International Journal of Fauna and Biological Studies
Available online at www.faunajournal.com

IJFBS International Journal of Fauna And Biological Studies

ISSN 2347-2677
IJFBS 2016; 3(1): 134-139
Received: 22-11-2015
Accepted: 25-12-2015

RK Bishnoi
Sr. Lecturer Department of Zoology, BRG, Govt. P.G. Girl's College, Shri Ganganagar, Rajasthan, India.

BK Sharma
Professor, College of Fisheries, MPUAT, Udaipur, Rajasthan, India.

Correspondence:
RK Bishnoi
Sr. Lecturer Department of Zoology, BRG, Govt. P.G. Girl's College, Shri Ganganagar, Rajasthan, India.

Planktonic variations in a lotic water body of Shri Ganganagar District, (Rajasthan)

RK Bishnoi, BK Sharma

Abstract
Plankton community is a heterogeneous group of tiny plants and animals mainly comprising of Phytoplankton and Zooplankton, respectively. 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.* The zooplankton of the Gang canal comprised of six genera, out of which three belong to the Rotifera, two to Cladocera and one to Protozoa. The zooplankton assemblage of the Gangcanal is contributed primarily by Rotifers, followed by Cladocerans and Protozoans.

Keywords: phytoplankton, zooplankton, *Xanthophyceae*, *Bacillariophyceae*, *Chlorophyceae* and *Myxophyceae*.

1. Introduction

1.1 Materials and Methods: The plankton samples were collected at monthly interval at four different stations *viz*. stations A, B, C and D at a distance of about 4 km from one another. This work is the first attempt of its kind in Rajasthan to investigate the limnology of this canal water. The investigation was conducted to study the plankton diversity and their seasonal variation in the Gang Canal. 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.

Systematic identification of phytoplankton was done with the help of standard works Fritsch, (1935) [16]; Smith, (1950) [40]; Desikachary, (1959) [12]; Prescott, (1962) [30]; Ramanathan, (1964) [32]; Philipose, (1967) [29] and APHA, (1976) [3]. The systematic identification of zooplankton was done with the help of standard works of Edmondson (1959) [15], Needham and Needham (1962) [26], Koste (1978) [24] and Pennak (1978) [28].

2. Results

2.1 Phytoplankton

The phytoplanktonic communities are distinguished as autotrophic organisms which are able to absorb radiant solar energy and with the help of chlorophyll to build up complex organic substances which incorporate considerable chemical energy in their bonds. 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 1.1).

The trends of variation in phytoplankton at the four stations studied are more or less similar both species wise and in abundance. The highest phytoplankton density (161 cells/ml) was observed in March at station 1 and the minimum (13 cells/ml) in September at station 1 and the minimum (12 cells/ml) in September at station 3 (Table 1.2).

In the seasonality of the phytoplankton, summer had the maximum species diversity (15 species) while winter and monsoon recorded 14 and 8 species respectively. Within the three seasons, the highest phytoplankton density (459.7 cells/ml) was in summer and the lowest was in (106.5 cells/ml) in monsoon. The average phytoplankton count during the period of study was 858.5cells/ml (Table 1.3).

Bacillariophyceae or Diatoms being the dominant phytoplankton of the canal water, their Percent contribution to the total phytoplankton ranged between 41.66.76 to 69.23% (Table 1.4). Their maximum number (82cells/ml) was in March at station 1 and the minimum of 7cells/ml in September at stations 1 and 3(Table 1.2). Further, the diatoms were maximum (238.2 cells/ml) in summer and at ebb (57.5 cells/ml) during monsoon (Table 1.3).

Chlorophyceae were the second largest group in the phytoplankton of the Gang canal. Their percent contribution to the total phytoplankton varied between 30.76 to 46.15% (Table 1.4). Their minimum number (4 cells/ml) was in September at station 2 and the maximum (60 cells/ml) in March at station 1 (Table 1.2). Seasonally, *Chlorophyceae* were highest (165.2 cells/ml) during summer and lowest (39 cells/ml) in monsoon (Table 1.3).

