Universal Journal of Environmental Research and Technology
 eISSN 2249 0256
Available Online at: **www.environmentaljournal.org**
Volume 3, Issue 2: 266-272

Open Access **Research Article**

Primary Productivity in Relation to Planktonic Biodiversity in a Stretch of Gang Canal (Rajasthan)

R.K.Bishnoi[1], B.K.Sharma[2] , V.S. Durve[3] and L.L.Sharma[4]

[1].Sr. Lecturer Department of Zoology, BRG, Govt. P.G. Girl's College, Shri Ganganagar (Rajasthan).
[2]Professor, College of Fisheries, MPUAT, Udaipur (Rajasthan)
[3].Ex. Professor, Department of Limnology & Fisheries, MPUAT, Udaipur (Rajasthan)
[4] Ex. Professor, & Dean College of Fisheries, MPUAT, Udaipur (Rajasthan)

Corresponding author: bhanuksharma@yahoo.co.in

Abstract:

The primary productivity of any aquatic ecosystem depends on the planktonic biodiversity. The estimation of primary productivity of a water body helps in measuring its ability to support a biological population and sustain a level of growth and respiration. It is the most important of all biological phenomena on which the entire diverse life depends directly or indirectly. The phytoplankton of Gang canal comprises of 16 species belonging to 15 genera. Out of these, 8 species belong to *Bacillariophyceae*, 5 to *Chlorophyceae*, 2 to *Myxophyceae* and 1 to *Xanthophyceae*. The present investigation was carried out to estimate the primary productivity of Gang canal. The annual yield at the four stations, of Gang canal gives the average GPP as 0.132gc/m^3/hr at station 1 while NPP was 0.089gc/m^3/hr. At station 2, the corresponding values were 0.130 and 0.088gc/m^3/hr respectively. At stations 3 and 4 the average GPP values were 0.118 and 0.119gc/m^3/hr respectively, while the NPP was 0.08gc/m^3/hr on both the stations. The overall average values for the GPP and NPP in the Gang canal, based on the data of all the four stations were 0. 124gc/m^3/hr as GPP and 0.084gc/m^3/hr as NPP (Table 1.3).

Keywords: Canal, Gross Primary Productivity, Lentic water, Lotic water, Net Primary Productivity, Phytoplankton, Potamoplankton, Respiration rate.

1.0 Introduction:

True plkanktonic communities are said to be absent in lotic waters (Maitland, 1990).With the decrease in the water flow, localized lentic conditions develop which support a sparse plankton. Such a plankton is invariably contributed by *chlorophyceae*, diatoms, protozoans, rotifers and some small crustaceans. Such localized lentic conditions normally occur in long rivers with meandering. In man-made or irrigation canal conditions as is the case in the present investigation, such lentic niche are rare as the basin itself is designed to give constant and rapid flow of water. However, the basic characteristics of the potamoplankton are probably also applicable to the canal plankton in that the planktonic organisms here are derived from a number of sources and they are subjected to fluctions in water quality. Further, probably, some of the benthic forms also contribute to the plankton. The primary productivity of any aquatic ecosystem depends on the planktonic biodiversity. The estimation of primary productivity of a water body helps in measuring its ability to support a biological population and sustain a level of growth and respiration. It is the most important of all biological phenomena on which the entire diverse life depends directly or indirectly.

2.0 Material and Methods:

Four sampling stations were selected at a distance of about 4km from one another and samples were collected at monthly interval during Aug. 1990 to Sept. 1991. The Gang canal is located in the district Shri Gangangar in the desert north-western part of the state of Rajasthan (Lat. 29^0-08' to 30^0-12' , Long . 73^0-05' to 73^0-58'). The climatic conditions around canal system vary widely with temperatures reaching minus in winter and those of summer touching 50^0 c. the region experiences dust storms during the period May to June. For this purpose, the productivity was measured at all the stations, using glass stoppered light and dark BOD bottle method. The productivity was measured about 0.3 m below the water surface at all the four sampling stations. The dark bottles were painted with black enamel paint to prevent the entry of sunlight. Three hours incubation period was found adequate to illustrate the change in productivity. Oxygen estimation in the BOD bottles was made using usual Winkler's method.

