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Diversity of Plankton and their seasonal variation of Density in the Yamuna River at Dakpathar, District Dehradun, Uttarakhand

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Abstract

Present paper deals with the analysis of diversity of Plankton (i.e. Phytoplankton and Zooplankton) and their seasonal variation of density in the Yamuna river at Dakpathar, District Dehradun, Uttarakhand. As understanding the process of plankton variations is useful in water quality improvement and management decisions, the present investigation was carried out o know the Limnobiotic status of Yamuna river, over a period of April 2021 to March 2022. In this study the plankton composition; abundance; seasonal variations were studied based on monthly sampling campaign from four sampling stations. A total 38 genera and 60 species which belong to chlorophyta (18 genus, 34 species), Bacillariophyta (11 genus, 12 species), Cyanophyta (10 genus, 12 species), Euglenophyta (2 genus, 3 species) were identified. Phytoplankton community structure and water quality variable changed. Phytoplankton population size was correlated with physico-chemical parameters (Temperature, pH, Alkalinity, Dissolved oxygen, Biological oxygen demand, Total solids, Total dissolved solids, chloride, Nitrate, Sulphates and Phosphates). Pearson correlation analysis as was applied to analyse the relationship among them.

Temperature, phosphorous and nitrate played vital roles in the phytoplankton dynamics of Yamuna river during all periods investigated.

Keyword : Plankton, Phytoplankton, Yamuna river, physico-chemical parameters

Introduction

The term 'Plankton' is used for assemblage of microscopic, free floating organisms in water which wander at the mercy of winds and currents. Depends upon the nature plankton can be divided in two named as phytoplankton and zooplankton. Phytoplankton are chlorophyll bearing suspended microscopic organisms consisting mainly of algae. The majority of the members of phytoplankton belongs to Chlorophyceae, Cyanophyceae and Bacillariophyceae group of algae. Phytoplankton are the basic members of aquatic ecosystems and hence change in phytoplankton population has a direct link with the change of water quality in any aquatic medium. Phytoplankton, being the primary producer, forms the lowest trophic level in the food chain of fresh water ecosystem. In water bodies, seasonal qualitative and quantitative fluctuations occurs in plankton communities. Their density varies according to the nature of water (Kumar and Khare, 2015). Zooplankton are the microscopic animal components of aquatic system which move at the mercy of the water movements : Protozoans, Rotifers, Cladocerans and Copepods constitute the major groups of Zooplankton. Zooplankton constitute an important link between primary producers (phytoplankton) and higher consumers (fishes) in aquatic food webs. Zooplankton diversity is one of the most important ecological parameter in water quality assessment. Considering the importance of plankton diversity and variation in their density, several studies have been made in this area. Dhanapathi, 2000; Rajshekhar, 2010; Khanna et al., 2012; Shinde, 2012 Kadam et al., 2014; Kumar and Khare, 2015. Environmental variables such as temperature, phosphates and nitrates play a decisive role in altering the phyoplankton density. Plankton is most sensitive floating community which is being the first target of water pollution. Thus undesirable change in aquatic ecosystem, affects diversity as well as biomass of this community. The measurements of plankton productivity help to understand conservation's ratio at

varies tropical level and resources as an essential input for proper management of aquatic water bodies. Therefore, this study was carried out to investigate the composition diversity of plankton (Phyoplankton and Zooplankton) and physico-chemical parameters of Yamuna river at Dakpathar, district Dehradun, Uttarakhand.

Materials and Methods

Study Area : Dakpathar, also spelled Dakpatthar and Dak Pather is a small hill town situated in Dehradun district of Uttarakhand, India. It is on the left bank of the Yamuna River and 45 km (28 mi) north-west of the city of Dehradun. Dakpathar lies about 790 meters (2,590 ft) above sea level at the foothills of Shivalik range. It is the location of the Dakpathar Barrage, which forms a reservoir along the town that is popular for recreation. The Dam itself is 518 m (1,699 ft) long and is a combination of river Yamuna and river tons at khodri. It serves to divert water into the East Yamuna Canal for hydroelectric power production at the Dhakrani and Dhalipur Power Plants. The Yamuna is the second largest tributary of the Ganges by discharge and the longest tributary in India. Originating from the Yamunotri Glacier at a height of about 4,500 m on the southwestern slopes of Bandarpunch peaks of the Lower Himalaya in Uttarakhand, it travels 1,376 kilometres and has a drainage system of 366,223 square kilometres, 40.2% of the entire Ganges Basin. It merges with the Ganges at Triveni Sangam, Allahabad (Prayag Raj).