The *Myxophyceae* were represented only by two species. Their percent contribution ranged between 6.52 to 13.48% (Table 1.4). The lowest density (3 cells/ml) was noticed in August at all the four stations while the highest (16 cells/ml) was observed in March and May at stations 2 and 1 respectively. Blue green were absent from September to November (Table 1.2). Seasonally, summer had the highest density (53.2 cells/ml) while the lowest density (10 cells/ml) was observed in monsoon (Table 1.3).

Xanthophyceae was the lowest in density in the phytoplankton of Gang canal. Their percent contribution to the total phytoplankton varied between 2.23 to 12.5% (Table 1.4). It was represented only by one species (*Vaucheria* spp.) which showed its appearance only in winter and early summer month of March. The maximum number (6 cells / ml) was observed in January and February at stations 4 and 1 respectively. The lowest density (2 cells / ml) was seen in November at station 3 (Table 1.2). Seasonally, winter had the highest density (21cells/ml) and summer the lowest (3cells/ml) (Table 1.3). They were absent in monsoon. During August and September, the plankton could not be studied due to the heavy silt laden water in the Gang canal.

2.2 Zooplankton

The zooplankton of a lotic system comprises mainly of three major groups, the rotifers, cladocera and copepoda. Member of the non-pigmented protozoa and certain insect larval stages may also contribute to this assemblage.

The zooplankton of permanent swift water streams is characteristically reduced in number of species and biomass. Those streams which, however, derive water directly from standing waters like lakes do have lentic plankton communities. Most studies on fluvial plankton have shown that zooplankton constitute relatively small portion of the aquatic biomass. For example, in Sacramento river in U.S.A., the zooplankton ranged from nil to 10% of the total plankton (Greenberg, 1964) [19].

The zooplankton of the Gang canal comprised of six genera, out of which three belonged to the Rotifera, two to Cladocera and one to Protozoa (Table 1.1). The zooplankton assemblage of the Gang canal is contributed primarily by Rotifers, followed by Cladocerans and Protozoans. The highest zooplanktonic density of 23 No./l was observed in March at station 2 and minimum 2 No./l in September at station 4 (Table 1.5).

From the seasonal point of view, summer had the highest density (73.75 No./l) while the monsoon had the lowest (27.25 No./l). The average zooplankton count during the period of study was 169 no. /l (Table 1.6).

Rotifers being the highest (47.33%) in density their maximum number (11 No. /l) was observed in March and June at stations 2 and 1 respectively while the minimum (1 No./l) was at station 4 in September. Seasonally, summer had a higher density (33.75 No/l) while monsoon recorded the lowest of 13.5 No/l (Table 1.6).

Cladocerans ranked second in abundance. The highest number (7No. /l) in June at stations 2 and 4, while the lowest (1No./l) was seen in September at stations 1, 3 and 4. Seasonally, summer had the highest density of 21.25 No/l while the monsoon showed lowest density of 10 No/l (Table 1.6). Cladocerans ranked second in abundance with the highest number (7 No/l) was observed in June at stations 2 and 4, while the lowest (1 No/l) was seen in September at stations 1, 3 and 4. Seasonally, summer had the highest density of 21.25 No/l while the monsoon showed lowest density of 10 No/l (Table 1.6).

Protozoans were the sparsest in zooplankton of the Gang canal, as this group was represented only by one species. The maximum number of (7 No/l) was observed in March at stations 2 and 3. The minimum number (1No/l) was, however, in October at station 3. Protozoans disappeared in August and September (Table 1.5). Seasonally, their maximum density (18.75No/l) was during summer and minimum (3.75No/l) during monsoon (Table 1.6).

3. Discussion

The earliest studies on lotic plankton are probably by Lauterborn (1893) [25] who noted the planktonic rotifers, copepods and diatoms in the river Rhine. Later, Zacharias (1898) [44] identified rotifers, cladocerans and copepods from open waters of rivers besides the blue green alga *Microcystis.* Based on this, it was hypothesized that small low land rivers have a plankton resembling that of small low land rivers which have a plankton resembling that of ponds in its composition and the plankton of larger river harbour diatoms like lakes. A view was expressed by Brehm (1911) [6] that the 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. 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* besides 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 waters.