3.0 Results and Discussion:

3.1 Primary productivity:

The phytoplanktonic communities are distinguished as autotrophic organisms which are able to absorb radiant solar energy and with the help of chlorophyll build up complex organic substances which incorporate considerable chemical energy in their bonds. The algae are a collective term for all those chlorophyll bearing organisms which are thalloid. The modern algologists describe algae under 11 divisions. The plankton of rivers has been investigated by scores of workers in temperate countries but in tropics especially in India, the work on river limnology is still scanty and mention could be made of Chacko and Ganapati (1949), Rai (1974), Jindal (1975), Dogra (1977) etc.

The limnology of irrigation canal is the most untouched part of the studies on lotic system. Vasisht and Jindal (1980), Jindal and Vasisht (1981) are perhaps the only works on the limnology of irrigation canal system in India. In their studies, the distribution and seasonal fluctuations of plankton in relation to selected physico-chemical characteristics has been reported. Primary productivity is grouped into two categories – the first being the gross primary productivity (GPP) and second the net primary productivity (NPP).

In the present investigation, primary productivity has been determined in terms of gc/m^3/hr. The experiments were carried out at the surface (depth of 30 cm) of four stations of Gang canal. The monthly primary productivity values at the four stations are given in (Table 1.1). The gross primary production (GPP) ranged between 0.075 to 0.175 gc/m^3/hr. The lowest value (0.075 gc/m^3/hr) was observed in September at stations 1, 3 and 4. The highest value (0.175gc/m^3/hr) was noticed in February at stations 1 and 2 and in April at all the four stations. The net primary productivity (NPP) values ranged between 0.05 to 0.125 gc/m^3/hr. The minimum NPP value (0.05 gc/m^3/hr) was in May at stations 3, 4 and in September at stations 1, 3 and 4. The maximum value (0.125 gc/m^3/hr) was observed in February at stations 1 2 and in April at stations 1, 2 and 3. The community respiration rate (RR) was also calculated and this ranged from 0.025 to 0.062gc/m^3/hr with an average at 0.04gc/m^3/hr for the entire study period. During August and September the primary productivity was found nil.

An attempt was made to calculate the seasonal primary productivity at the four stations studied from the seasonal average values (Table 1.2). The maximum GPP (0.15 gc/m^3/hr) was observed in summer at stations 1 and 2 while the lowest (0.099 gc/m^3/hr) was in monsoon at station 4. Similarly, the maximum NPP (0.1gc/m^3/hr) was also in summer at stations 1 and 2 with a minimum of 0.066 gc/m^3/hr during monsoon at stations 1 and 3. The highest respiration rate of 0.053gc/m^3/hr was also observed during summer at station 4 whereas the minimum (0.025gc/m^3/hr) was in monsoon at station 3. The annual yield at the four stations, calculated on the basis of average annual production gave the average GPP of 0.132gc/m^3/hr at station 1 while NPP was 0.089gc/m^3/hr. At station 2, the such values were 0.130 and 0.088gc/m^3/hr, respectively. At stations 3 and 4 the average GPP values were 0.118 and 0.119 gc/m^3/hr respectively, while the NPP was 0.08gc/m^3/hr on both the stations. The overall average values for the GPP and NPP in the Gang canal, based on the data of all the four stations were 0.124gc/m^3/hr as GPP and 0.084gc/m^3/hr as NPP. (Table 1.3). The annual gross primary productions at four stations were found to be 578.16, 569.76, 519.76, 524.14gc/m^3/year serially at stations 1 to 4. The corresponding annual NPP at the four stations were calculated as 382.88, 387.26, 351.13 and 350.76gc/m^3/year. The annual GPP and NPP for the entire Gang canal stretch investigated thus comes to 547.95 and 368.00 gc/m^3/year respectively.