Physico-Chemical Analysis : Surface water was collected from all four sampling sites. Collections were made using plastic containers of 2 litre capacity. The containers were rinsed thoroughly with sampling water before use. After filling the containers, they were sealed and transferred to the laboratory for physico-chemical analysis. Water temperature was recorded in the field using sensitive mercury thermometer. The pH of the samples was determined using digital pH meter. The transparency of water to light was measured by using Secchi disc. Physico-chemical parameters of the water analysed according to standard Methods (APHA-AWWA and WEF, 2005).

Phytoplankton Analyses : Plankton net (Mesh size 25μm) was swept on surface water and plankton was collected and transferred into plastic. Then plankton samples were on centrifuged at 1500-2000 rpm for 10-12 minutes. The phytoplanktons settled were diluted to a desirable concentration in such a way that they could be easily counted individually under compound binocular microscope and phytoplankton were measured and multiplied with the dilution factors using Sedwick Rafter Cell. Pearson correlation matrix was used to establish the relationship among various environmental variables and phytoplankton density with help of SPSS 16.0 for window.

Results and Discussion

The phytoplankton composition of Yamuna river was constituted by Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae variation in the qualitative and quantitative estimation of phytoplankton was recorded seasonally with the biomodal fluctuation of individual group in Table 1 to 2.

In present study, the phytoplanton community in Yamuna river was represented by members of Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae as represented in Table 1 and their stationwise occurrence is depicted in Table 2. The phytolpankton comprised 38 species of which 14 species belong to Chlorophyceae, 11 species of Bacillariophyceae, 10 species of Cyanophyceae and 3 species of Euglenophyceae. In present study, the abundance of phytoplankton was highest during winter and summer season, which could be attributed to more stable hydrographical conditions prevailing during summer months. The abundance of phytoplankton was lowered during the rainy season when the water column was remarkably stratified to a large extent because of heavy rainfall, high turbidity caused by runoff and decreased temperature and pH (Table 3). Chlorophyceae, Cyanophyceae and Euglenophyceae were found to be most abundant in the summer season followed by the rainy, winter season.

In the present investigation the dominance of Chlorophyceae like *Spirogyra, Scenedesmus, Chlamydomonas, Coelastrum, Microspora, Pediatrum* etc. was recorded (near Kunja Grant, Dhalipur and Asan) and second dominant group is Bacillariophyceae like *Synedra, Novicula, Cymbella, Fragillaria* was noted (near Kunja Grant, Dhalipur and Asan). The most pollution tolerant species *Euglena, Naviculla, Nitzschia, Scendedesmus, Chalamydomonas* were recorded at all the stations, indicating the highest degree of organic pollution.

Water quality such as temperature, pH, Dissolved Oxygen, Phosphate and Nitrate clearly influence the distribution of organism and effect their density in wetland system. The major inorganic nutrients required by phytoplankton for growth and reproduction are nitrate and phosphate. Similar observation

were noted by Kumar and Jha (2015), who gave a detailed account of dominant species of diatoms being used as indicators of water quality.