In the horizontal distribution of total plankton, its density is reported to increase downstream, especially when the rate of water flow is low (Swale, 1964) [41]. It is now accepted that in any river or flowing water, the amount of plankton increases downstream. Further, phytoplankton is more abundant than zooplankton and in the former the diatoms are always dominant. Besides the true phytoplanktonic genera such as *Asterionella*, *Tabellaria, Fragilaria*, *Cyclotella, Stephanodiscus*, and the benthic phytoplankton of the genera *Synedra. Nitzschia*, *Navicula*, *Diatoma* are common. In the flowing waters of tropic (warm water), the truely planktonic *Chlorophyceae* such as *Ankistrodesmus, Scenedesmus*, *and Pediastrum*; flagellates such as *Cryptomonas,*

Chlamydomonas, Euglena and Cynophyceae represented by *Anabaena*, *Lyngbya* also occur. The zooplanktonic organisms of the potamoplankton include protozoans mainly *Arcella, Difflugia,* some ciliates and rotifers such as *Keratella*, *Synchaeta*, *Polyarthra*, *Brachionus* etc. Crustaceans belong to genera Cyclops, *Bosmina*, *Alona*, *Chydorus* and *Diaptomus.* These, however, are rare but do occur.

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) [7], Roy (1949) [36], Roy (1955) [37], Chacko *et al.* (1953) [8],Chakraborty *et al.* (1959) [9], Pahwa and Mehrotra (1966) [27], Ray *et al.* (1966) [33], Rai (1974) [31], Jindal (1975) [20], Dogra (1977) [13].

The limnology of irrigation canal is the most untouched part of the studies on lotic system. Vasisht and Jindal (1980) [42], Jindal and Vasisht (1981) [21] made notable contributions 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.

In the present investigation, during monsoon and early months of winter (Oct., Nov.), the plankton was minimum due to fast water current. This supports the hypothesis of Schroder (1897) [39] "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) [23], Allen (1920) [2], Galstoff (1924) [17], Reinhard (1931) [34], Eddy (1934) [14], Rice (1938) [35], Abdin (1948) [1] and Blum (1957) [5]. 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) [4], Roy (1955) [37], Ray *et al*. (1966) [33] and Rai (1974) [31] have also expressed similar views.

Probably, during this period the plankton was low in August and September owing to heavy silt laden incoming waters. The silt laden incoming water blanketed the penetration of light and the fast flow of water further discouraged plankton production owing to friction and washing off of the earlier developmental stages of the planktonic algae. Ray *et al*. (1966) [35], Rai (1974) [31], Vasisht and Jindal (1980) [42] expressed similar views. Among the phytoplankton, diatoms were dominant throughout the study period probably, the diatoms which are typical lentic flora get continuously washed into Gang canal from Harike Barrage. However, this needs further study. Chakraborty *et al*. (1959) [9], Jindal and Vasisht (1981) [21] have noted the abundance of diatoms in river and canal water respectively.

The absence of *Myxophyceae* in post monsoon and early winter months of September to November could be due to the influx of clean freshwaters containing less of dissolved organic. The fast flowing water further discouraged their development as *Myxophyceae* are the algae of standing waters. High dissolved oxygen during turbulence would also discourage the production of blue green algae. *Xanthophyceae* showed its appearance only in winter and early summer month of March thus showing the preference for low temperature.

The zooplankton in the Gang canal showed a direct relationship with phytoplankton. The zooplanktons were higher in summer following higher temperatures, pH, transparency and low water velocity. The lowest zooplanktonic density was in monsoon probably due to high water current and turbidity. The latter is known to damage the respiratory organs of minute organisms.

