Indian J.Sci.Res. 4(2) : 211-217, 2013
ISSN : 0976-2876 (Print)
ISSN : 2250-0138 (Online)

STUDIES ON SEASONAL VARIATIONS IN PHYTOPLANKTON DIVERSITY OF RIVER MAHANADI, CUTTACK CITY, ODISHA, INDIA

SUBHASHREE PANIGRAHI[a1] AND A. K. PATRA[b]

[ab]Fish Research Laboratory, P.G., Department of Zoology, Utkal University, Bhuneshwar, India

ABSTRACT

Phytoplankton in Mahanadi of Odisha investigated seasonally from January 2008 to December 2009 at three stations Up stream S_1, middle stream S_2 & down stream S_3. Result revealed that diversity of species Chlorophyceae 53.45% whrease Cyanophyceae 20.78% and Bacillariophyceae 25.77% were composed. The physicochemical parameters such as water temperature, pH, total nitrogen, total alkalinity, chloride and phosphate were significantly related to phytoplankton abundance, but total abundance and community structure of phytoplankton were not influenced by environmental factors.

KEYWORDS : Seasonal Variations, Phytoplankton Diversity, River Mahanadi, Odisha

Planktons, particularly, phytoplankton was used as indicators of water quality (APHA, 2005). Phytoplankton the most important biological phenomenon in nature on which the entire array of life depends, is the integral component of riverine ecosystem which determines the primary productivity of the system. It is the bio-indicators of water pollution. Its appearance, disappearance, density and pattern of distribution depend on biotic and a biotic factors (Escaravage and Prins, 2002; Gupta et al., 2005; Kauppila et al., 2004; Komala et al., 2013; LeQuere et al., 2005 and Lewitus et al., 1998; Escaravage et al., 1999)

The present dissertation complies the data of two consecutive years, 2008 and 2009) of study on various qualitative (Taxonomic Identification) and quantitative survey of various phytoplankton, and epiphytic groups, bimodal population peaks (standing stock and percentage composition of plank tonic tax).

MATERIALS AND METHODS

The plankton samples were collected by a plankton net of standard bolting silk cloth No. 25 (Mesh size 0.03 -0.04 mm.). Planktons were collected in every month from different zones of the sampling sites (S_1, S_2 & S_3) from 100 liters of water sample by a plastic bucket of 20 liters capacity through the plankton net. Finally, plankton sediment volume was adjusted to 30 ml. in the plankton net tube and preserved in 4% formaldehyde solution. The samples were then taken to the laboratory for qualitative and quantitative estimation under the binocular stereoscopic microscope using a Sedgwick rafter type counting cell (1ml. capacity) Escaravage and Prins ,(2002). After shaking the container containing the concentrated sub sample, 1 ml. was quickly drawn with a wide mouth pipette and poured in the plankton counting cell. All the organisms encountered were represented in absolute number. About ten counting of each sample were made and the data represented in the text were average values of the counting.

The density of population of three major groups of algae viz. Chlorophyceae, Bacillariophyceae and Cyanophyceae were estimated seasonally from 2008 to 2009. The percentage of occurrence of three groups was calculated every month by taking their value from density population (Reynolds et al., 2001).

Index of Similarity

The index of similarity between the study sites was calculated with the help of the following equation :

$$S = \frac{2c}{A+B} \times 100$$

Where, S = Czeckanovski's index of similarity

a = Number of species in a site A

b = Number of species in a site B

c = Number of species common to A and B

RESULTS

The phytoplankton composition of upstream (S_1), Dam Reservoir (S_2) and downstream (S_3) was constituted mainly by Chlorophyceae, Cyanophyceae and Bacillariophyceae. Variation in the qualitative and quantitative estimation of phytoplankton was noted