Water quality parameters such as temperature, nitrate and phosphate clearly influence the distribution of organisms and affect their density in wetland systems. The major inorganic nutrients required by phytoplankton for growth and reproduction is nitrate. Other inorganic and organic nutrients may be required in small amounts. All of these nutrients are the limiting factors for phytoplankton productivity under good conditions. Temperature has a direct effect on certain chemical and biological activities of the organisms in aquatic media. The increase in temperature could due to the fact that in winter the photoperiod is shorter and less intense than in summer (Kumar and Jha, 2015). DO and pH are indicator of good quality water, indicating various favourable conditions for high primary and secondary phytoplankton production. Dissolved oxygen is fit for the survival of aquatic organisms and is also used to evaluate the degree of freshness of a river system. Phosphate is a major nutrient for plankton growth, which might be due to utilization of phosphate as nutrients by algae and other aquatic plants. In present study, the phytoplankton community in Yamuna river was represented by members of Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae. Chlorophyceae was the dominant group of all the four stations, followed by Bacillariophyceae, Cyanophyceae and Euglenophyceae. Near Kunja Grant, Dhalipur, Tarlittur and Asan, the phytoplankton occurrence was in the order as Chlorophyceae > Bacillariophyceae > Cyanophyceae > Euglenophyceae throughout the study period. Palmar (1969) recorded to identify and prepare a list of genera and species of algae tolerant to organic pollution and also observed that genera like *Oscillatoria, Euglena, Scenedesmus, Nevicula, Chamydomonas* were species found in organically polluted water as supported by Kumar and Jha (2015). Saha et al. (2000) recorded that *Oscillatoria, Euglena* and *Chlorella* are typical inhabiting of heavily polluted water and that *Euglena* and *Oscillatoria* are highly pollution tolerant genera. The present investigation near Kunja Grant, Dhalipur and Tarlittur phytoplankton were found abundant throughout the study even more interestingly with a greater number of genera and species of pollution tolerant algae, with high Palmer's; grade point, clearly indicating a high degree of pollution. The Planktonic forms *Scenedemus, Navicula, Chlorella, Anabaena* and *Closterium* were noticed in the present study as indicators of organic pollution-tolerant species. Cyanophyta dominance and sometimes biomass are among the most visible symptoms of accelerated eutrophication of water body of Asan wetland. Patra et al. (2012) worked on seasonal variation of phytoplankton dynamics observed at Puri seashore of Bay of Bengal. Pailwar et al. (2008) recorded of limnological features, plankton diversity and fishery at Kagal, Kaneriwadi and Kandalgaon of Kolhapur district of Maharashtra. Negi et al. (2013) studied phytoplankton diversity of some selected streams of Dehradun district of Uttarakhand. Malik and Bharti (2012) noticed plankton diversity of Sahastradhara stream at Uttarakhand.

Registered zooplankton were belong to 22 species of 16 genera of different groups like as Protozoa (3 species of 3 genera), Rotifera (15 species of 5 genera), Cladocera (5 species of 5 genera) and Copepoda (2 species of 2 genera). Among recorded zooplankton Rotifera population was dominant during entire study span. Data was given in table 5. Highest density of protozoan was recorded in the month of June and lowest density was recorded in the month of July (rainy season). Maximum density of Rotifers was observed in the month of June while their minimum density was noticed in the month of August (rainy season). The finding is similar to those observed by Kumar and Khare (2015). The highest density of Cladocerans was recorded in the month of May (summer season) and their lowest density was recorded in the month of October. Maximum density of Copepods was noticed in the month of June (summer) and lowest density of this group recorded in the month of October.

Conclusion

Yamuna river was rich in diversity of Plankton. Registered phytoplankton were being 39 genera and 60 species which belong to Chlorophyta (18 genus, 34 species), Bacillariophya (11 genus, 12 species), Cyanophyta (10 genus, 12 species), Euglenophyta (3 genus, 3 species). In the study period group Chlorophyceae was dominant over rest of the phytoplankton population. Registered zooplankton were belong to 15 species of 14 genera of different group like as Protozoa (3 species, 3 genera), Rotifera (15 species), Cladocera (5 species of 5 genera) and Copepoda (2 species of 2 genera). Among recorded zooplankton Rotifera population was dominant during entire study period. It was recorded that density of plankton was maximum in summer, minimum in rainy season and intermediate in winter season.