The higher pH values in summer results in the increase in numbers of phytoplankton. pH showed a direct relationship with alkalinity as also observed by Roy (1949, 1955) [36] [37], William (1964) [43], John and Alexander (1968) [22]. During late winter and summer months, phytoplankton abundance coincided with high values of alkalinity, thereby showing its direct relationship. Similar observations have been made by Roy (1949) [36], Ray *et al*. (1966) [33].

Zooplankton showed a positive correlation with phyto plankton. However, the peak of zooplankton followed the peak of phytoplankton. This could be due to the rapid multiplication of phytoplankton which neutralized the effect of grazing by zooplankton. Similar observations have been made by Pahwa and Mehrotra (1966) [27], Ray *et al*. (1966) [33], Rupsingh and Singh (1973) [38]. No zooplanktonic group showed a definite trend of sessional fluctuations. However, they showed their abundance from late winter month of February to summer month of June due to high penetration of light, high dissolved oxygen and pH and low water current.

4. 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.

Table 1.1: Phyto and Zooplankton occurring at four sampling stations in the Gang canal

	Phytoplankton		**Zooplankton**
	Bacillariophyceae		**Protozoa**
1.	*Achnanthes exigua*	1.	Arcella spp.
2.	*Cocconeis spp.*		
3.	*Gamphonema parvulum*		Rotifera
4.	*Cymbella Cistula*	1.	Brachionus spp.
5.	*Navicula simplex*	2.	Keratella spp.
6.	*Navicula spp.*	3.	Filinia spp.
7.	*Nitzschia spp.*		
8.	*Fragilaria brevistriata*		Cladocera
		1.	Bosmina spp.
		2.	Moina spp.
	Chlorophyceae		
1.	Ulothrix zonata		
2.	Microspora spp.		
3.	Pithophora spp.		
4.	Ankistrodesmus convolutus		
5.	Scendesmus platydiscus		
	Myxophyceae		
1.	Rivularia spp.		
2.	Phormidium spp.		
	Xanthophyceae		
1.	*Vaucheria* spp.		

Table 1.2: Monthly variations of different algal groups at four sampling stations in Gang canal (Cells/ml)

Group / Month	Aug.	Sept.	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	7	484
Chlorophyceae	-	-	19	22	20	26	38	60	46	50	38	24	13	6	362
Myxophyceae	-	-	-	-	5	9	13	14	15	16	13	9	3	-	97
Xanthophyceae	-	-	4	5	4	5	6	5	-	-	-	-	-	-	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	9	418
Chlorophyceae	-	-	18	20	17	20	33	49	39	40	37	22	11	4	310
Myxophyceae	-	-	-	-	3	8	12	16	14	14	12	6	3	-	88
Xanthophyceae	-	-	4	3	5	5	4	3	-	-	-	-	-	-	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	7	421
Chlorophyceae	-	-	18	20	19	22	32	44	41	38	32	21	13	5	305
Myxophyceae	-	-	-	-	4	8	10	15	11	13	11	7	3	-	82
Xanthophyceae	-	-	-	2	4	5	5	4	-	-	-	-	-	-	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	5	283
Myxophyceae	-	-	-	-	4	7	11	15	10	13	11	6	3	-	80
Xanthophyceae	-	-	4	4	5	6	4	-	-	-	-	-	-	-	23
Total	-	-	32	46	45	62	86	121	97	115	86	57	33	15	795

Table 1.3: 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 (1)	86.7
4.	*Xanthophyceae*	21 (1)	3 (1)	-	24
5.	Total	292.4 (14)	459.6 (15)	106.5 (8)	858.5

Figures in bracket indicate number of species.

Table 1.4: Monthly variations in percent contribution of various groups of phytoplankton at four sampling stations in Gang canal

Group / Month	Aug.	Sept.	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	-	-	-	-	-	-	-

Table 1.5: Monthly variations of different groups of Zooplankton (No. /l) at four sampling stations in Gang Canal.

