemical parameters and their impact on biological variables.

3. Results

Table 1 shows mean values of the physico-chemical parameters of the samples collected from both the sites of the river. Temperature is one of the important parameters which affects the chemical and biological characteristics of surface water. A little variation in the temperature at S-1 was 19.33±2.40^{0}C and at S-2 was19.45±2.45^{o}C was noted. Electrical conductivity (EC) is also used to know the water quality. The value of EC was noted in the range of 0.491±0.05 to 0.410±0.05 µmhos cm $^{-1}$ at the sites. It is noted in a study that, dilution of solids in water decreases EC, alkalinity and zooplankton production [17]. PH doesn't have adverse effects on health, but, it reduces germicidal potential of chloride. High pH results in formation of tri-halomethanes which are toxic in nature [26]. But, pH has adverse effects on the dissolved oxygen level, photosynthesis of aquatic plants, metabolic rates of aquatic organisms and the sensitivity of these organisms to pollution, parasites and disease [16]. The pH recorded at S-1 was 6.13±0.98 and at S-2 was 7.02±0.19. Alkalinity occurs due to dissolution of calcium carbonate (CaCO3) from limestone rock during the natural weathering processes. It ultimately results into release of carbon dioxide (CO_2) from the calcium carbonate into the water which undergoes several reactions (Schlesinger, W. H. 1991). The highest alkalinity value in river was recorded at S-2 259.33±65.60 mg/l as compare to S-1 120.11±2.73 mg/l. Turbidity of the water at S-1 was more than at S-2. Hardness is used to measures the presence of calcium and magnesium in the water, but it also includes other ions such as aluminum, hydrogen, iron, manganese, strontium and zinc. Most aquatic organisms can bear with high level of calcium hardness, but a required range is between 75mg/l - 250 mg/l with a minimum concentration of 20 mg/l. Total hardness values ranged from 115.16±19.70 mg/l to 231.44±21.17 mg/l. The mean free CO_2 values at S-1 and S-2 vary from1.21±0.15 mg/l to 2.55±0.59 mg/l. Phytoplankton and macrophyte community influences the concentration of free CO_2 concentration, as they require light and nutrient supply to convert dissolved CO_2 into plant tissue by photosynthesis [23]. The concentration of free CO_2 was within recommended value i.e. below 6.0 mg/l [7]. Dissolved oxygen (DO) is another vital water parameter. The highest DO level was noted at S-1 9.31±0.79 mg/l

and the lowest at S-2 was 6.89±0.69 mg/l. Minor fluctuation in the values of biochemical oxygen demand (BOD) at both the sites was noted. The mean values of BOD varied between 2.97±0.78 mg/l at S-1 to 3.05±0.65 mg/l at S-2. The higher BOD at S-2 may be due to organic matter degradation which utilized oxygen within the water.

The mean values of Phosphate varied from 1.02±0.20 mg/l at S-1 to 0.891±0.07 mg/l at S-2. The nitrate values varied from 0.789±0.21 mg/l to 0.925±0.45 mg/l site S-1 and S-2 respectively. No great variation was noted in sodium and potassium concentration. Sodium was found to be in the range of 0.491±0.22 mg/l at S-1 and 0.594±0.19 mg/l at S-2.

Table 1: Mean values at sampling sites for the period April 2017-March 2018.

