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PHYTOPLANKTON DIVERSITY AND ABUNDANCE IN RELATION TO POLLUTION LEVELS IN THE HAZARIBAGH TANNERY EFFLUENT SEWAGE WATER OF THE RIVER BURIGANGA

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Abstract: About 185 leather processing industries have been operating in Hazaribagh and discharging solid and liquid wastes to the downstream areas of the river Buriganga and to the canals around. The physico-chemical parameters and biological examination of tannery effluents sewage water were carried out in relation to phytoplankton abundance at four selected points (viz. Kamrangirchar: K1, K2 and K3; Hazaribagh Tempo Stand: H) of the Buriganga river from October 2009 to September 2010. Altogether 27 genera of Phytoplankton belonging to the families Cyanophyceae, Bacillariophyceae, Chlorophyceae, Euglenophyceae and Cryptophyceae were identified from the above points. *Merismopedia* was the most abundant form (3.6×10^4 - 2.4×10^6 cell/L) compared to those (1.4-72 $\times10^3$ cell/l) genera of other phytoplankton (*Nitzschia*, *Synedra*, *Pleurosigma*, *Euglena* , *Strusastrum*, *Crucigenia*, *Ourococcus*) at K1, the station closest to the tannery effluent outfall. The abundance of *Merismopedia* increased gradually (K2: 6.45×10^4 - 3.68×10^6, K3: 6.95×10^4 -1.68×10^7 and H: 1.0×10^5 - 2.06×10^7) along with the decreasing pollutant concentrations of the water.

Key words: Phytoplankton, Tannery effluent, Buriganga river, Pollution, *Merismopedia*, Cyanophyceae, Bacillariophyceae

INTRODUCTION

Hazaribagh is a densely populated area of Dhaka city where about 185 leather processing industries are operating and discharging solid and liquid wastes directly or indirectly to the low-lying areas, river and natural canals through two open drains without proper treatment. The water in the lowlying areas near Hazaribagh, with a direct link to the Buriganga river, is polluted in such a degree that it has become unsuitable for public uses. The river is seriously polluted by the discharge of industrial effluents (toxic Chemicals: hydrogen sulphide, ammonia, poisonous chlorine, heavy metals) into river water, indiscriminate throwing of household, clinical, pathological and commercial wastes, and discharge of fuel and human excreta. The water of the river has become so polluted that its aquatic life has almost been extinguished. A survey carried out in 1999 revealed that up to 40,000 tones of tannery waste flows into the river Buriganga, Turag, Dhaleshwari, Balu, and Narai daily along with sewage water (Arias *et al.* 2010). Phytoplanktons occupy the functional and

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basic significance in the overall food web (Kalavati *et al.* 1997). Due to the pollution, phytoplankton population is affected and leading to drustic change in the food chain of the fresh water environment (Narendar 1990). Some phytoplankton species are often used as a good indicator of water quality and pollution. Studies revealed that there was an outburst of *Skeletonema costatum* as a result of pollution in Visakhaplanam harbor (Raman 1995). The phyto-plankton community was stressed by the large and continues out flow from El-Umoum effluents (Dorgham 1997). So far no study was conducted in the Buriganga river to evaluate the relationship between phytoplankton and pollutants.

The aim of this work was to study the diversity and abundance of phytoplankton in relation to the level of pollution near Hazaribagh area of the Buriganga river.

MATERIAL AND METHODS

To evaluated the physical, chemical and biological variables, sampling was performed at four selected different points of Hazaribagh (Kamrangirchor) tannery complex area, located in Dhaka, Bangladesh (23°43'N, 90°21'E). These points were K1 main tannery effluent discharging point (Companyghat), K2 about 100 meters north from K1 downstream location from the sluice gate, K3 about 150 meters from K2, and Hazaribagh tempo stand (H) about 240 meters from K1 location from October 2009 to September, 2010. The water samples were collected in the morning between 7.00 a.m. and 9.00 a.m. Water temperature (by using a precise mercury thermometer), hydrogen ion concentration (by using a pH meter), electrical conductivity (with a conductivity meter), turbidity level (by using turbidity-meter) were recorded at the spot and the rest of the parameters were determined in the laboratory. Water samples were collected for chemical and biological analysis using pre-washed polyethylene bottle by water sample twice before filling and stored at 4°C in the laboratory. Following physiochemical parameters were measured in the laboratory: Dissolved oxygen (by using a DO meter), Biological oxygen demand, BOD (5-day BOD test), Chemical oxygen demand, COD (by sample digestion method), Phosphate (by using Standard Colorimetric method, ascorbic acid) (Apha 1998). Nitrite-nitrogen, Nitrate-nitrogen and Ammonia (by using spectrophotometric method) (Apha 1998). Collected algal samples were preserved in 4% formalin and lugol's iodine solution. Algal identification was done by using a standard monograph (Anand 1998).