[1]Corresponding author

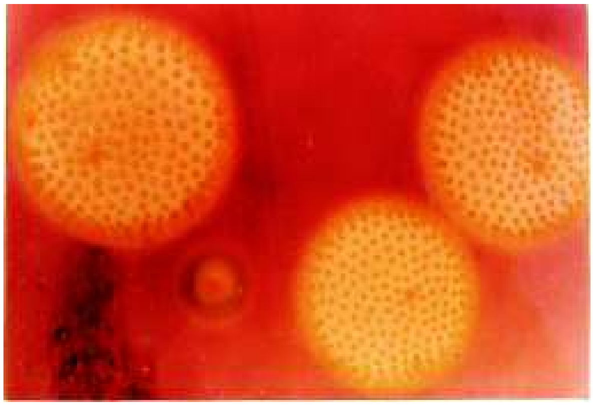

Plate.1: Photomicrograph of a Volvox colony (*Volvox globator*) at the study site. (6 x 60)

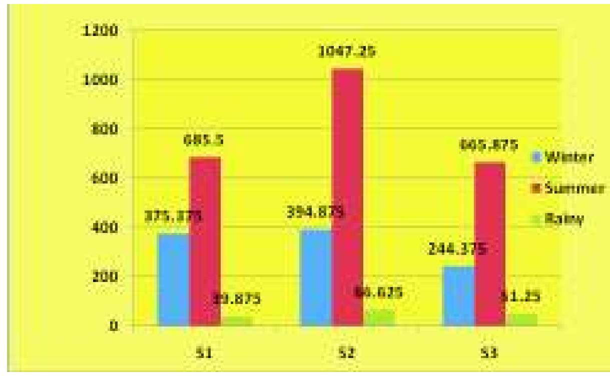

Figure 1: Seasonal Variation of distribution of (nl^{-1}) of Chlorophyceae at S_1, S_2 & S_3

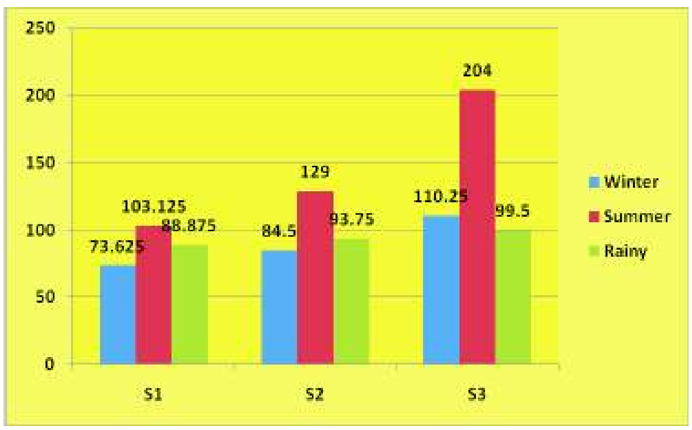

Figure 2 : Seasonal Variation of distribution of (nl^{-1}) of Cyanophyceae at S_1, S_2 & S_3

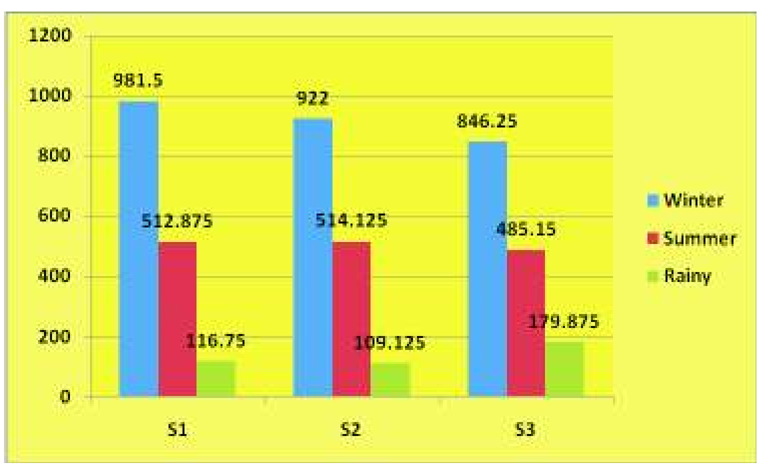

Figure 3 : Seasonal Variation of distribution of (nl^{-1}) of Bacillariophyceae at S_1, S_2 & S_3

Table 1 : Phytoplankton Abundance at Banki upstream (S_1), Dam Reservior (S_2) and Kaliaboda (S_3) of River Mahanadi During 2008 and 2009