Physico-chemical Parameters	Standard Permissible Limits (*WHO*/ BIS)	S-1	S-2
Temperature ^{o}C	*27^{0}C*	19.33 ±2.40	19.45±2.45
Transparency cm	-	11.25 ±3.95	11.45 ±4.65
Turbidity JTU	1-5	287.65 ±298.24	338.27 ±12.09
Conductivity µmhocm/l	200	0.491 ±0.05	0.410 ±0.05
T.S mg/l	-	625.0 ±299.17	578.16 ±245.34
TDS mg/l	500	244.19 ±89.51	275.10 ±105.65
TSS mg/l	-	306.32 ±256.83	191.56 ±205.42
pH	*6.5-9.2*	6.13 ±0.98	7.02 ±0.19
Total alkalinity mg/l	200	120.11 ±2.73	259.33 ±65.60
Total Hardness mg/l	*100-500*	115.16 ±19.70	231.44 ±21.17
Calcium mg/l	*200*	43.57 ±6.45	45.29 ±2.15
Magnesium mg/l	*150*	39.72 ±5.01	38.85 ±4.94
Chloride mg/l	*200–300*	28.60 ±4.59	28.44 ±4.04
Free CO_2 mg/l	-	1.21 ±0.15	2.55 ±0.59
D.O mg/l	*4-6*	9.31 ±0.79	6.89 ±0.69
B.O.D mg/l	*28-30*	2.97 ±0.78	3.05 ±0.65
C.O.D mg/l	10	4.24 ±0.57	5.09 ±0.43
Phosphates mg/l	-	1.02 ±0.20	0.891 ±0.07
Nitrates mg/l	*50*	0.789 ±0.21	0.925 ±0.45
Sodium mg/l	-	0.491 ±0.22	0.594 ±0.19
Potassium mg/l	-	0.485 ±0.10	0.589 ±0.16

4. Discussion

Relationship between various Physico-chemical parameters

Pearson's correlation (r values) was used to identify the relationships between various physico-chemical parameters. Table 2 shows: Transparency was positively correlated with Temperature ($r = 0.249$, $p < 0.10$) and Electrical Conductivity ($r = 0.406$, $p < 0.10$). Whereas, Turbidity was negatively correlated with transparency ($r = 0.846$, $p < 0.10$). Total Solids were negatively correlated with Transparency ($r = -0.285$, $p< 0.10$) and Turbidity ($r = -0.879$, $p > 0.001$). TDS was found to be positively correlated with Transparency ($r = 0.060$, $p > 0.05$) and Total Solids ($r = 0.954$, $p > 0.001$). PH was negatively correlated with Temperature ($r = -0.879$, $p> 0.001$) and TSS ($r = -0.456$, $p< 0.10$). Total alkalinity was found to be negatively correlated with TDS ($r = -0.789$, $p > 0.001$) and positively correlated with pH ($r = 0.756$, $p > 0.001$). Total hardness was negatively correlated with Electrical Conductivity ($r = -0.388$, $p<0.10$) and positively correlated with total alkalinity ($r = 0.901$, $p>0.001$). Free CO_2 was positively correlated with Temperature ($r = 0.956$, $p > 0.001$) and negatively correlated with pH ($r = -0.957$, $p > 0.001$). DO was negatively correlated with temperature ($r = -0.920$, $p > 0.001$) and free CO_2 ($r = -0.931$, $p>0.001$). BOD was positively correlated with temperature ($r = 0.973$, $p >0.001$) and negatively correlated with DO ($r = -0.947$, $p > 0.001$). The study showed negative correlation between DO and pH. Clausen, B. and Biggs, B. J. F. (1997) also noted the same in their respective studies. No significant correlation among Potassium, Nitrate, Phosphate and Sodium ions was noted and also with other parameters during the study period.

Table 2: Pearson Correlation (r-values) calculated between physico-Chemical parameters for the period April 2017-March 2018

	Temp.	Transparency	Turbidity	EC	T.S	TDS	TSS	pH	T Alk	T HD	Ca	Mg	Cl	F CO_2	DO	B.O.D	C.O.D	PO_4	NO_3	Na	K
Temp.	1																				
Transparency	0.249	1																			
Turbidity	-0.846	0.295	1																		
EC	0.406	-0.765	-0.801	1																	
T. Solids	0.743	-0.285	-0.879	0.793	1																
TDS	0.857	0.060	-0.896	0.478	0.954	1															
TSS	0.369	-0.823	-0.775	0.912	0.785	0.576	1														
pH	-0.879	-0.107	0.873	-0.477	-0.805	-0.979	-0.456	1													
T Alk	-0.867	-0.483	0.597	-0.049	-0.588	-0.789	-0.028	0.756	1												
T HD	-0.837	-0.186	0.769	-0.388	-0.789	-0.789	-0.286	0.886	0.901	1											
Ca	-0.841	-0.225	0.748	-0.267	-0.784	-0.894	-0.278	0.879	0.897	0.901	1										
Mg	-0.859	-0.215	0.764	-0.250	-0.798	-0.873	-0.297	0.898	0.888	0.905	1	1									
Cl	-0.778	-0.783	0.271	0.267	-0.283	-0.598	0.267	0.648	0.898	0.711	0.716	0.715	1								
F CO_2	0.956	0.173	0.419	0.415	0.752	0.897	0.398	-0.957	-0.873	-0.805	-0.891	-0.918	-0.709	1							