RESULTS

Physicochemical parameters: Difference in the water quality and phytoplankton composition and abundant were observed between the highly polluted sites (K1, K2 & K3) and the last point H, which was comparatively less polluted (Table 1).

Table 1. Physico-chemical properties and phytoplankton diversity of Buriganga river from September 2009 to August 2010.

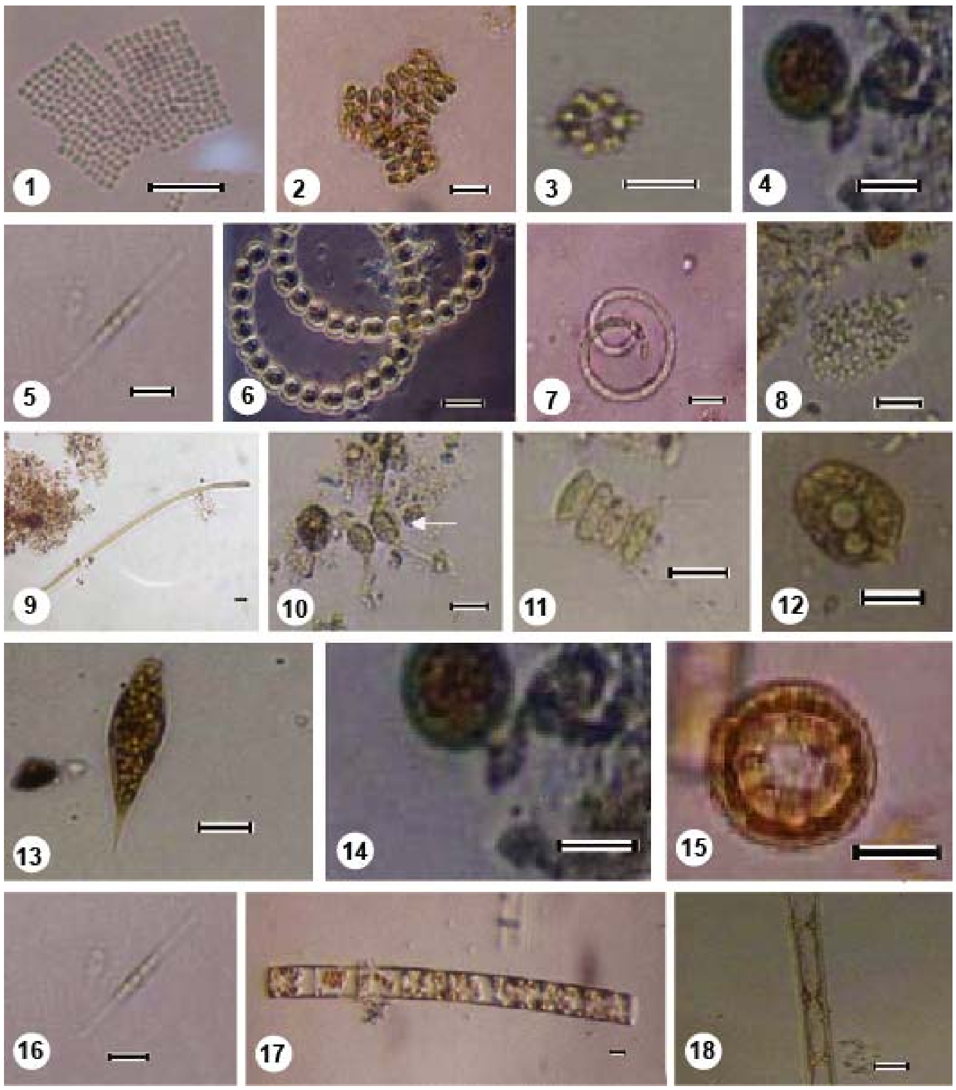
Sampling parameters	Sampling point (K1)	Sampling point (K2)	Sampling point (K3)	Sampling point (H)
Water Temperature (^{0}C)	19-26	18-26.5	18.5-26	17.8-26
pH	6.00-7.54	6.69-7.58	6.80-7.79	6.89-7.74
Dissolved Oxygen (mg/l)	0.9-1.23	1.0-1.19	0.89-1.31	1.35-1.89
Chemical Oxygen Demand (mg/l)	59.56-66.48	69.0-70.84	50.65-54.49	54.23-55.58
Biochemical Oxygen Demand (mg/l)	10.23-12.55	11.65-13.65	9.0-11.75	8.5-10.05
Turbidity (NTU)	8.69-9.12	7.65-8.78	6.69-7.85	6.52-7.65
Nitrate-Nitrogen (mg/l)	2.23-2.61	2.85-3.45	3.0-3.74	3.23-4.22
Nitrite-Nitrogen (mg/l)	0.23-0.52	0.31-0.65	0.56-0.72	0.71-0.78
Phosphate (mg/l)	4.65-5.03	3.56-5.02	0.23-0.86	0.16-0.97
Conductivity (μS/cm)	865-912	866-902	789-862	856-899
Ammonia as Nitrogen (mg/l)	5.81-6.13	5.03-6.39	4.96-6.51	3.56-6.18

