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Quantitative and qualitative assessment of plankton: some ecological aspect and water quality parameters of the river Meghna, Bangladesh

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Abstract
Investigation on the seasonal distribution and abundance of various major taxa of phyto- and zooplankton and the corresponding physico-chemical characteristics were carried out in four selected stations between the latitude 22°35.494Ñ N-23°23.987 N and longitude 90°35.793 E - 90°49.061 E of the Meghna river system, Bangladesh. Drop count method was followed for the qualitative and quantitative analysis of both phyto- and zooplankton. A total of 41 phytoplankton genera belonging to 17 families and 13 zooplankton genera belonging to 11 families were recorded. Zooplankton growth cycle was noticeably less (3.0%) than the phytoplankton abundance almost throughout the study period. Quantity of plankton registered to increase chronologically from the upper to lower stretches of the river. During summer investigation the load of phytoplankton was recorded maximum (11,300-51,850 No/l). Ratio-wise quantitative difference between zoo- and phytoplankton in composition of the total standing crop fluctuated between 1.0 : 5.5 and 1 : 1037. Among the phytoplanktonic groups, Chlorophyceae was found to be dominating (95.0%) in all sampling stations. *Protococcus*, a single genus of Chlorophyceae played a unique role during summer, contributing the highest density of about 74.0%. The pattern of qualitative and quantitative difference of plankton standing crop in different sampling sites can be attributed to the existing physico-chemical characteristics, mainly water temperature, pH and hardness.

Key words : Plankton productivity, Physico-chemical parameters, Meghna river

Introduction

Bangladesh lies in the delta of the world's three great river systems (the Ganges-Padma, the Brahmmaputra-Jamuna and the Meghna river system and a complex network of 230 rivers. These three mighty river basins drain a catchment area of 1,720,000 km^2 of which only seven per cent lies in Bangladesh (UN 1995). These rivers carry heavy amount of silt especially during monsoon season and erodes bank on both sides. About 2.4 billion tons of sediments are carried by the river system in Bangladesh yearly (Holemen 1986). With the rapid growing urbanization, the rivers have been receiving a very high

quantum of sewage and huge amount of untreated discharge of effluents from various industries, which have posed a serious impact on aquatic life. Maximum portion of industrial wastes are non-degradable and that affect the environment for the long time.

The confluence of Padma-Meghna is a very significant water body, the major nursery ground of hilsa (*Tenualosa ilisha*) and many other commercially important riverine fishes.

Biological potentiality of an aquatic ecosystem depends on the biomass of the plankton. The knowledge on the abundance, composition and seasonal succession of the same is a prerequisite for the successful management of an aquatic ecosystem. The enormous volume of pollutants discharged from different industries has greatly dislodged the biological rhythm of the lotic ichthyofauna. Information on the productivity of the lotic waters of Bangladesh in relation to the physico-chemical and biological factors is very scanty (Sarker 1971, Islam *et al.* 1974, Islam and Haroon 1975, Patra and Azadi 1985, Ahmed *et al.* 1997). Limnology of the Meghna river system has been studied only by Shafi *et al.* (1978). However, much attention has not been paid to correlate the abiotic and biotic components of the system. In this paper, attempt has been made to put forth an interrelationship between the selected abiotic and plankton productivity in the Meghna river ecosystem.

Materials and methods

This study was carried out in four selected stations *viz.*, Mohonpur (Station-I), Kaligonj (Station-II) , Charludua (Station-III) and Daulatkhan (Station-IV) in the Meghna river system between the latitude $22^0$35.494Ñ N - $23^0$23.987 N and longitude $90^0$35.793 E-$90^0$49.061 E. Samplings were done in two prominent seasons of Bangladesh, the winter and summer during July'02 to June'03. Some parameters were analysed in the field and other were analysed in the laboratory. Mean value for each parameter for this study was calculated from the four different stations.

Replicate plankton samples, each of 50 L, were collected from various spots around each station by means of a bucket and filtered through bolting silk plankton net of 50 μ. The filtrate was transferred to other bottle and preserved immediately in 1:100 Lugol's solution. Qualitative and quantitative analysis of both phyto-and zooplankton were done following drop count method (APHA 1995). Identification of plankton was made following Ward and Whipple (1959) and Presecot (1962).