DO	-0.920	-0.501	0.519	-0.089	-0.614	-0.788	-0.059	0.875	0.896	0.864	0.892	0.897	0.904	-0.931	1						
B.O.D	0.973	0.201	-0.786	0.381	0.789	0.901	0.298	-0.887	-0.905	-0.879	-0.864	-0.892	-0.745	0.898	-0.947	1					
C.O.D	0.897	0.508	-0.486	0.010	0.544	0.789	-0.010	-0.782	-0.911	-0.892	-0.879	-0.886	-0.910	0.907	-0.904	0.879	1				
PO_4	0.889	0.065	-0.867	0.512	0.876	0.794	0.492	-0.987	-0.803	-0.905	-0.918	-0.915	-0.605	0.911	-0.807	0.897	0.798	1			
NO_3	-0.783	0.287	0.895	-0.782	-0.884	-0.86	-0.765	0.897	0.587	0.783	0.779	0.785	0.298	-0.789	0.659	-0.787	-0.46	-0.905	1		
Na	0.286	0.907	0.182	-0.765	-0.183	0.127	-0.698	-0.201	-0.597	-0.289	-0.309	-0.304	-0.804	0.284	-0.598	0.287	0.605	0.151	0.188	1	
K	0.784	-0.296	-0.879	0.816	0.891	0.835	0.801	-0.789	-0.487	-0.794	-0.704	-0.703	-0.198	0.824	-0.578	0.789	0.487	0.799	-0.902	-0.215	1

Temp. = Temperature, EC = Electric Conductivity, TS = Total Solids, TDS = Total Dissolved Solids, TSS =Total Suspended Solids, T ALK = Total Alkalinity, T HD= Total Hardness, Ca = Calcium, Mg = Magnesium FCO_2 = Free Carbon Dioxide, D.O = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand, PO_4= Phosphate, NO_3 = Nitrate, Na = Sodium, K = Potassium

Relationship between Physico-chemical parameters of water and Phytoplankton diversity

Maximum number of total phytoplankton indicates good physico-chemical conditions (Guru, S. D. 2008). The study identified 35 taxa of phytoplankton residing in the river. The distribution of the same was: Bacillariophyceae (14 genera), Chlorophyceae (15 genera) and Myxophyceae (6 genera). Table 4 shows mean variation at both the sites. Maximum diversity of phytoplankton was recorded for Bacillariophyceae which was 239.25±84.03 unit/ l at S-1 and 167.53±74.18 unit/l at S-2. The family Bacillariophyceae was represented by *Ceratoneis, Amphora, Caloneis, Fragilaria, Navicula, Synedra, Diatoms, Gomphonema, Pinnularia, Melosira, Tabellaria, Denticula, Cymbella, and Cyclotella.* The Bacillariophyceae was positively correlated with pH (r = 0.253, p < 0.10) and DO (r = 0.630, p< 0.02). The Chlorophyceae was the highest at S-1, 144.13±89.43 Unit/l and 109.48±67.38 Unit/l at S-2.

The family Chlorophyceae was represented by *Chlorella, Chlaymydomonas, Spirogyra, Ulothrix, Hydrodictyon, Cladophore, Cosmarium, Chlorococcum, Oedogonium, Microspora, Desmidium, Chara, Zygenema, Syndesmus, and Volvox.* Chlorophyceae was positively correlated with turbidity (r = 0.347, p <0.10), total alkalinity (r = 0.655, p >0.02), DO (r =0.946, p > 0.001) and negatively correlated with temperature (r = -0.800, p < 0.001), free CO2 (r = -0.780, p > 0.01) and phosphate (r = -0.691, p> 0.01).