3.2 Plankton:

In the present investigation, the canal algae were represented by *chlorophyceae*, *Bacillariophyceae, Myxophyceae* and *Xanthophyceae.* The phytoplankton of Gang canal comprises of 16 species belonging to 15 genera. Out of these, 8 species belong to *Bacillariophyceae*, 5 to *Chlorophyceae*, two to *Myxophyceae* and one to *Xanthophyceae*. (Table 1.4). The trends of variation in phytoplankton at the four stations studied are more or less similar both specieswise and in abundance. The highest phytoplankton density (161 cells/ml) was observed in March at station 1 and the minimum (12 cells/ml) in September at station 1 and the minimum (12 cells/ml) in September at station 3 (Table 1.5).

Within the total phytoplankton biomass, *Bacillariophyceae* was the dominant followed by *Chlorophyceae* . The *Myxophyceae* and *Xanthophyceae* were the lowest in their contribution to the phytoplanktonic biomass. In the seasonality of the phytoplankton, summer had the maximum species diversity (15 species) while winter and monsoon recorded 14 and 8 species respectively. The seasonal variation in the phytoplankton counts is shown in (Table 1.6). Within the three seasons, the highest phytoplankton density (459.6 cells/ml) was in summer and the lowest (106.5 cells/ml) in monsoon. The average phytoplankton count during the period of study was 858.5cells/ml. As stated earlier, the *Bacillariophyceae* or Diatoms were the dominant phytoplankton of the canal water.. Their maximum number (82 cells/ml) was in March at station 1 and the minimum of 7 cells/ml in September at station 1 and 3. In the seasonality pattern, the diatoms were maximum (238.2 cells/ml) in summer and at station 4 (57.5 cells/ml) during monsoon (Table 1.6).

Table 1.1: Monthly variations of primary productivity (gc/m^3/hr) at Four sampling stations in Gang canal.

Productivity / Month	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sept.**
STATION No. 1												
GPP	.112	.125	.150	.125	.175	.150	.175	.125	.150	.125	.100	.075
NPP	.087	.075	.112	.075	.125	.100	.125	.075	.100	.075	.075	.050
RR	.025	.050	.037	.050	.050	.050	.050	.050	.050	.050	.025	.025
STATION No. 2												
GPP	.112	.125	.125	.112	.175	.150	.175	.125	.150	.112	.100	.100
NPP	.087	.075	.087	.075	.125	.100	.125	.075	.100	.062	.075	.075
RR	.025	.050	.037	.037	.050	.050	.050	.050	.050	.050	.025	.025
STATION No. 3												
GPP	.100	.125	.137	.112	.125	.125	.175	.100	.150	.100	.100	.075
NPP	.075	.075	.112	.075	.075	.075	.125	.050	.100	.075	.075	.050
RR	.025	.05	.025	.037	.050	.050	.050	.050	.050	.025	.025	.025
STATION No. 4												
GPP	.100	.125	.112	.125	.150	.125	.175	.100	.125	.112	.112	.075
NPP	.075	.100	.087	.075	.100	.075	.112	.050	.075	.087	.075	.050
RR	.025	.025	.025	.050	.050	.050	.062	.050	.050	.025	.037	.025

Table 1.2: Seasonal average primary productivity (gc/m^3/hr) at Four stations in Gang canal.

Season / Productivity	Station No. 1			STATION No. 2			STATION No. 3			STATION No. 4		
	GPP	NPP	RR	GPP	NPP	RR	GPP	NPP	RR	GPP	NPP	RR
Winter	0.137	0.094	0.042	0.129	0.089	0.039	0.119	0.082	0.037	0.122	0.087	0.035
Summer	0.150	0.100	0.050	0.150	0.100	0.050	0.137	0.087	0.050	0.131	0.078	0.053
Monsoon	0.100	0.060	.0330	0.104	0.070	0.033	0.091	0.066	0.025	0.099	0.070	0.029

Table 1.3: Annual average primary productivity (gc/m^3/hr) at Four stations in Gang canal.