Collection of samples and necessary preservation for various physico-chemical parameters and their estimation were carried out following Standard Methods (APHA 1995). Temperature (air and water), transparency, dissolved oxygen (DO), free carbon-dioxide (CO_2), total hardness, total alkalinity, total dissolved solids (TDS) and chemical oxygen demand (COD) were investigated following APHA (1995). Ammonia and nitrite were estimated using HACH water test kit. Conductivity and pH meter were used to determine water pH and specific conductance respectively. Pearson's correlation coefficient was computed to determine the extent of relationships among the hydrobiological factors.

Results and discussion

Abundance of phytoplankton, zooplankton and total plankton in different sampling stations of the Meghna river system has been presented in Table 1. During the investigation, 41 genera of phytoplankton belonging to 17 families and 13 genera of zooplankton belonging to 11 families were recorded. Data on standing crop of total plankton of the river ecosystem revealed a wide variation in different sampling stations. Similar observations were also made by Shafi *et al.* (1978) and Patra and Azadi (1985) in the Meghna and Halda river respectively. Seasonal mean abundance (No./l) of total plankton was found to be varied between 10,200 and 30,300 with recorded minimum and maximum concentration at Station-I and Station-IV respectively. The mean abundance was recorded as 23,525±9,254 with lower quantity of plankton (72,00) in the upper stream with a chronological increase in amount (51,850) in the upper station. Although the mean monthly summer and winter population density of zooplankton showed a little difference but the total plankton production was much higher in summer than that of winter. In 1978, it was reported that plankton population at the same river was fluctuated between $83.3x10^4/m^2$ and $171.5x10^4/m^2$ (Shafi *et al.* 1978), indicating higher density at that period. It is assumed that plankton density has been decreased over time due to the problem of anthropogenic environmental distortion that continuously affecting the river Meghna. With the rapid urbanization in the recent decade this river receives huge quantum of industrial and domestic effluents of multiple nature. Such industrial pollutant load, metal-toxicity and nutrient-gradient play a significant role on the nature of the ecosystem and stressing the biota there in as well. In the winter months value of water flow reduces and proportionate concentration of pollutant becomes higher which affect the concentration of plankton in the ecosystem. The general law was found true when winter density (No./l) of total plankton (12,500±4,593) was found less than the summer density (34,550±16,901) attributing larger mean standing crop in the summer months. The finding is also in agreement with the findings like the effect of temperature intensity and photoperiod that have a great supportive role for the luxuriant growth of plankton (Shafi *et al.* 1978, Patra and Azadi 1985, Chakrabarty *et al.* 1995, Khan *et al.* 1998).

Though Phytoplankton was found largely dominated over zooplankton in the Meghna river throughout the investigation period, no significant correlation between phyto-and zooplankton was found which was also observed by Ahmed *et al.* (1997). While a direct correlation between zoo- and phytoplankton was reported by Chakrabarty *et al.* (1959) and Ayyapan and Gupta (1980). On the Cotrary, Khan and Siddiqui (1974) showed an inverse relation between the two. The mean contribution of phytoplankton was about 97.0% of the total planktonic organisms and zooplankton contributed the rest. Shafi *et al.* (1978) also reported higher percentage composition of phytoplankton (76.0-93.6%) from the same ecosystem. At the same period contribution of zooplankton was found to fluctuate between 6.4 and 23.8%. In present communication, phytoplankton density ranged between 7,200 and 51,850 with a mean of 23,031±9,555. The highest count of phytoplankton (51,850) was recorded in and around the estuarine environment.