The Myxophyceae was represented by *Nostoc, Anabaena, Oscillatoria, Rivularia, Coccochloris, Phormidium.* The study showed the diversity of Myxophyceae values ranged from 28.14±22.11 Unit/l to 21.91±20.33 unit/l. Myxophyceae was found to be positively correlated with temperature (r = 0.071, p >0.01) and DO (r = 0.239, p < 0.10). Phosphate, nitrate and chloride contents play an important role in their distributional pattern (Rai, H. 1974 and Barrett, P. H. 1957). Figure 2 (a-e) show various types of phytoplankton found in the Godavari river water during the study period.

Table 4: Qualitative and quantitative distribution (mean values at sampling sites) of phytoplankton (Unit/l) for the period of April 2017- March 2018

Phytoplankton	S-1	S-2
Bacillariophyceae		
Ceratoneis	9.00±3.11	8.41±3.87
Amphora	9.66±7.35	5.90±4.05
Caloneis	4.00±3.03	3.90±3.67
Fragilaria	42.45±15.03	20.90±8.04
Navicula	30.33±9.76	33.39±7.65
Synedra	8.91±3.03	12.62±6.25
Diatoms	28.16±6.33	13.00±5.23
Gomphonema	19.25±8.20	13.30±6.45
Pinnularia	6.25±4.47	7.53±4.21
Melosira	15.41±4.12	6.41±4.20
Tabellaria	22.25±4.52	14.50±6.12
Denticula	14.75±6.84	4.70±2.53
Cymbella	14.25±4.05	19.47±9.01
Cyclotella	14.58±4.19	3.50±2.90
Total	239.25±84.03	167.53±74.18
Chlorophyceae		
Chlorella	18.58±8.68	13.16±10.12
Chlaymydomonas	13.83±9.09	8.41±4.50
Spirogyra	14.58±13.43	6.91±4.25
Ulothrix	8.49±5.41	7.41±6.03
Hydrodictyon	5.91±4.37	6.80±3.54
Cladophore	7.83±4.46	4.12±3.21
Cosmarium	5.90±4.46	8.41±6.29
Chlorococcum	8.83±4.04	6.33±4.11
Oedogonium	11.89±5.63	9.53±3.37
Microspora	9.33±7.42	9.14±5.40
Desmidium	13.41±7.33	13.41±5.38
Chara	8.08±3.51	3.40±2.35

Zygenema	6.74±4.04	2.50±2.47
Syndesmus	5.58±3.26	4.70±3.35
Volvox	5.15±4.30	5.25±3.31
Total	144.13±89.43	109.48±67.68
Myxophyceae		
Nostoc	5.75±4.19	3.33±2.07
Anabaena	4.25±3.62	3.68±4.12
Oscillatoria	1.91±2.30	2.50±3.01
Rivularia	3.57±3.01	4.21±3.08
Coccochloris	5.40±4.35	4.13±4.02
Phormidium	7.26±4.64	4.06±4.03
Total	28.14±22.11	21.91±20.33

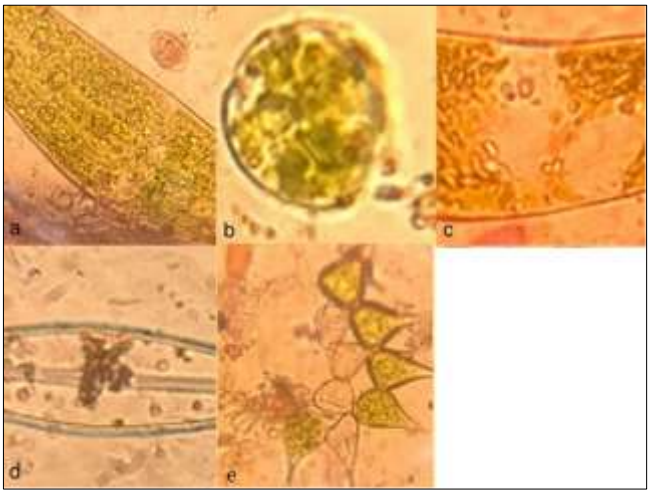


Fig 2(a-e): Various types of phytoplankton found in Godavari river water: a. Bacillariophyceae -Ceratoneis b. Chlorophyceae - Volvox c. Bacillariophyceae - Pinnularia. d. Bacillariophyceae - Cymbella e. Myxophyceae – Pediastrum