STATION Productivity	**GPP**	**NPP**	**RR**
Station 1.	0.132	0.089	0.042
Station 2.	0.130	0.088	0.041
Station 3.	0.118	0.080	0.038
Station 4.	0.119	0.080	0.039
Average	0.124	0.084	0.04

Table 1.4: Phytoplankton occurring at Four sampling stations in the Gang canal.

PHYTOPLANKTON	
(A) BACILLARIOPHYCEAE	***(B) CHLOROPHYCEAE***
1. Achnanthes exigua	1. Ulothrix zonata
2. Cocconeis spp.	2. Microspora spp.
3. Gamphonema parvulum	3. Pithophora spp.
4. Cymbella Cistula	4. Ankistrodesmus convolutus
5. Navicula simplex	5. Scendesmus platydiscus
6..Navicula spp.	***(C) MYXOPHYCEAE***
7..Nitzschia spp.	1. Rivularia spp.
8. Fragilaria brevistriata	2.Phormidium spp.
	(D) XANTHOPHYCEAE
.	Vaucheria spp.

Table 1.5: Monthly variations of different algal groups at four sampling stations in Gang canal (Cells/ml)

Group / Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
STATION No. 1													
Bacillariophyceae	21	27	26	33	47	82	61	74	54	35	17	07	484
Chlorophyceae	19	22	20	26	38	60	46	50	38	24	13	06	362
Myxophyceae	-	-	5	9	13	14	15	16	13	09	03	-	97
Xanthophyceae	04	05	04	05	06	05	-	-	-	-	-	-	29
Total	44	54	55	73	104	161	122	140	105	68	33	13	972
STATION No. 2													
Bacillariophyceae	19	26	21	28	40	66	53	60	47	31	18	09	418
Chlorophyceae	18	20	17	20	33	49	39	40	37	22	11	04	310
Myxophyceae	-	-	03	08	12	16	14	14	12	06	03	-	88
Xanthophyceae	04	03	05	05	04	03	-	-	-	-	-	-	24
Total	41	49	46	61	89	134	106	114	96	59	32	13	840
STATION No. 3													
Bacillariophyceae	21	24	20	25	44	68	49	64	52	30	17	07	421
Chlorophyceae	18	20	19	22	32	44	41	38	32	21	13	05	305
Myxophyceae	-	-	04	08	10	15	11	13	11	07	03	-	82
Xanthophyceae	-	02	04	05	05	04	-	-	-	-	-	-	20
Total	39	46	47	60	91	131	101	115	95	58	33	12	828
STATION No. 4													
Bacillariophyceae	15	24	21	29	38	63	48	67	45	30	19	10	409
Chlorophyceae	13	18	15	20	33	43	39	35	30	21	11	05	283
Myxophyceae	-	-	04	07	11	15	10	13	11	06	03	-	80
Xanthophyceae	04	04	05	06	04	-	-	-	-	-	-	-	23
Total	32	46	45	62	86	121	97	115	86	57	33	15	795

Table 1.6 : Season wise count cells/ml of the different algal groups.

S. No.	Group Season	Winter	Summer	Monsoon	Total
1.	*Bacillariophyceae*	137.2 (7)*	238.2 (7)*	57.5 (4)*	432.9
2.	*Chlorophyceae*	110.7 (4)	165.2 (5)	39.0 (3)*	314.9
3.	*Myxophyceae*	23.5 (2)	53.2 (2)	10.0 (1)	86.7
4.	*Xanthophyceae*	21.0 (1)	03.0 (1)	-	24.0
5.	Total	292.4 (14)	459.6 (15)	106.5 (8)	858.5

Figures in bracket indicate number of species.