Phytoplankton	2008			2009		
	S_1	S_2	S_3	S_1	S_2	S_3
Total species (nl^{-1})	49	49	46	41	50	44
Total number (nl^{-1})	72-2509	91-2663	53-2005	76-2332	115-2394	47-1967
Chlorophyceae species (nl^{-1})	23	26	23	20	29	24
Chlorophyceae number (nl^{-1})	7-1573	13-1487	10-1162	12-1392	25-1541	8-1009
Cyanophyceae species (nl^{-1})	11	10	10	8	9	9
cyanophyceae number (nl^{-1})	32-122	41-223	22-308	22-208	22-170	18-332
Bacillariophyceae species (nl^{-1})	15	13	13	13	12	11
Bacillariophyceae number (nl^{-1})	20-1490	15-1761	21-1160	18-1368	30-1508	21-1503

Table 2 : Seasonal variation in physico chemical parameters of River Mahanadi in Cuttack City, Odisha, India

	2008			2009			
season	water temerature	disolved oxygen	p^H	total nitrogen	total alkalinity	chloride	phosphate
winter	21°C	7.5	7.9	0.101	70.6	5	0.017
summer	30°C	5.09	7.6	0.182	73.4	7.8	0.031
rainy	27°C	6.5	7.2	0.336	40.8	3.8	0.053

seasonally with the bimodal fluctuation of individual group in Table, 1&2,Plate-1and Figure1,2 & 3 respectively.

Diversity

The total number of species belonging to different taxonomic groups were 50, 56 and 47 at (S_1), (S_2) and (S_3) respectively. Thirty five genera comprising of fifty species (Twenty six of Chlorophyceae, eleven of Cyanophyceae and thirteen of Bacillariophyceae) were identified in upstream (S_1) water whereas thirty three genera consisting of forty seven species (twenty six of Chlorophyceae, nine of Cyanophyceae and twelve of Bacillariophyceae) were identified in downstream (S_3) water. In dam reservoir (S_2) totally fifty six species of phytoplankton were identified representing thirty of Chlorophyceae, eleven of Cyanophyceae and fifteen of Bacillariophyceae. Bimodal nature of population peaks for whole phytoplankton was observed during winter and summer in term of percentage of distribution and standing stock.

Among the phytoplankton, Chlorophyceae was dominated in numerical form as well as percentage composition. Primary peak stage of plank tonic blooming was reported during winter and secondary peak was noticed during summer . Chlorophyceae showed its peak period only during summer, while Cyanophyceae showed the primary peak during summer and secondary peak during late monsoon (winter). The standing stock and percentage composition of phytoplankton flora showed the seasonal fluctuation due to the variation in composition of its different groups seasonally. Among the phytoplankton, Chlorophyceae was dominated in numerical form as well as percentage composition. Primary peak stage of plank tonic blooming was reported during winter and secondary peak was noticed during summer.

Chlorophyceae showed its peak period only during summer, while Cyanophyceae showed the primary peak during summer and secondary peak during late monsoon (winter). The standing stock and percentage composition of phytoplankton flora showed the seasonal fluctuation due to the variation in composition of its different groups seasonally.

Abundance

In the present study, it was observed that, at S_1, out of 49 species, 23 species belonged to Chlorophyceae (46.93%), 11 species to Cyanophyceae (22.44%) and 15 species to Bacillariophyceae (30.61 %) during 2008. While out of 41 species, 20 species belonged to Chlorophyceae (48.78%), 08 species to Cyanophyceae (19.51%) and 13 species to Bacillariophyceae (31.70%) during 2009.

At S_2, out of 49 species, 26 species belonged Chlorophyceae (50.94%), 10 species to Cyanophyceae (20.76%) and 13 species to Bacillariophyceae (28.30%) during 2008 and out of 50 species, 29 species belonged to Chlorophyceae (58%), 9 species to Cyanophyceae (18%) and 12 species to Bacillariophyceae (24%) population during 2009.