In points K1, K2 and K3, the results obtained regarding physiochemical parameters revealed that the overall range of temperature was 18-26.5^{0}C, turbidity 6.69-9.12 NTU, pH 6.0-7.79, conductivity 789-912 μS/cm, dissolved oxygen 0.89-1.31 mg/l, Nitrite-Nitrogen (NO_2-N) 0.23-0.72 mg/l, Nitrate-Nitrogen (NO_3-N) 2.23-3.74 mg/l, ammonia (NH_4) 4.96-6.51 mg/l, total phosphorus 0.23-5.03 mg/l, Chemical Oxygen Demand (COD) 50.65-70.84 mg/l and Biological Oxygen demand (BOD) was 9.0-13.65 mg/l.

On the other hand, in point H, temperature was 17.8-26.^{0}C, turbidity was 6.85-7.52 NTU which is remarkably less than that of K1, pH was 6.89-7.74 and conductivity 856-899 μS/cm. Dissolve oxygen (1.35-1.89 mg/l), inorganic nitrogen (NO_2-N 0.71-0.78 mg/l, NO_3-N 3.23-4.22 mg/l) were higher than the other three points. However, Biological Oxygen demand (BOD, 8.5-10.05 mg/l) was less than the rest of the points. Chemical Oxygen Demand (COD, 54.23-55.58 mg/l), ammonia (NH_4 3.56-6.18 mg/l) and total phosphorus (0.16-0.97 mg/l were more or less similar to K1, K2 & K3.

Biological Characteristics: Altogether 27 genera of Phytoplankton belonging to families Cyanophyceae, Bacillariophyceae, Chlorophyceae, Euglenophyceae and Cryptophyceae were identified from these four points (Fig. 1 and Table 2)

Merismopedia of Cyanophyceae was evidently the most abundant and frequent genera. The green algae (Chlorophyceae) were the more diverse group, and their diversity and abundance increased with the decrease of pollution. Notable genera of this group were *Crucigenia, Ankistrodesmus*, *Tetradesmus, Clostridium,* *Coelostrum*, *Strusastrum,* *Ourococcus,* *Chlamydomonas, Senedesmus*.



Figs. 1-18: Eighteen representatives of frequently available genera of phytoplanktons observed in various points (K1, K2, K3 and H) around the Buriganga river. 1. *Merismopedia* sp., 2. *Crucigenia* sp., 3. *Coelastrum* sp., 4. *Trachelomons* sp., 5. *Nitzschia* sp., 6. *Anabaena* sp., 7. *Anabaenopsis* sp., 8. *Microcystis* sp., 9. *Oscillatoria* sp., 10. *Staurastrum* sp., 11. *Scenedesmus* sp., 12. *Phacus* sp., 13. *Euglena* sp., 14. *Trachelomonas* sp., 15. *Cyclotella* sp., 16. *Nitzschia* sp., 17. *Melosira* sp. and 18. *Synedra* sp.

After Chlorophyceae, Diatom (Bacillariophyceae) and Blue green alga (Cyanophyceae) showed the remarkable diversity and abundance. The genera *Oscillatoria, Raphideonema, Arthrospira, Microcystis, Anabaenopsis* of Cyanophyceae and *Nitzschia, Synedra, Navicula, Pleurosigma, Cymbella, Cycotella* of Bacillariophyceae were recorded during the study.