Table 1.7: Monthly variations in percent contribution of various groups of phytoplankton at four sampling stations in Gang canal

Group / Month	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
STATION No. 1												
Bacillariophyceae	47.72	50.0	47.27	45.20	45.19	50.93	50.0	52.85	51.42	51.47	51.51	53.84
Chlorophyceae	43.18	40.47	36.36	35.61	36.53	37.26	37.70	35.71	36.19	32.29	39.39	46.15
Myxophyceae	-	-	9.09	12.32	12.5	8.69	12.29	11.42	12.38	13.23	9.09	-
Xanthophyceae	9.09	9.25	7.27	6.84	5.76	3.10	-	-	-	-	-	-
STATION No. 2												
Bacillariophyceae	46.34	53.06	45.65	45.90	44.94	49.25	50.0	52.63	48.95	52.54	56.25	69.23
Chlorophyceae	43.90	40.81	36.95	32.78	37.07	36.56	36.79	35.08	38.54	37.28	34.37	30.76
Myxophyceae	-	-	6.52	13.11	13.48	11.94	13.20	12.28	12.5	10.16	9.37	-
Xanthophyceae	9.75	6.12	10.86	8.19	4.49	2.23	-	-	-	-	-	-
STATION No. 3												
Bacillariophyceae	53.84	52.17	42.55	41.66	48.35	51.90	48.51	55.65	54.73	51.72	51.51	58.33
Chlorophyceae	46.15	43.47	40.42	36.66	35.16	33.58	40.59	33.04	33.68	36.20	39.39	41.66
Myxophyceae	-	-	8.51	13.33	10.98	11.45	10.89	11.30	11.57	12.06	9.09	-
Xanthophyceae	-	4.34	8.51	8.33	5.49	3.05	-	-	-	-	-	-
STATION No. 4												
Bacillariophyceae	46.87	52.17	46.66	46.77	44.18	52.06	49.48	58.26	52.32	52.63	57.57	66.66
Chlorophyceae	40.62	39.13	33.33	32.25	38.37	35.53	40.20	30.43	34.88	36.84	33.33	33.33
Myxophyceae	-	-	8.88	11.29	12.79	12.39	10.30	11.30	12.79	10.52	9.09	-
Xanthophyceae	12.5	8.69	11.11	9.67	4.65	-	-	-	-	-	-	-

Chlorophyceae or green algae were the second largest group in the phytoplankton of the Gang canal. Seasonally, *chlorophyceae* were highest (165.2 cells/ml) during summer and lowest (39.0 cells/ml) in monsoon (Table 1.6). The *myxophyceae* were represented only by two species. Blue green were absent from September to November (Table 1.5). Seasonally, summer had the highest density (53.2 cells/ml) while the lowest density (10 cells/ml) was observed in monsoon (Table 1.6). *Xanthophyceae* was the lowest in density in the phytoplankton of Gang canal. It was represented only by one species (*Vaucheria spp*.) which showed its appearance only in winter and early summer month of March. Seasonally, winter had the highest density (21 cells/ml) and summer the lowest (3 cells/ml) (Table 1.6). They were absent in monsoon. During August and September the plankton could not be studied due to the heavy turbid water in the Gang canal.

The physiology and productivity of phytobiota along with abiotic and biotic characteristics of the system, influence its primary productivity. Another exclusive parameter which affects the primary productivity of lotic water is the velocity of water flow and its variations in the different portions of the river system. This affects the metabolism of primary producers. In the case of canal system, three factors viz., the speed of current, uniformity of substratum (silt or cemented) and the absence of macrophytes probably greatly affect the primary production pattern and thus show its variance from a typical lotic system of a river. In the present investigation, the seasonal variations in gross (GPP) and net primary productivity (NPP) at four stations appear more or less constant. In general, the primary productivity appears low when it is compared with the available figures from reservoirs in Rajasthan where GPP has been recorded to be 0.125, 0.124, 0.338, 0.265, 0.322 and 0.160 gc/m^2/hr for Rana Pratap Sagar (Kota), Gandhi Sagar (Kota), Jaisamand (Udaipur), Ramgarh Dam (Jaipur), Balsamand (Jodhapur) and Fateh sagar (Udaipur) respectively (Sharma, 1980). These values are very high in some lentic waters in comparison to those observed in the Gang canal.