Mean summer density of phytoplankton (34,162±17,098) was higher than that of winter period (11,900±4,829), indicating larger mean abundance of phytoplankton in summer which is probably due to the increased metabolic rate and reproduction of aquatic flora due to the increase in temperature. Therefore water temperature was found to have a positive influence on the phytoplankton population ($r=0.792$, $p<0.05$) which enhanced the abundance of total plankton ($r=0.791$, $p<0.05$) (Table 2). Phytoplankton growth was also reported much higher during the summer months in the Halda river when water current was high (Patra and Azadi 1985). Except Mohonpur (9.3%), the major nursery area of hilsa, mean zooplankton population recorded in other three stations found merely lower in number that fluctuated between 0.6-1.7%. With the exception of Station-I (1,300) in winter and Station-IV (50) in summer standing crop of zooplankton in winter and summer investigations showed close quantitative resemblance. However, zooplankton was comparatively a little more in winter months than the summer. The mean standing crop of zooplankton in the Meghna river over the investigation period was 494±332 within the range 50-1,300. Zooplankton contributed more than 3.0% to the total planktonic organisms. Low production of zooplankton in a lotic system is not uncommon. Shyam Sundar *et al.* (1995) reported the major contribution of phytoplankton (>97.0%) and lower concentration of zooplankton (0.13-2.4%) at three sampling sites in the Gaula river of Uttar Pradesh, India.

Table 1. Abundance of plankton in different stations of the Meghna river

Station	Phyto- (No/l)	Zoo- (No/l)	Total plankton (No/l)	Phyto- (%)	Zoo- (%)
Station-I (Mohonpur)	9,200 (7,200-11,300)	950 (600-1,300)	10,200	90.69	9.31
Station-II (Kaligonj)	24,000 (15,000-33,000)	350 (300-400)	24,350	98.56	1.44
Station-III (Charludua)	28,750 (17,000-40,500)	500 (500-500)	29,250	98.29	1.71
Station-IV (Daulatkhan)	30,125 (8,400-51,850)	175 (50-300)	30,300	99.42	0.58
Mean ± SD	23,031± 9,555	494± 332	23,525±9,254	96.74	3.26

* Ranges in parenthesis

Table 2. Coefficient of correlation (r) among the different abiotic and biotic factors in the Meghna

Characteristics			Coefficient of correlation (r)
Water temperature	Vs.	Total plankton	0.791*
Water temperature	Vs.	Phytoplankton	0.792*
Water temperature	Vs.	Rotifers	-0.742*
Water temperature	Vs.	Copepoda	0.710*
Water temperature	Vs.	Protococcus	0.972**
pH	Vs.	Rotifers	-0.708*

pH	Vs.	Protococcus	0.714*
pH	Vs.	Pedestrum	-0.901**
Hardness	Vs.	Protococcus	0.784*
Ammonia	Vs.	Zooplankton	0.798*
Nitrate	Vs.	Zooplankton	0.767*
Total plankton	Vs.	Phytoplankton	0.999**
Total plankton	Vs.	Protococcus	0.751*
Phytoplankton	Vs.	Protococcus	0.749*
Chlorophyceae	Vs.	Myxophyceae	-0.895*
Protococcus	Vs.	Pedestrum	-0.765*
Rotifers	Vs.	Copepoda	-0.915**
Rotifers	Vs.	Brachionus	0.941**
Cladocera	Vs.	Daphnia	0.898**

A considerable fluctuation in the quality and quantity of plankton with various climatic condition and physico-chemical factors in the Meghna river was observed. Proportional seasonal abundance of zoo- and phytoplankton have been presented in Table 3. Maximum difference in quantity between zoo- and phytoplankton in composition of total crop was observed at Station-IV during summer (1.0 : 1037) and minimum at Station-I during winter (1.0 : 5.5). Proportional seasonal abundance of zoo- and phytoplankton was found remarkably higher in summer (1: 305) than that of winter months (1: 29.4). The mean ratio of zoo- and phytoplankton was 1: 167.2 during the investigation period.

