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SEASONAL DYNAMICS OF AQUATIC PLANTS AND PHYSICOCHEMICAL FACTORS IN AN URBAN POND OF JATRABARI, DHAKA

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Abstract

Samad Nagar pond situated in Jatrabari, Dhaka showed mean air temperature 20 - 30 ^{0}C and water temperature 19 - 28^{0}C. Secchi depth (Zs) varied from 28.67 - 44.5 cm and pH 6.6 - 8.8. The mean DO and alkalinity ranged 5.34 - 10.00 mg/l and 0.58 - 1.08 meq/l, respectively. Free CO_2, SRP and SRS ranged 1.31 - 4.21 mg/l, 158.39 - 635.70 µg/l and 13.32 - 28.65 mg/l, respectively. During the study period, seasonal mean values of transparency was higher in monsoon and lower in winter. pH, alkalinity remained higher in winter but lower in monsoon. From aquatic plant communities of the pond, phytoplankton represented by 33 species of which 54.55% belonged to Chlorophyceae (54.55%) followed by Bacillariophyceae (13.64%), Cyanophyceae (13.64%), Euglenophyceae (13.64%) and Dinophyceae (4.55%). The population density of phytoplankton community ranged 6.16 - 25.96×10^6 ind/l. Benthic diatom density varied from 2.64 – 11.00 ×10^6 ind/l. Benthic diatom population was the highest (11×10^6 ind/l) in late October and lowest in early September (2.64 ×10^6 ind/l). Chl *a* and phaeophytin concentration varied 5.10 - 228.51 µg/l and 2.05 - 1513.36 µg/l, respectively. Aquatic macrophyte communities were represented by 23 species where *Eichhornia* crassipes (Mart.) Solms. , *Ipomoea aquatica* Forsk, *Ipomoea fistulosa* Mart., *Telanthera philoxeroides* Moq., *Rumex maritimus* L., *Eclipta prostata* (L.) L. and *Salvinia natans* L. were observed all over the study period.

Key words: Limnology, Seasonality, Aquatic plants, Urban pond, Jatrabari

Introduction

In aquatic ecosystem phytoplankton together with benthic algae and macrophytes, constitute the autochthonous primary producers and form part of the basis of the food web in terms of energy and material input (Hötzel and Croome 1999). Due to their short life cycle, phytoplankton respond quickly to environmental changes and are thus a valuable indicator of water quality (Domingues and Galvão 2007 and Cabecinha *et al.* 2009). Other than phytoplankton, diatoms are the most preferable biological component of the submerged mud surface in almost all aquatic habitats and aquatic macrophytes play an important role in structuring communities in aquatic environments (Thomaz and Cunha 2010).

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In the process of urbanization, most ponds of large cities of Bangladesh are dwindling. In Dhaka metropolis, ponds are converted to lands at a great scale due their values and anthropogenic pressure and uses from the catchment. Some ponds of the city center of Dhaka were studied limnologically over the past few decades (Oppenheimer *et al.* 1978, Begum and Alam 1987, Khondker *et al.* 1990, Khondker and Kabir 1995, Khondker and Talukder 1995, Talukder and Khondker 1995, Alfasane *et al.* 2003, Hossain *et al.* 2007 and Sultana and Khondker, 2009 a,b). From the phytodiversity and limnological standpoint ponds and aquatic habitats of Jatrabari area of Dhaka were not studied in the past. Samadnagar pond situated in Jatrabari has therefore been selected to study its limnology and to assess its aquatic plant resources.

Materials and Methods

Samadnagar Pond (A= 12.60 acre Zmax= 9 m) situated at 23°71′31″ - 23°70′43″ N and 90°43′44″ - 90°43′55″ E. pond was excavated for the purposes of bathing and household uses by Haji Samad in 1973. Every day over 500 hundred people use the water of the pond for taking bath and cooking. The water is also used by people for land irrigation and building construction.