In Silver Spring of Florida (U.S.A.), odum (1957) observed the GPP of 5.2gc/m^2/day. Hammer (1965) found that the GPP ranged from 0.08 – 0.13gc/m^2/day in Rio Negro of Venezuela, Sharma (1980) recorded the GPP value 0.098gc/m^2/hr in Bedach river and nil productivity in Banas river (Rajasthan). The value of 0.124gc/m^3/hr observed in

Gang canal is fairly close to that observed by Sharma (1980) in Bedach river near Udaipur (Rajasthan). During August and September the primary productivity was nil probably due to high turbidity caused by inflowing silt laden water. It is felt that the present level of productivity in Gang canal is the result of nutrients brought by the canal from the upper reaches. Had this water been a standing one, the primary productivity would probably have been more, thus matching with a lake or a lentic water. The low primary productivity of this canal is reflected in the poverty of benthic, nektonic and sestonic organisms.

The earliest studies on lotic plankton are probably by Zacharias (1898) identified rotifers, cladocerans and copepods from open waters of rivers besides the blue green alga *Microcystis*. Based on this, it was hypothised that small low land rivers have a plankton resembling that of ponds in its composition and the plankton of larger river harbour diatoms like lakes. Planktonic organisms of rivers also occur in still water and hence the true plankton must originate in still water and these become temporary inhabitants in running waters Brehm (1911). It has been found that the free water of stream contains representative of the benthic algae, mostly diatoms, washed up from stream bed, besides the occassional presence of true planktonic diatoms such as *Asterionella*, *Fragilaria* and *Melosira,* the planktonic rotifers *Keratella* and *Brachionus* and the copepod *Cyclop*. It is now generally agreed that potamoplankton contains a considerable volume of true plankton of lakes and ponds which get strayed into the flowing water. Swale (1964) opined that in the horizontal distribution of total plankton, its density is reported to increase downstream, especially when the rate of water flow is low). It is now accepted that in any river or flowing water, the amount of plankton increases downstream.

In the present investigation, during monsoon and early months of winter (Oct., Nov.), the plankton was minimum. This supports the hypothesis of Schroder (1897)" The volume of plankton present in any stream is inversely proportional to the rate of the water current". This is also confirmed by Kofoid (1903), Allen (1920), Galstoff (1924), Reinhard (1931), Eddy (1934), Rice (1938), Abdin (1948) and Blum (1960). The fast water current not only causes the mechanical damage to the plankton but also results in high turbidity (lower penetration of light) which in turn causes the destruction of plankton by churning. Berner (1951), Roy (1955), Ray *et al*. (1966) and Rai (1974) have also expressed similar views. In most cases phytoplankton abundance grossly determine primary productivity.

4.0 Conclusion:

- The annual yield at the four stations, of Gang canal gave the average GPP as 0.132gc/m^3/hr at station 1 while NPP was 0.089gc/m^3/hr.
- At station 2, the corresponding values were 0.130 and 0.088gc/m^3/hr respectively.
- At stations 3 and 4 the average GPP values were 0.118 and 0.119gc/m^3/hr respectively, while the NPP was 0.08gc/m^3/hr on both the stations.
- The overall average values for the GPP and NPP in the Gang canal, based on the data of all the four stations were 0. 124gc/m^3/hr GPP and 0.084gc/m^3/hr as NPP.
- The primary productivity was measured for surface water and was found very low.

5.0 Acknowledgement:

The authors are thankful to Dean, Rajasthan college of Agriculture, Udaipur for his kind help and facilities provided to carry out this research work.

References:

1) Abdin, G. (1948). Physical and chemical investigations relating to algal growth in the river Nile, Cairo. Bull. Inst. Egypt, 29; 19-44.