At S_3, out of 46 species identified 23 species belonged to Chlorophyceae (50%), 10 species to Cyanophyceae (21.73%) and 13 species to Bacillariophyceae (28.26%) during 2008. Whereas, out of 44 species, 24 species belonged to Chlorophyceae (54.54%), 09 species to Cyanophyceae (20.45%) and 11 species to Bacillariophyceae (25%) population during 2009. Among these three study sites, S_2 was dominated in total number of species in both the years .

Chlorophyceae showed only one population peak during summer; whereas, Cyanophyceae possessed two peaks i.e. primary peak during summer and the secondary peak during late monsoon (winter). Bacillariophyceae showed its primary peak during winter and the secondary peak during summer when the population strength is lower than the primary peak.

Chlorophyceae obtained its population peak during summer i.e. 1573 nl^{-1} (62.69% of total phytoplankton) at S_1 (summer'2008). Highest number of Cyanophyceae was obtained 332 nl^{-1} (27.39% of total phytoplankton) at S_3 during mid summer'2009. Bacillariophyceae reached its peak 1662 nl^{-1} (74.22% of the total phytoplanktonic stock) at S_2 during winter'2008. Population minimum (08 nl^{-1}) of Chlorophyceae during monsoon (winter' 2008) from S_1, Cyanophyceae (22 nl^{-1}) from S_2 during Rainy' 2009 and Bacillariophyceae (16 nl^{-1}) during Rainy' 2008 from S_2 were reported. Further, two prominent peaks, one in summer (blooming of Chlorophyceae) and the second one in winter (diatom blooming) were noticed amidst the lowest population in the wet season (rainy season).

The correlation coefficient between species diversity of phytoplankton groups with important physicochemical parameters has been shown in table, 2.

DISCUSSION

The present investigation had been discussed in relation to the phytoplankton composition, frequency, periodicity of dominant species in different physicochemical conditions of the aquatic environment. Presence of three groups of phytoplankton viz. Chlorophyceae, Cyanophyceae and Bacillariophyceae (diatoms) agrees with the findings of (APHA, 2005) in other riverine systems of India.

The volume and percentage contribution of phytoplankton vary from season to season in upstream (S_1), dam reservoir (S_2) and downstream (S_3) of river Mahanadi. Further, the availability of phytoplankton in the riverine ecosystem depended upon its physiographic. Reduced numbers of phytoplankton had been reported from acidic water and it was supported by Lewitus et al.,(1998).

The maximum number of phytoplankton population was recorded in winter and summer and minimum in monsoon (Gupta et al., 2005) demonstrated that phytoplankton has a remarkably adaptability to change in salinity. The maximum numerical abundance of the phytoplankton community in the post monsoon might be attributed to the impact of nutrients through surface run off during monsoon at high precipitation rate. In dam reservoir (S_2) water ,the phytoplankton density was higher than the upstream (S_1) and downstream (S_3) water. This increase in algal density and diversity was perhaps due to the nutrient load in the water from the catchment area during monsoon and low water current. On the other hand, in upstream and downstream water the phytoplankton density was lower which might be due to high water current distribution of algal forms in any habitat depends Upon the natural changes in environmental conditions, seasonal variation, water quality and the relative adaptability of species. The results of the present study indicate that moderate flow of water provides benefits to increase phytoplankton population during winter and early summer months. Similar results had also been observed by Le Quere et al. 2005. Observed winter peak of Chlorophyceae too. The plankton community on which the whole aquatic population depends directly or indirectly was largely influenced by the interaction of number of factors (Lewitus et al.,1998). However, during the investigation it is noticed that the effect of physical forces like light and heat is of great limn logical significance as they are solely responsible for many of the phenomena like thermal stratification, chemical stratification, diurnal and seasonal variations in the number and distribution of plankton, spatial distribution of micro-and macro organisms, and cyclomorphosis etc. Further, higher value of chloride and silica may not be favorable for growth of the algae in the riverine system. It indicated that the algal population increases when the level of chloride is low. Thus, water quality has a greater influence on the ability of aquatic plants and animals to exist and grow in a stream, lake, pond or bay and pointed out that a number of physical, chemical and biological environmental circumstances acting simultaneously must be taken to consideration in understanding the fluctuations of plankton population. The effects of pollutants coming from various anthropogenic activities and factors operating on land are more pronounced at the interface. As a. major element in aquatic biota, the algal column often exhibits dramatic challenges in response to different types of pollutants. Hence, the diversity of algal components in the aquatic ecosystem serves as a reliable index for biomonitoring of pollution load (Komal et al., 2013).