Point K1, located close to industrial discharge, nine species were recorded. The average abundance of phytoplankton number in this area was 7.7×10^5 Cell/ml (Table 1). The species dominance was shown by *Merismopedia* (2.86×10^6 Cell/ml) from the total number of $1.75\text{x}10^7$ Cell/ml. *Nitzschia* (1.4×10^3 Cell/ml), *Synedra* (1.4×10^3 Cell/ml), *Pleurosigma* (9.5×10^2 Cell/ml), *Oscillatoria* (8.6×10^2 Cell/ml), *Euglena* (3.5×10^2 Cell/ml), *Ourococcus* (9.5×10^2 Cell/ml), *Strusastrum* (2.5×10^2 Cell/ml), *Crucigenia* (1.4×10^2 Cell/ml).

Table 2. Abundance, diversity and dominant taxa of phytoplankton in the water samples of selected points (K1, K2, K3 and H) of the Buriganga river.

Sampling parameters	Sampling point (K1)	Sampling point (K2)	Sampling point (K3)	Sampling point (H)
Phytoplankton No of species	9	13	21	23
Abundance of phytoplankton (No.ML-1)	7240- 2681880 (703786.4)	60540- 3771600 (1303318)	110600-17606750 (3142771.6)	124670-27926730 (5741871.6)
Dominant genus	*Merismopedia*	*Merismopedia* *Ankistrodesmus*	*Merismopedia* *Coelostrum* *Ankistrodesmus* *Nitzschia* *Trachaelomonas*	*Merismopedia* *Crucigenia* *Ankistrodesmus* *Coelostrum* *Clostridium* *Nitzschia* *Tetradesmus*
Correlation values of *Merismopedia* btween abundance in different station	0.85 (K1-K2) 0.33 (K1-K2)	0.57 (K2-K3)	0.78 (K3-H)	0.17 (H-K1) 0.34 (H-K2)

At point K2, total 13 species of phytoplankton were recorded and represented by average 1.13×10^6 Cell/ml. The genus dominance was shown by *Merismopedia* (3.68×10^6 Cell/ml) from the total number of 3.25×10^7 Cell/ml followed by *Ankistrodesmus* (6.5×10^4 Cell/ml), *Oscillatoria* (2.94×10^4 Cell/ml) and *Crucigenia* (1.75×10^4 Cell/ml). Other genera which were collected and identified form this area are *Nitzschia* (8.4×10^3 Cell/ml), *Clostridium* (8.4×10^2

Cell/ml), *Microcystis* (7.0×10^3 Cell/ml), *Synedra* (1.4×10^3 Cell/ml), *Anabaenopsis* (7.0×10^2 Cell/ml), *Navicula* (3.5×10^2 Cell/ml), *Cymbella* (3.5×10^2 Cell/ml), *Euglena* (3.5×10^2 Cell/ml) and *Cycotella* (1.4×10^2 Cell/ml).

Total 21 genera of phytoplankton were recorded from the point K3 and the average phytoplankton of this point was 3.14×10^6 Cell/ml. Like other points, here also *Merismopedia* (1.68×10^7 Cell/ml) showed the prime dominance from the total number of phytoplanton of this area (7.85×10^7 Cell/ml) followed by *Nitzschia* (7.0×10^5 Cell/ml), *Coelostrum* (4.65×10^5 Cell/ml), *Trachaelomonas* (3.15×10^5 Cell/ml) and *Ankistrodesmus* (1.4×10^5 Cell/ml), *Crucigenia* (8.8×10^4 Cell/ml), *Oscillatoria* (3.6×10^4 Cell/ml), *Cryptomonas* ($2.1\text{x}\times10^4$ Cell/ml), *Euglena* (3.5×10^2 Cell/ml), *Rhodomonas* (1.4×10^4 Cell/ml), *Synedra* (1.4×10^3 Cell/ml), *Senedesmus* (1.05×10^4 Cell/ml), *Clostridium* (9.6×10^3 Cell/ml), *Microcystis* (8.5×10^3 Cell/ml), *Phacus* (7.0×10^3 Cell/ml), *Raphideonema* (7.0×10^3 Cell/ml), *Navicula* (2.8×10^3 Cell/ml), *Cymbella* (1.4×10^3 Cell/ml), *Chlamydomonas* (1.4×10^3 Cell/ml), *Anabaenopsis* (1.4×10^3 Cell/ml), *Arthrospira* (3.5×10^2 Cell/ml).