Table 3. Ratio-wise composition of zoo- and phytoplankton in the Meghna river

Station	Seasonal composition	
	Winter ratio (Zoo : Phyto)	Summer ratio (Zoo : Phyto)
Station-I	1 : 5.5	1 : 18.8
Station-II	1 : 50	1 : 82.5
Station-III	1 : 34	1 : 81.0
Station-IV	1 : 28	1 : 1037
Mean	1 : 29.4	1 : 305

The data of the physico-chemical characteristics of Meghna river are summarized in Table 4. The values of water temperature at surface ranged between 24.1 and 30.5^{0}C with a mean of 27.6±0.68. The surface water temperature of the river was found always lower than air temperature. The Secchidisc visibility ranged from 12 to 90 cm with a mean of 34.2±18.08 at different stations. The transparency of water was found higher at the upper stretch of the river than that of the lower stretch. Almost muddy water was found in and around the estuarine region. Dissolved oxygen (DO) content was found gradually decreasing from the upper to lower stretches of the river system. The mean value of DO was recorded 6.7±0.81mg/l. The highest value of free CO_2 (7.7 mg/l) was observed in Station-I that also gradually decreased following the trend of DO. The values of pH in the river water found to range from neutral to alkaline (7.0-8.0) at the sampling stations.

It exhibited a narrow range of fluctuation throughout the investigation period. Total alkalinity was detected in appreciable quantities (48.0-88.7 mg/l) indicated the river water to be nutrient enriched and hard water type (42.3-95.1 mg/l) and such waters could be considered as good for optimum fish production. The ammonia concentration was found little high and ranged from 0.1 to 0.6 mg/l. It showed a gradually decreasing trend from upward to downward stretches. Except Station-I the concentration of nitrite was found zero for the other stations. The values of chemical oxygen demand (COD) were found tremendously high in the Station-I and Station-IV, which is far above the critical range. The causes of higher values of COD at the aforesaid stations could not be explained. Total dissolved solids (TDS) fluctuated between 0.12 and 0.32 µg/l with a mean of 0.20±0.05. The highest value (220 µS/cm) of conductivity was recorded at Station IV, which is about 2.5 fold higher than those of other recorded values in different stations at the same period. Statistical analysis detected the existence of significant correlation among various physico-chemical and biological variables in few cases in the Meghna river system.

Table 4. Physico-chemical characteristics of the Meghna river

Parameters	Station-I Mohonpur	Station-II Kaligonj	Station-III Charludua	Station-IV Daulatkhan	Mean±SD
Global position (Latitude/ Longitude)	23°23.987Ñ N 90°35.793Ñ E	22°51.252Ñ N 90°39.169Ñ E	22°42.456Ñ N 90°49.061Ñ E	22°35.494Ñ N 90°45.446Ñ E	-
Air temp. (°C)	(25.3 –28.7) 27.0	(27.2 – 31.6) 29.4	(27.8 – 31.8) 29.8	(28.9 – 31.5) 30.2	29.1±1.44
Water temp. (°C)	(24.1-29.2) 26.6	(24.8 – 30.4) 27.6	(26.0 – 30.5) 28.2	(25.5 – 30.2) 27.8	27.6±0.68
Secchidisc Transparency (cm)	(26 – 90) 58.0	(15 – 62) 38.5	(12 – 25) 18.5	(14 – 30) 22.0	34.2±18.08
Dissolved Oxygen (mg/l)	(7.4 – 8.3) 7.8	(6.8 – 6.9) 6.8	(5.9 – 6.6) 6.3	(5.1 – 6.9) 6.0	6.7±0.81
Free CO_2 (mg/l)	(2.4 – 7.7) 5.0	(3.4 – 7.3) 5.3	(4.3 – 6.4) 5.3	(3.6 – 4.0) 3.8	4.8±0.74
pH	(7.8 – 8.0) 7.9	(7 – 8) 7.5	(7.7 – 8.0) 7.8	(7.7 – 8.0) 7.8	7.8±0.18
Alkalinity (mg/l)	(48.0 – 78.1) 63.0	(80.5 – 81.4) 80.9	(80.6 – 83.2) 81.9	(73.2 – 88.7) 79.4	76.3±8.91
Hardness (mg/l)	(42.3 – 84.8) 63.5	(54.9 – 94.3) 74.6	(60.5 – 95.1) 77.7	(63.7 – 84.8) 74.2	72.5±6.21
Ammonia (mg/l)	(0.1 – 0.8) 0.4	(0.1 – 0.6) 0.3	(0.1 – 0.6) 0.3	(0.1- 0.4) 0.1	0.35±0.08
Nitrite (mg/l)	(0 – 0.03) 0.01	0	0	0	0 – 0.01±0
COD (mg O_2/l)	(33.6 – 70.7) 52.1	(8.3 – 53.8) 31.0	(4.2 – 56.9) 30.5	(53.7 – 62.4) 58.1	42.9±14.24
TDS (µg/l)	(0.12 – 0.26) 0.19	(0.12 – 0.18) 0.15	(0.22 – 0.32) 0.27	(0.18 – 0.21) 0.19	0.20±0.05
Conductivity (µS/cm)	(75 – 91) 83.0	(98 – 147) 122.5	(96 – 150.4) 123.2	(152.2 – 220) 186.1	128.7±42.63