Group / Month	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
Station No. 1															
Protozoa	-	-	2	2	4	3	5	6	3	4	5	5	-	-	39
Rotifera	-	-	6	6	5	8	9	8	7	8	11	7	5	3	83
Cladocera	-	-	4	4	5	4	3	5	4	6	6	4	4	1	50
Total	-	-	12	12	14	15	17	19	14	18	22	16	9	4	172
Station No. 2															
Protozoa	-	-	2	3	4	3	5	7	4	4	5	3	-	-	40
Rotifera	-	-	6	5	5	8	7	11	8	7	8	9	5	2	81
Cladocera	-	-	4	4	4	3	4	5	5	6	7	5	4	2	53
Total	-	-	12	12	13	14	16	23	17	17	20	17	9	4	174
Station No. 3															
Protozoa	-	-	1	2	4	3	6	7	3	3	6	4	-	-	39
Rotifera	-	-	6	5	6	8	7	9	8	7	10	6	4	2	78
Cladocera	-	-	3	4	5	4	3	6	4	6	5	5	4	1	50
Total	-	-	10	11	15	15	16	22	15	16	21	15	8	3	167
Station No. 4															
Protozoa	-	-	2	4	3	4	5	6	3	4	5	3	-	-	39
Rotifera	-	-	6	6	6	7	9	10	8	7	8	6	4	1	78
Cladocera	-	-	3	4	4	3	3	4	4	5	7	6	3	1	47
Total	-	-	11	14	13	14	17	20	15	16	20	15	7	2	164

Table 1.6: Season wise count (No/l) of the different groups of Zooplankton in the Gang canal.

S. No.	Group Season	Winter	Summer	Monsoon	Total
1.	Protozoa	16.5	18.75	3.75	39.0
2.	Rotifera	32.75	33.75	13.5	80.0
3.	Cladocera	18.75	21.25	10.0	50.0
	Total	68.00	73.75	27.25	169.0

5. References

1. Abdin G. Physical and chemical investigations relating to algal growth in the river Nile, Cairo. Bull. Inst. Egypt 1948; 29:19-44.
2. Allen WE. 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 1920; 22:1-292.
3. APHA Standard Methods for the Examination of Water and Waste Water. 14th edition, APHA Inc., New York, 1976, 1193.
4. Berner LM. Limnology of the lower Missouri River. Ecology 1951; 32:1-12.
5. Blum JL. An ecological study of the algae of the saline river, Michigan. Hydrobiologia 1957; 9(4):361-408.
6. Brehm V. Beobachturigen uber die Entstehung des Potamoplanktons Int. Rev. ges. Hydrobiol. Hydrogr 1911; 4:311-314.
7. Chacko P1, Ganapati SV. Some observations on the Adyar river with special reference to its hydro- biological conditions. Indian Geogr. J. 1949; 24(3):35-49.
8. Chacko P1, Srinivasan R, Evangeline G. Hydrobio J. ogy of the Malarnpuzha river with reference to development of fisheries in Malampuzha reservoir. Indian Comm. J Madras. 1953; 8(1):118 bis 124.
9. Chakraborty RD, Roy P, Singh SB. A quantitative study of plankton and the physico-chemical conditions of the river Yamuna at Allahabad in 1954-55. Indian J Fish. 1959; 6(1):186-208.
10. Das SM, Moitra SK. Studies on organic production in high altitude lakes of India. Part I. The general ecology and zooplankton of Kashmir lakes. Kashmir Sci 1969; 6(1-2):1-22.
11. Das SM. Ecology of Dal Lake, Kashmir, India. Icashmir Sci 1970; 7(1-2):18-23.
12. Desikachary TV. Cyanophyta. Indian Council of Agri-cultural Research, Monographs on Algae No. 2, 1959.
13. Dogra VK. 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, 1977.
14. Eddy S. A study of freshwater plankton communities. Illinois biol. Monogr 1934; 12(4):1-93.
15. Edmondson WT. Ward and Whiples Fresh water biology, 2nd edition. John Wiley and Sons, Inc., New York, 1959.
16. Fritsch FE. The structure and reproduction of algae. Cambridge Univ. Press, London 1935; 1:791.
17. Galtsoff PS. Limnological observations in the Upper Missiccippi, 1921. Bull. Bur. Fish. Wash 1924; 39:347-438.
18. Govind BV. Preliminary studies on plankton of the Tungabhadra reservoir. Indian J Fish. 1963; 10(1):148-158.
19. Greenberg AE. Plankton of the Sacramento river Ecology. 1964; 45:40-49.
20. Jindal R. Rheological survey of Patiala (Pb). India. Thesis submitted to the Punjab Univ. for the degree of Master of Science, 1975.
21. Jindal R, Vasisht H. Hydrobiological studies of a tributary of Sirhind canal at Sangrur (Punjab, India). Proc. Syrnp. Ecol. Anim. Popul. Zool. urv. India. Pt.2, 1981, 1-17.
22. John J, Alexander KM. A preliminary report on the hydrobiology of Beypore river for the year, 1964. Hydrobiologia 1968; 31:492-496.
23. Kofoid CA. 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 1903; 6:95-629.
24. Koste W. Rotatoria, Vols. Borntraeger. Berlin, Stuttgart, plates 1978; 2:673-234.
25. Lauterborn R. Beitrage zur Rotatorienfauna des Rheins und Seiner Aitwasser. Zool. Jb. Abt. Syst 1893; 7:254-273.