Relationship between Physico-chemical parameters of water and Zooplankton diversity

The study found 28 taxa of zooplanktons in the Godavari River. Among them Protozoa - 10 genera, Rotifera - 11 genera, Copepoda - 6 genera and Ostracoda - 2 genera. Table 5 shows mean variation in their population at both the sites. Zooplankton diversity was noted maximum for Rotifera 181.99±85.94 Unit/l at S-1, and 137.09±59.79 Unit/l at S-2. The dominance of Rotifera was not unexpected as it is the most dominant group in the most aquatic ecosystems [14, 2]. Among the zooplankton the Rotifera was represented by *Ascomorpha, Asplanchna, Brachionus, Keratella, Nolthoca, Philodina, Pompholix, Polyarthra Rotatoria, Testudinella, Trichocera.* Near about 1700 species of rotifers have been described around the world and 500 species (only 330 species belonging to 63 genera and 25 families have so far been authenticated) was described from Indian water bodies [29]. Rotifera was found to be positively correlated with pH ($r = 0.694$, $p < 0.02$), Total Alkalinity ($r = 0.957$, $p > 0.001$) and DO ($r = 0.913$, $p > 0.001$) and negatively correlated with Temperature ($r = -0.743$, $p > 0.01$) and BOD ($r = -0.728$, $p > 0.01$). The study found that Protozoans was found to be highest 135.44±72.35 Unit/l at S-1 and 107.66±57.43 Unit/l at S-2. The Protozoa was represented by *Actinophrys, Actinosphaerium, Arcella, Campenella, Diffugia, Epistylis, Euglena, Paramecium, Peridinium, and Vorticella*. The population density and biomass of zooplankton during the study period can be correlated with high population of phytoplankton food source which were highly abundant within the river. It has been observed that increase in primary production (phytoplankton), leads to increase in zooplankton number and biomass [31]. Increase in phytoplankton population leads to increase in the zooplankton biomass. The protozoa was found to be positively correlated with TSS ($r = 0.085$, $p < 0.10$) and Chloride ($r = 0.878$, $p > 0.001$) and negatively correlated with Temperature ($r = -0.868$, $p > 0.001$) and Phosphates ($r = -0.757$, $p < 0.001$). Copepoda were in the range of 72.50±33.34 Unit/l at S-1 and 43.38±28.71 Unit/l at S-2. The Copepoda was represented by *Bosmina, Cyclops, Daphnia, Diaptomus, Helobdella and Nauplius Stages.* Copepoda were positively correlated with Total Alkalinity ($r = 0.498$, $p < 0.05$) and negatively correlated with Temperature ($r = -0.212$, $p > 0.10$) and Free CO_2 ($r = -0.152$, $p < 0.10$). Ostracoda were recorded maximum and minimum in the water and represented by Cypris and Stenocypris. Ostracoda were positively correlated with pH, Total Alkalinity, Chloride and DO. The species composition of zooplankton with dominance of rotifers was also observed in present study. Pearson's correlation coefficient showed several environmental variables exert pressure on the zooplankton abundance. Especially, DO, Temperature, Total Alkalinity, Total Hardness, Phosphate and pH. The present study also asserts the influence of these abiotic factors on zooplankton population. The below figure 3 (a and b) shows the species found in the water at the selected sites

Fig 3: a. Cladocera and b. Rotifiera

Table 5: Qualitative and quantitative distribution (mean values at sampling sites) of Zooplankton (Unit/l) for the period April 2017 - March 2018