So far the report of Escaravage and Prins, (2002) is concerned, the seasonal variation in a plankton population is a common phenomenon and has been attributed to many factors. During the study it was observed that the phytoplankton population was comparatively high during winter and early summer and low in rainy. The lowest population in the rainy season may be attributed to unfavorably hydrographic and physicochemical conditions of the water, which corroborated with the reports of Escaravage and Prins, (1999) and had also recorded the low density of plankton during rainy season due to high influx of flood water and rain washings and ultimately much of it was also lost in the heavy draw-down. The plank tonic concentration decreased during monsoon floods, but increased rapidly with decline in water current and turbidity during post-monsoon months. The lower values for the plankton communities during monsoon season may be attributed to high inflow of water from the catchment area changing the hydrology of the river system as a result of dilution (LeQuere et al., 2005).

Phytoplankton shows the seasonal variation in composition (nl^{-1}) with the periodic maxima and minima of Chlorophyceae, Cyanophyceae and Bacillariophyceae. The maximum number of total phytoplankton during summer season and winter season indicates the good physicochemical condition in relation to the phytoplankton population. Numerical abundance of phytoplankton has been reported from dam reservoir (S^2) and upstream (S^1) throughout the study. Comparatively its lower number from downstream (S_3) throughout the year may be attributed to the greater water current, basin morphometry and available nutrients. Further, downstream (S_3) receives many upland allochthonous components from open cast mines, which agrees with Le Quere et al.(2005). The high values of the phytoplankton number reflect entropic conditions. The high density of phytoplankton was caused due to increased levels of phosphorus and nitrogen of which the former acts as primary limiting factor. It was because phosphorus is most rapidly and commonly used by vast majority of algae and the algal growth was affected when phosphorus level was below the critical level (Kauppila et al.,2004).

The phytoplankton increases more in number after post monsoonal period and reaches its peak during early summer, utilizing phosphate and nitrogen from the medium showing an inverse correlation ship with these nutrients (with phosphate $r = -1.094$; $p < 0.01$ and with nitrogen, $r = -0.087$; $p < 0.01$). During winter and early summer the phosphate and nitrogen contents decrease with increase of autotrophy level.

The maximum phytoplankton populations found from winter and summer leading to higher productivity in summer, may be due to the favorable conditions of the water. In rainy season, the population was low, probably due to increased rainfall, the increase in water level, high water current, increase turbidity run off and dilution effect of flood. Similar results had also been observed by Kumar et al. (2005). In the present study, dissolved oxygen and phytoplankton showed a positive correlation ($r = - 0.073$; $p < 0.01$) which was in agreement with the studies of Kauppila et al.,2004.The study also revealed that the abundance of phytoplankton community was positively significant with total alkalinity ($r = 0.576$; $p > 0.01$), with chloride ($r = 1.01$; $p > 0.05$), with pH ($r = 0.262$; $p > 0.01$) whereas it was inverse with nitrogen ($r = - 0.087$; $P < 0.01$), with silicate ($r = - 0.852$; $p < 0.01$), and water temperature ($r = - 0.768$; $P < 0.05$).

Chlorophyceae

Among Chlorophyceae, the dominant species are Euglena viridi Volvox globator (Plate .1), Ulothrix zonata, Zygnema peliosporum, Pandorina morum, Phacus pleuronectes, Spirogyra sp.t appeared during major parts of the year. Some like Cosmarium reniforme Chiarella vulgaris majority of algae and the algal growth was affected when phosphorus level was below the critical level.(Komala et al., 2013)

Bacillariophyceae (Diatoms)

The results of analysis of variance showed a greater variation in both seasons and sampling stations. Lewitus et al., 1998 reported that in winter and spring the group Bacillariophyceae showed a peak density in lake Ohakari, Newzealand. Kumar et al. (2005) observed that the Bacillarian population was known to be the inhabitant of polluted water in Jhelum river, Kashmir.