26. Needham JG, Needham PR. A guide to the study of freshwater biology. Holden-Day, Inc., San Francisco, 1962, 108.
27. Pahwa DV, Mehrotra SN. Observations on fluctuations in abundance of plankton in relation to certain hydrological conditions of river Gang. Proc. Nat. Acad. Sci. 36B 1966; 2:157-189.
28. Pennak RW. Freshwater invertebrates of the United States, 2nd edition, John Wiley & Sons Inc., New York, 1978; 803.
29. Philipose MT. Chiorococcales. Indian Council of Agricultural Research. Monographs on Algae, 1967, 365.
30. Prescott GW. Algae of the Western Great lakes area. W.M.C. Brown Company, Pubi. Dubugue, IOWA, 1962, 977.
31. Rai H. Limnological studies on the river Yamuna at Delhi, India. Part II. The dynamics of potamoplankton populations in the river Yamuna. Arch. Hydrobiol 1974; 73:492-517.
32. Ramanathan KR. Ulotrichales. Indian council of Agricultural Research. Monographs on Algae. 1964.
33. Ray P, Singh SB, Sehga KL. A study of some aspects of ecology of the rivers Ganga and Jamuna at Allahabad (U.P. in 1958-59. Proc. natn. Acad. Sci. India. B 1966; 36(3):235-272.
34. Reinhard EG. The plankton ecology of the upper Mississippi Minneapolis to Winona. Ecol. Monogr. 1931; 1(7):395-464.
35. Rice CH. Studies on the phytoplankton of the river Thames 1; 2. Ann. Bot. N.S. 1938; 2:539-557, 559-581.
36. Roy HK. Some potamological aspects of the river Hoogly in relation to Calcutta water supply. Sci. Cult. 1949; 14(8):318-326.
37. Roy HK. Plankton ecology of the river Hooghly at Patna. Ecology. 1955; 36:169-175.
38. Rup Singh TK, Singh SB. Studies on the physicochemical factors affecting the plankton production in Brahmaputra lake (Muzaffarpur, Bihar). Proc. 60th md. Sci. congr. Part 1973; 3:307.
39. Schroder B. Uber des plankton der Oder. Ber dtsch bot. Ges. 1897; 15:482-492.
40. Smith GM. Freshwater algae of the United States, 2nd edn. McGraw Hill Co., New York and London, 1950, 719.
41. Swale EMF. A study of the phytoplankton of a calcareous river. J Ecol. 1964; 52:433-446.
42. Vasisht US, Jindal R. Rheological survey of pucka stream of Patiala (Punjab, India). Lirnnologica (Berlin) 1980; 12(1):77-83.
43. William LG. Possible relationship between plankton diatom species, numbers and water quality estimates. Ecology 1964; 45:809-823.
44. Zacharias O. Das Potamoplankton. Zool. Anz 1898; 21:41-48.