Zooplankton	S-1	S-2
Protozoans		
Actinophrys	11.00±7.07	9.25±5.99
Actinosphaerium	10.25±6.01	9.00±5.03
Euglena	14.66±8.31	15.25±6.41
Paramecium	16.66±9.16	15.58±7.15
Peridinium	11.44±7.30	9.66±7.04
Campenella	11.44±6.22	9.83±7.38
Epistylis	13.69±6.24	9.16±5.10
Vorticella	15.38±7.73	9.12±5.15
Arcella	15.63±7.42	10.50±5.11
Diffugia	15.29±6.89	10.31±6.07
Total	135.44±72.35	107.66±57.43
Rotifera		
Keratella	16.00±9.04	12.16±6.29
Nolthoca	18.75±8.56	12.05±6.01
Rotatoria	16.58±7.28	8.78±3.38
Testudinella	17.91±9.69	9.55±4.07
Ascomorpha	16.15±7.28	13.91±4.27
Trichocera	18.65±9.42	10.96±4.29
Philodina	17.82±10.66	15.53±7.02
Asplanchna	15.57±5.51	12.20±5.48
Pompholix	16.41±5.22	16.01±6.07
Brachionus	14.41±5.21	16.03±6.47
Polyarthra	13.82±8.07	9.91±6.44
Total	181.99±85.94	137.09±59.79
Copepoda		
Cyclops	13.00±5.34	5.33±3.18
Diaptomus	14.58±6.95	5.08±5.01
Daphnia	12.66±7.03	8.58±5.25
Bosmina	11.08±5.17	5.16±4.05
Helobdella	8.03±4.49	7.15±4.11
Nauplius Stages	13.15±4.36	12.08±7.11
Total	72.50±33.34	43.38±28.71
Ostracoda		
Cypris	10.24±6.29	5.11±3.04
Stenocypris	8.16±6.36	6.03±5.03
Total	18.40±12.65	11.14±8.07

Table 6: Pearson Correlation (r-values) calculated between Phytoplankton diversity and Physico-Chemical parameters for the period April 2017-March 2018

Phytopl	Te	Tr	T	E	T.	T	T	p	T	T	C	M	Cl	F	D.	B.	C.	P	N	N	K
Chlorop	-	-	0.	0.	-	-	0.	0.	0.	0.	0.	0.	0.	-	0.	-	-	-	0.	-	-
Bacillari	-	-	-	0.	0.	-	0.	0.	0.	0.	0.	0.	0.	-	0.	-	-	-	-	-	0.
Myxoph	0.0	-	-	0.	0.	0.	0.	-	0.	-	-	-	0.	0.	0.	0.0	-	0.	-	-	0.
Protozo	-	-	0.	0.	-	-	0.	0.	0.	0.	0.	0.	0.	-	0.	-	-	-	0.	-	-
Rotifera	-	-	0.	0.	-	-	0.	0.	0.	0.	0.	0.	0.	-	0.	-	-	-	0.	-	-
Copepo	-	-	-	0.	0.	-	0.	0.	0.	0.	0.	0.	0.	-	0.	-	-	-	-	-	0.
Ostraco	-	-	-	0.	0.	-	0.	0.	0.	0.	0.	0.	0.	-	0.	-	-	-	-	-	0.

Temp. = Temperature, Trans. = Transparency, Turb. = Turbidity, EC = Electric Conductivity, TS = Total Solids, TDS = Total Dissolved Solids, TSS =Total Suspended Solids, T ALK = Total Alkalinity, T HD= Total Hardness, Ca = Calcium, Mg = Magnesium, FCO_2 = Free Carbon Dioxide, D.O = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand, PO_4= Phosphate, NO_3 = Nitrate, Na = Sodium, K = Potassium

5. Conclusion

Water serves as a natural medium in the growth of aquatic life, whether it's flora or fauna. Release of the wastes by natural or artificial (human activities) factors results into disturbing its composition. This affects the optimum conditions favorable for the growth of the aquatic life. In case of the present study very contrasting hydro and biological conditions were noticed at the both the sites during the study period. It has been noticed that the overall plankton diversity was higher at S-1 than at S-2. The reason might be the conditions that are more favourable for the planktonic diversity present at S-1. However, the river was not devoid of pollution but the abiotic factors, being in good condition, made the plankton to survive in the water. It can be concluded from the study that the pollution of the river has attained alarming dimensions and affected badly its algal community. The hydrological parameters of the river have been greatly declined due to industrial and human activities. The abiotic factors have directly affected the diversity of plankton and resulted in decreased in their diversity. If the necessary steps are not taken by Government and non-Government agencies then it can help in alleviating and abating further degradation of the river and its ecosystem.

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