At the point H, total 23 genera of phytoplanktons were recorded and represented by average Cell/ml. The genus dominance was shown by *Merismopedia* (2.06×10^7 Cell/ml) from the total number of 1.43×10^8 Cell/ml followed by *Nitzschia* (7.0×10^6 Cell/ml), *Crucigenia* (4.9×10^5 Cell/ml), *Ankistrodesmus* (4.2×10^5 Cell/ml), *Senedesmus* (1.25×105 Cell/ml) and *Clostridium*(1.05×10^5 Cell/ml). *Synedra* (8.7×10^4 Cell/ml), *Chlamydomonas* (7.0×104 Cell/ml), *Oscillatoria* (3.6×10^4 Cell/ml), *Cryptomonas* (2.5×10^5 Cell/ml), *Tetradesmus*(2.4×10^4 Cell/ml), *Navicula* (1.26×10^4 Cell/ml), *Raphideonema* (1.4×10^4 Cell/ml), *Microcystis* (1.0×10^4 Cell/ml), *Pleurosigma* (8.4×10^3 Cell/ml), *Phacus* (8.4×10^3 Cell/ml), *Trachaelomonas* (8.4×10^3 Cell/ml), *Arthrospira* (8.4×103 Cell/ml), *Anabaenopsis* (7.0×10^3 Cell/ml), *Coelostrum* (7.0×10^3 Cell/ml), *Strusastrum* (7.0×10^3 Cell/ml), *Euglena* (1.4×10^3 Cell/ml), *Anabaena* (3.2×10^2 Cell/ml).

DISCUSSION

Many human activities cause pollution of the aquatic environment, modification of the environmental conditions, and thereby changes in the aquatic communities (Mihaljevic *et al.* 1998). High concentration of heavy metals, *viz.* Cr, Zn, Pb, Ni, Cu, Cd, As and other ions like Cl^-, Na^+, K^+, Ca^{+2}, $SO4^{-2}$ were reported from the tannery effluents previously from the identical location in Hazaribagh area by Zahid *et al.* (2006) and Arias (1998) which are considered as major pollutants of river Buriganga. BOD and COD were high in the first point (K1) and gradually decreased in the rest of the points K2, K3 and H; on the other hand, dissolved oxygen increased from the first point (K1) to the remaining points (Table 1). This indicates that the pollution level gradually decreased from the K1 to H points as these are the indicators of water quality (Tsukatani *et al.* 2003). In this study, we found significantly lower numbers of phytoplankton in comparison with that in the less polluted area of the river, lake and dam water (Verma and Singh 2010, Nowrouzi and Valavi 2011). We found a least diversity and abundance of phytoplankton at the point which is closest to the opening mouth of tannery effluents. The abundance and diversity increased along with the decrease of pollution at the rest of the points (Tables 1 and 2). This result is comparable to other similar studies in South east coast in India, Estuarine Creek in Lagos, Nigeria (Periyanayagi *et al.* 2007 and Onyema 2007). *Merismopedia* of Cyanophyceae was found to be dominant. This genus seems to be resistant to polluted environment (Begum and Hossain 1993). Begum (2008) also observed more or less similar abundance of these species in a pond receiving effluents from two textile industries. The taxa recorded in the present study along with their abundance in different points are given in Table 2 in which the abundance of five genera, viz. *Crucigenia, Ankistrodesmus*, *Clostridium, Coelostrum* and *Senedesmus* of Chlorophyceae and Bacilariophycae *Nitzschia* is evident. For Bacilariophycae, more or less similar observations were reported by Begum and Hossain (1993), and similarly chlorophycean phytoplanktons are common in this habitat. Previously Begum (2008) reported their abundance in polluted water bodies and textile industrial effluents, respectively. Moreover the entire representative genera mentioned above accumulates these heavy metals significantly reported by Aticil *et al.* (2010). With a few exceptions, among all the groups of phytoplankton recorded, *Trachaelomonas* of Euglenophyceae showed dominance in K2 station (Table 2). Similar observation was also reported earlier in textile industrial effluents by Begum and Hossain (1993).

Concluding remarks: Altogether 27 genera of phytoplanktons belonging to five families, viz. Cyanophyceae, Bacillariophyceae, Chlorophyceae, Euglenophyceae and Cryptophyceae were identified from four points near the river Buriganga. *Merismopedia* was the most abundant form in comparison with the presence of other phytoplanktons, *viz. Crucigenia, Ankistrodesmus*, *Clostridium, Coelostrum, Senedesmus* and *Nitzschia*. The abundance of *Merismopedia* increased gradually along with the decreasing pollutants concentration of the water.

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