Species Diversity and Equitability

Shannon -Weaver's diversity index (H) in upstream (S_1), dam reservoir (S_2) and downstream (S_3) of river Mahanadi and had shown relative changes in phytoplankton population. It was observed that throughout the studies the values were very low. In upstream and dam reservoir the index value was comparatively low than the downstream for both Cyanophyceae and Bacillariophyceae. The high diversity index value indicated that Cyanophyceae and Bacillariophyceae grow richly in the polluted area whereas Chlorophyceae can not tolerate the pollutants to the same degree as Cyanophyceae and Bacillariophyceae. However, in the present study it was revealed that the percentage contribution of different groups of phytoplankton to total plankton community varied from season to season and from station to station.

The number of plank tonic species was higher in the pollution free sites than in the sewage disposal site. The higher diversity of phytoplankton species at the pollution free sites might be attributed to the more favorable. environmental conditions. For instance, while there was more light penetration due to low total dissolved solids, dissolved oxygen was high due to greater primary productivity. The low diversity values associated with the sewage disposal site may be due to pollution stress imposed by sewage effluent and reduced transparency the maximum value H (Shannon -Weaver Index) was observed from winter to summer when physical environmental conditions were normal and lowest values during June-July to October when the environment was disturbed due to rains. According to (APHA, 2005) the Shannon Weaver Index reflects the change in community brought about by the environmental stress. The present observations land support to .(Komala et al., 2013) who opined that the higher values of H indicates the absence of stress factor and the low values appear during monsoon.

In all the study sites (S_1, S_2 and S_3) of river Mahanadi two peaks, one in winter for Bacillariophyceae and other in summer were observed for Chlorophyceae and Cyanophyceae. Winter and early summer were favorable for the growth of phytoplankton. This might be due to accumulation of nutrient in low temperature.

ACKNOWLEDGEMENT

The authors are grateful to Head of the Department of Zoology, Utkal University for providing necessary laboratory facilities.

REFERENCES

APHA 2005., Standard methods for the examination of water and waste water. 21st Edn., APHA, AWWA, WPCF, Washington, D.C.,USA

Escaravage V. and Prins T.C. 2002. Silicate availability, vertical mixing and grazing control of phytoplankton blooms in mesocosms. Hydrobiologia, **484**: 33-48.

Escaravage V., Prins T. C., Nijdam C., Samal A.C. and Peeters J.C.H., 1999. Response of phytoplankton communities to nitrogen input reduction in mesocosm experiments. Marine Ecology Progress Series, **179**: 187-199.

Gupta S.K., Dixit S. and Tiwari S., 2005. An assessment of Heavy Metals in surface water of lower lake, Bhopal, India, Poll. Res., **24**(4):805-808.

Kauppila P., Pakanen H., Raike A., Kiirikki A., Back M. and Kangas S. & P.,2004.The Baltic waters around Finland; Eutrophication continues despite decreased nutrient loading. In: P. Elorantant(ed.). Inland and Costal waters of Finland. SIL XXIX Congress, Lahti, Finland:8-14.

Komala, H.P., Nanjundaswamy L. and Devi Prasad.A.G.,2013. An assessment of Plankton diversity and abundance of Arkavathi River with reference to pollution. Advances in Applied Science Research, 4(2): 320-324.

Kumar R., Singh R.D. and Sharma K.D.,2005.Water Resources of India, Current Science, **89**(5): 794-811.

LeQuere C., Harrison S.P., Prentice I.C., Buitenhuis E.T., Aumont O., Bopp L.and Clauster H. ,2005. Ecosystem dynamics based on plankton functional type for Global ocean biogeochemistry models. Global change Biology, **11**: 2016-2040.

Lewitus, A J., Koepfler E.T. and Morris J.T. ,1998. Seasonal variation in the regulation of phytoplankton by nitrogen and grazing in a salt-marsh estuary. Limnology and Oceanography, **43**(4):636-646.

Reynolds C.S., Irish A. E. and Elliott J.A .,2001. The Ecological basis for simulating Phytoplankton responses to environmental change (Protech). Ecological modeling, **140**: 271-291.