Table 1 : Phytoplankton of the River Yamuna at Dakpathar (Dehradun)

Chlorophyceae	Bacillariophyceae	Cyanophyceae	Euglenophyceae
1. *Spirogyra rivularis* 2. *Spirogya biformis* 3. *Spirogyra hollandieae* 4. *Scenedesmus* sp. 5. *Scenedesmus dimorphus* 6. *Scenedesmus quadricauda* 7. *Chlamydomonas* sp. 8. *Coelastrum microporum* 9. *Ulothrix zonata* 10. *Microspora willeana* 11. *Eudorina* sp. 12. *Pediastrum simplex* 13. *Pediastrum duplex* 14. *Euastrum binate*	1. *Synedra incisa* 2. *Novicula baccata* 3. *Novicula cuspidata* 4. *Cymbella affinis* 5. *Fragillaria construens* 6. *Amphora veneta* 7. *Fragillaria construens* 8. *Nitzschina angustata* 9. *Nitzschia baccata* 10. *Cymbella affinis* 11. *Cymbella delicatula*	1. *Anabaena constica* 2. *Apnaocapsia biformus* 3. *Aphanococcus minor* 4. *Spirulina major* 5. *Spirulina* sp. 6. *Antrhrospira jenneri* 7. *Microcystis aeruginosa* 8. *Synechocystis aqualitis* 9. *Oscillatoria formossa* 10. *Oscillatoria animalis*	1. *Euglena acus* 2. *Euglena* sp. 3. *Euglena viridus*

Table 2 : Floristic Diversity of Phytoplankton at four stations of Yamuna River at Dakpathar

S. No.	Name of Species	S.S.I (Kunja Grant)	S.S.II (Dhalipur)	S.S.III (Tarlittur)	S.S.IV (Asan)
Chlorophyceae					
1	*Spirogyra rivularis*	+	+	-	+
2	*Spirogya biformis*	+	-	+	+
3	*Spirogyra hollandieae*	+	+		
4	*Scenedesmus* sp.	+	+	+	
5	*Scenedesmus dimorphus*	+	-	+	+
6	*Scenedesmus quadricauda*	+	+	+	+
7	*Chlamydomonas* sp.	+		+	-
8	*Coelastrum microporum*	+	+	+	+
9	*Ulothrix zonata*	+	+	+	+
10	*Microspora willeana*	+	+	+	+
11	*Eudorina* sp.	+	+	+	+
12	*Pediastrum simplex*	+	+	+	+
13	*Pediastrum duplex*	+	+	+	-
14	*Euastrum binate*	+	+	+	+
Bacillariophyceae					
1	*Synedra incisa*	-	+	+	-
2	*Novicula baccata*	+	-	+	-
3	*Novicula cuspidata*	+	+	+	+

4	*Cymbella affinis*	-	+	+	+
5	*Fragillaria construens*	+	-	+	+
6	*Amphora veneta*	+	+	-	+
7	*Fragillaria construens*	+	-	-	+
8	*Nitzschina angustata*	+	-	+	+
9	*Nitzschia baccata*	+	+	+	+
10	*Cymbella affinis*	+	+	+	+
11	*Cymbella delicatula*	+	+	+	+
Cyanophyceae					
1	*Anabaena constica*	+	+	+	-
2	*Apnaocapsia biformis*	+	-	+	-
3	*Aphanoococcus minor*	+	+	+	+
4	*Spirulina major*	+	+	+	+
5	*Spirulina* sp.	+	+	-	+
6	*Antrhrospira jenneri*	+	-	+	+
7	*Microcystis aeruginosa*	+	+	-	+
8	*Synechocystis aqualitis*	+	+	+	-
9	*Oscillatoria formossa*	+	+	+	+
10	*Oscillatoria animalis*	+	-	-	+
Euglenophyceae					
1	*Euglena acus*	+	-	+	-
2	*Euglena* sp.	-	-	+	+