The phytoplankton population was composed of algal flora belonging to the group Chlorophyceae, Myxophyceae, Bascillariophyceae and Euglenophyceae. The members of the group Chlorophyceae represented largely available phytoplanktons, these were found abundant throughout the investigation period. Chlorophyceae on an average consisted of about 95.0% (88.5-99.2%) (Table 5) of the total phytoplankton population and represented by various species belonging to genera *Scenedesmus, Protococcus, Gonatogygon, Mougeotia, Crucigenia, Pediastrum, Palmellococcus, Ankistrodesmus, Microspora, Closterium, Genecularia, Spirogyra, Schroederia, Hydrodictyon, Oocystis, Planktosphaeria, Pleodorina, Dicidium, Staurastrum, Netrium, Mesotenium* and *Zygnema* (Table 6). Chlorophyceae exhibited more or less similar pattern of fluctuation during the investigation period. Their density per liter was more than double during summer investigation. Among the phytoplankton *Protococcus* dominated over all other types of plankton in summer registering the highest density of 73.6±5.5%, the unique contribution of a single genera. It ranged betweeen 65.5% and 77.8%, indicating a narrow fluctuations in different stations. *Protococcus* played a significant role for the abundance of phytoplankton and total plankton as well. It showed a significant positive relationship with phytoplankton ($r=0.749$, $p<0.05$) and total plankton ($r=0.751$, $p<0.05$) also. It is also noted that the luxuriant growth of *Protococcus* was influenced by the temperature ($r=0.972$, $p<0.01$), hardness ($r=0.784$, $p<0.05$) and pH ($r=0.714$, $p<0.05$) during the investigation period. Shafi *et al.* (1978) quoted that phytoplankton crops of hardwater tend to be heavier than those of soft water. On the other hand, *Scenedesmus, Protococcus, Gonatogygon, Mougeotia* and *Crucigenia* combinely contributed about 85% during winter sampling. Comparatively higher relative number of these algal species occurred during summer and registered their lower presence in winter. Myxophyceae contributed more than 3.0% of the mean of total phytoplankton. Lower density (2.2%) of this group was noticed during summer indicating opposite pattern of fluctuation than Chlorophyceae. Myxophyceae established a strong significant inverse relationship with Chlorophyceae ($r=-0.895$, $p<0.01$). Patra and Azadi (1985) found the similar results in the Halda river. Myxophyceae included various species belonging to genera *Anacystis, Spirulina, Mycrocystis, Coelosphaerium, Phormidium, Anabaena, Nostoc, Oscillatoria, Merismopedia,* and *Aphanocapsa.* The contribution of the aforesaid group was about 4.0% during winter period. Bascillariophyceae on an average consisted of only 1.7% of the total phytoplankton population and represented by various species belonging to genera *Melosira, Synedra, Coscinodiscus, Stephanodiscus, Diatoma, Navicula, Gyrosigma.* Per cent composition showed their lesser abundance in winter months (0.6%) up to a maximum of 2.8% in summer. This group was found absent in upper stretches of the Meghna river (Stations I-III) during winter sampling. It appeared at all stations during summer. Appearance of Euglenophyceae was found at Station-I and Station-II and contributed only 0.2%. Euglenophyceae was totally absent in the lower stretches of the river (Station-III and IV) during the study period.