2) Allen, W.E. (1920). A quantitative and statistical study of the plankton of the San Joaquin River and its tributaries in and near Stockton, California, in 1913. Univ. Calif. 1s. Zool. 22 : 1-292.

3) Berner, L.M. (1951). Limnology of the lower Missouri river. Ecology. 32 : 1-12.

4) Blum, J.L. (1960). Algal populations in flowing waters. Spec. Pubis. Pymatuning Lab. Fld Biol. 2 : 11-21.

5) Brehm, V. (1911). Beobachturigen uber die Entstehung des Potamoplanktons Int. Rev. ges. Hydrobiol. Hydrogr. 4 : 311-314.

6) Chacko. P.1. and S.V. Ganapati (1949). Some observations on the Adyar river with special reference to its hydro- biological conditions. Indian Geogr. J. 24(3) : 35-49.

7) Dogra, V.K. (1977). Ecological studies on the Kucha Sirhind canal and Pucca Bhakra main canal, Rupnagar, Punjab (India).Thesis submitted to the Punjab Univ. for the degree of Master of Science.

8) Eddy, S. (1934). A study of freshwater plankton communities. Illinois biol. Monogr. 12(4) : 1-93.
9) Galtsoff, P.S. (1924). Limnological observations in the Upper Mississippi, 1921. Bull. Bur. Fish. wash. 39: 347-438.
10) Hammer, L. (1965). Photosynthese and Primarproduction in Rio Negro. Int. Rev, J. Hydrobiol. 50(3): 335-339.
11) Jindal, R. (1975). Rheological survey of Patiala (Pb). India. Thesis submitted to the Punjab Univ. for the degree of Master of Science.
12) Jindal, R. and H.. Vasisht (1981). Hydrobiological studies of a tributary of Sirhind canal at Sangrur (Punjab, India). Proc. Syrnp. Ecol. Anim. Popul. Zool. urv. India. Pt.2. 1-17.
13) John, J. and K.M. Alexander (1968). A preliminary report on the hydrobiology of Beypore river for the year, 1964. Hydrobiologia. 31 : 492-496.
14) Kofoid, C.A. (1903). Plankton studies. IV. The plankton of the Illinois river, 1894-1899, with introductory notes upon the hydrography of the Illinois river and its basin. Part I. Quantitative investigations and general results. Bull. III, St. Lab. nat. Hist. 6 : 95-629.
15) Rai, H. (1974). Limnological studies on the river Yamuna at Delhi, India. Part II. The dynamics of potamoplankton populations in the river Yamuna. Arch. Hydrobiol.73: 492-517.
16) Ray, P., S.B. Singh and K.L. Sehgal. (1966). A study of some aspects of ecology of the rivers Ganga and Yamuna at Allahabad (U.P. in 1958-59). Proc. Natn. Acad. Sci. India. B 36(3): 235-272.
17) Reinhard, E.G. (1931). The plankton ecology of the upper Mississippi Minneapolis to Winona. Ecol. Monogr. 1(7): 395-464.
18) Rice, CH. (1938). Studies on the phytoplankton of the river Thames 1; 2. Ann. Bot. N.S. 2, 539-557; 559-581.
19) Schroder, B. (1897). Uber des plankton der oder. Ber. dtsch. bot. Ges. 15: 482-492.
20) Sharma, M.S. (1980). Studies on plankton and productivity of Udaipur waters in comparison to the selected waters of Rajasthan. Thesis submitted to the University of Udaipur for the degree of Ph.D.
21) Swale, E.M.F. (1964). A study of the phytoplankton of a calcareous river. J. Ecol. 52 : 433-446.
22) Vasisht, U.S. and R. Jindal (1980). Rheological survey of pucka stream of Patiala (Punjab, India). Lirnnologica (Berlin). 12(1) : 77-83.
23) William, L.G. (1964). Possible relationship between plankton diatom species, numbers and water quality estimates. Ecology. 45 : 809-823.
24) Zacharias, 0. (1898). Das Potamoplankton. Zool. Anz. 21 41-48.