3	*Euglena viridus*	+	-	-	+

+ Present – Absent

Table 3 : Physico-chemical Parameters of Yamuna River at Dakpathar

Seasons	Stn.	Temp. (°C)	pH	D.O. (mg/l)	BOD (mg/l)	NO_3 (mg/l)	PO_4 (mgl)	Transparency (cm)	SO_4 (mgl)
Summer	1	24.30	7.02	3.41	3.51	0.78	0.19	40.62	10.00
	2	24.20	7.01	3.61	3.60	0.82	0.18	40.28	10.04
	3	25.12	7.03	2.54	5.50	1.00	0.21	40.51	11.30
	4	25.26	7.02	2.62	13.0	1.02	0.20	42.24	11.10
Rainy	1	20.10	6.64	5.12	2.00	1.30	0.27	30.42	10.70
	2	22.62	5.10	5.90	1.90	1.32	0.28	28.02	10.76
	3	21.02	6.00	5.80	2.01	1.30	0.30	30.00	10.10
	4	22.00	6.10	6.02	1.84	1.32	0.30	29.62	10.11
Winter	1	20.40	6.10	4.30	2.01	1.30	0.34	32.62	8.22
	2	19.36	6.60	4.20	2.40	1.31	0.38	34.00	8.21
	3	20.20	6.80	4.42	2.28	1.30	0.34	31.32	8.41
	4	20.27	6.12	4.40	2.30	1.34	0.31	34.92	8.10

Table 4 : Correlation Coefficient (r) among the Physico-chemical properties and Phytoplankton of River Yamuna at Dakpathar from April 2021 to March 2022

	Temp. (°C)	pH	D.O. (mg/l)	B.O.D. (mg/l)	SO_4 (mgl)	NO_3 (mg/l)	PO_4 (mgl)	Transparency (cm)	Phytoplankton
Temp.	1.00								
pH	0.51	1.00							
D.O.	-0.15	-0.90	1.00						
B.O.D.	0.62	0.96	-0.86	1.00					
SO_4	1.00	0.43	-0.08	0.56	1.00				

NO_3	-0.76	-0.45	0.77	-0.97	-0.71	1.00			
PO_4	-0.80	-0.90	0.71	-0.98	-0.76	1.00	1.00		
Transparency	0.59	1.00	-0.92	1.00	0.50	-0.96	-0.94	1.00	
Phytoplankton	0.32	0.99	-0.98	0.95	0.26	-0.86	-0.81	0.95	1.00

Table 5 : List of Recorded Zooplankton in the Yamuna river at Dakpathar (Dehradun)

S. No.	Genera	Species
Protozoa		
1.	Vorticella	campanula
2.	Paramecium	caudatum
3.	Arcella	dentata
Rotiera		
1.	Filinia	longiseta
2.	Keratella	cochlearis
3.	Philodina	citrina
4.	Brachionus	calyciflorus
5.	Brachionus	falcatus
6.	Brachionus	plicatilis
7.	Bropchionus	rubens
Calocera		
1.	Alona	rectangula
2.	Bosmina	longirostris
3.	Moina	brachicta
4.	Daphnia	carinata
5.	Ceriodaphina	reticulata
Copepoda		
1.	Cyclops	bicuspidataus
2.	Macrocylops	albidus

Table 6 : Average Value of Seasonal Density of Recorded Zooplankton in the Yamuna river at Dakpathar (Dehradun)

Season	Period April 2021 to March 2022	Protozoa (Org./J)	Rotifera (Org./J)	Cladocera (Org./J)	Copepoda (Org./J)
Summer Season	March	15	40	56	12
	April	18	56	70	14
	May	20	80	86	20
	June	30	100	70	31
Total		83	276	276	77
Rainy Season	March	2	19	36	30
	April	3	7	30	21
	May	5	22	20	10
	June	4	40	10	8
Total		14	88	86	69
Winter Season	March	16	50	20	20
	April	8	30	30	31
	May	6	28	21	32
	June	4	20	19	14
Total		**34**	**128**	**90**	**97**
Grand Total		**131**	**492**	**452**	**243**
Percent (%) contribution		**10.91**	**41.0**	**37.0**	**20.25**

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