Table 5. Composition of planktonic organisms at four sampling sites of the Meghna river

Plankton composition	Site-I	Site-II	Site-III	Site-IV
Phytoplankton major components (%)				
Chlorophyceae	(88.5-98.5)	(92.4-96.0)	(98.7-99.2)	(90.5-96.1)
	93.5	94.2	99.0	93.3
Myxophyceae	(0-6.2)	(0.3-7.5)	(0.2-1.0)	(2.1-7.1)
	3.1	3.9	0.6	4.6
Bacillariophyceae	(0-5.3)	(0-3.3)	(0-1.0)	(1.2-1.7)
	2.6	1.6	0.5	1.4
Euglenophyceae	(0-1.4)	(0-0.3)	(0-0)	(0-0)
	0.7	0.1	0	0
Zooplankton major components (%)				
Copepods	(23.1-66.7)	(0-100)	(40.0-80.0)	(0-100.0)
	44.9	50.0	60.0	50.0
Rotifers	(33.3-38.5)	(0-75.0)	(20.0-20.0)	(0-75.0)
	35.9	37.5	20.0	37.5
Cladocera	(0-38.5)	(0-25.0)	(0-20.0)	(0-25.0)
	19.2	12.5	10.0	12.5
Ostracods	(0-0)	(0-0)	(0-20.0)	(0-0)
	0	0	10.0	0

Table 6. The list of planktonic algae at different sites in the Meghna river

Plankton	Group	Genera
Phyto-	Chlorophyceae	*Scenedesmus, Protococcus, Gonatogygon, Mougeotia, Crucigenia, Pediastrum, Palmellococcus, Ankistrodesmus, Microspora, Closterium, Genecularia, Spirogyra, Schroederia, Hydrodictyon, Oocystis, Planktosphaeria, Pleodorina, Dicidium, Staurastrum, Netrium, Mesotenium, Zygnema*
	Myxophyceae	*Anacystis, Spirulina, Mycrocystis, Coelosphaerium, Phormidium, Anabaena, Nostoc, Oscillatoria, Merismopedia, Aphanocapsa*
	Bacillariophyceae	*Melosira, Synedra, Coscinodiscus, Stephanodiscus, Diatoma, Navicula, Gyrosigma*
	Euglenophyceae	*Trachelmona, Phacus*
Zoo-	Rotifers	*Brachionus, Trichocerca, Kellicottia, Keratella, Gastropus, Polyarthra*
	Cladocera	*Daphnia, Bosmina*
	Copepoda	*Calanoid, Cyclops, Diaptomus,* Nauplius
	Ostracoda	*Cypris*

Zooplankton population was mainly dominated by the members of the group Copepoda (51.2%), followed by Rotifera (32.7%), Cladocera (13.5%) and Ostracoda (2.5%). Not a single species of zooplankton of various groups was found as a regular component for all the sampling stations. Copepods were mainly represented by both common and uncommon genera like, *Cyclops, Diaptomus* and *Calanoid* and dominated over other groups during the investigation period. Relative abundance of copepods registered higher per cent composition in summer investigation (76.7%). It fluctuated

between 45% and 60% during the study period for all the stations. Rotifers were found much abundant during winter investigation (52.1%) than the summer (13.3%). Rotifers included various species of *Brachionus, Trichocerca, Kellicottia, Keratella, Gastropus* and *Polyarthra.* The per cent composition of Rotifers varied from 20.0% to 37.5% in different stations during the investigation period. It is evident from Table 6 that water temperature was found to have a negative significant relationships with Rotifers ($r=0.742$, $p<0.05$) and a positive significant relationship with copepoda ($r=0.710$, $p<0.05$). Relative abundance of Cladocera was much higher per cent (22.1%) in winter than the summer (5.0%). Different species belonging to cladoceran genera were *Daphnia* and *Bosmina.* In different stations, it ranged from 10.0%-19.2% during the study period. Ostracodan did not appear in the sample during winter. It contributed only 5.0% during summer investigation. They were the lowest component showing the mean monthly proportional abundance of 2.5% .of the total zooplankton population (0-20.0%).

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