Sampling was carried out from July - December 2014 fortnightly during morning. A total of 12 samples was collected in each of which *in situ* measurement of air temperature, water temperature, pH and Secchi depth were conducted using portable devices (Temp.=mercury thermometer, pH=Hanna Instruments, USA) and Secchi disc (dia.=314.16cm^2). Integrated water samples were collected from one meter depth by a PVC pipe fitted with a check valve at the end for chemical analysis as well as phytoplankton counting. Collection of benthic diatoms was done as described by Taylor *et al.* (2005). A few drops of formaldehyde was added to the diatom sample and carried to the laboratory for analysis. After sampling all the materials were kept in a cool box and transported to the laboratory for further analysis of alkalinity, free carbon dioxide (CO_2), dissolved oxygen (DO), soluble reactive silicate (SRS), soluble reactive phosphorus (SRP), chlorophyll *a* (chl *a*) and phaeophytin concentration Murphy and Riley 1962, Mackereth *et al.* 1978, Wetzel and Likens 1979, and Marker *et al.* 1980). Enumeration of phytoplankton and benthic diatom was done with the help of a HBCC (Helber bacterial counting chamber) under compound microscope and phytoplankton were identified up to species level with the help of existing literature of Siddiqui *et al.* 2007, Ahmed *et al.* 2008, 2009. Various types of floating, hygrophytes and amphibious macrophytes were collected and indentified during the present investigation (Khan and Halim 1987). In the present study distinct seasons that prevail in Bangladesh were considered according to Rashid (1991). Pearson correlation was performed using the software of SPSS v 20 to find out the relationship between biological and physico-chemical variables.

Results and Discussion

In the present study mean air and water temperatures varied from 20 - 30^{0}C and 19 to 28^{0}C, respectively. Fluctuation of air and water temperatures recorded in the present investigation (Fig. 1) was similar to Begum and Alam (1987). The Secchi depth (Zs) of the pond ranged between 28.67 and 44.50 cm (Fig. 1). As expected the transparency was higher than results obtained from two fish ponds (Chowdhury and Mamun 2006). The highest and lowest value of Secchi depth was found in October and August respectively (Fig. 1). In autumn, the mean seasonal secchi depth was 36.41 cm, where, it was 35.36 cm in monsoon .The seasonal mean pH value was highest in autumn (8.70) and lowest in monsoon (8.11) (Table 1). Overall variation in pH value was observed during the study period ranged from 6.6 - 8.8 (Fig. 1). In Dhaka at Museum pond and SH- pond the value of pH was 6.14 - 7.92 and 6.19 - 7.93, respectively (Sultana and Khondker 2009a). Seasonal mean alkalinity of the studied pond obtained in monsoon and autumn was 0.66 meq/l and 0.91 meq/l, respectively (Table 1). The highest value (1.08 meq/l) of alkalinity was found in late December and the lowest (0.58 meq/l) was from late July (Fig.1). In two urban ponds of Dhaka monthly mean alkalinity ranged between 1.39meq/l and 2.06 meq/l (Sultana and Khondker 2009a). In some ponds of Noakhali and Comilla districts alkalinity ranged from 0.3 - 1.2 meq/l and 0.3 - 2.4 meq/l, respectively (Khondker and Talukder 1995 and Talukder and Khondker 1995).

Dissolved oxygen (DO) is a good indicator of water quality. This parameter measured during sampling period ranged from 5.34 - 10 mg/l (Fig. 1). Overall DO concentration in two urban ponds of Dhaka was within in the range of 4.96 -8.2 mg/l (Sultana and Khondker 2009b). A little higher concentration of DO ranged 9.0 - 12.0 mg/l and 8.5 - 14 mg/l were reported from rural ponds of Noakhali and Comilla, respectively (Khondker and Talukder 1995 and Talukder and Khondker 1995). This is an indication that water quality of rural ponds is better than urban ponds. The overall range of free CO_2 was 1.31-4.21 mg/l. A sharp high single peak was obtained at late November (4.21 mg/l) while the minimum concentration was recorded in early September (1.31 mg/l) (Fig. 1). The highest and lowest seasonal mean CO_2 were 3.01 mg/l and 1.69 mg/l in autumn and winter, respectively (Table 1). However, Bhuiyan and Gupta (2007) recorded higher value of free carbon-di-oxide (CO_2) ranging from 10.1 - 23.47 mg/l in nine ponds of Airongmara in Assam. SRP concentration in the pond was found extremely high (158.39 -635.70 µg/l) that exceeded the mandatory phosphate limit (22 - 300 µg/l) specified in the surface water regulations in the EU. So, there was an immense pollutant load of organic origin in the pond water. Very high concentration of SRP (130 - 1050 µg/l) was also recorded in some ponds of Dhaka city (Oppenhiemer *et al.* 1978).

SRS (Soluble Reactive Silicate) concentration in the pond water ranged from 13.32 - 28.65 mg/l. The highest value was obtained during late December, where the lowest was recorded during early June (Fig. 1). In winter and autumn the value of SRP was

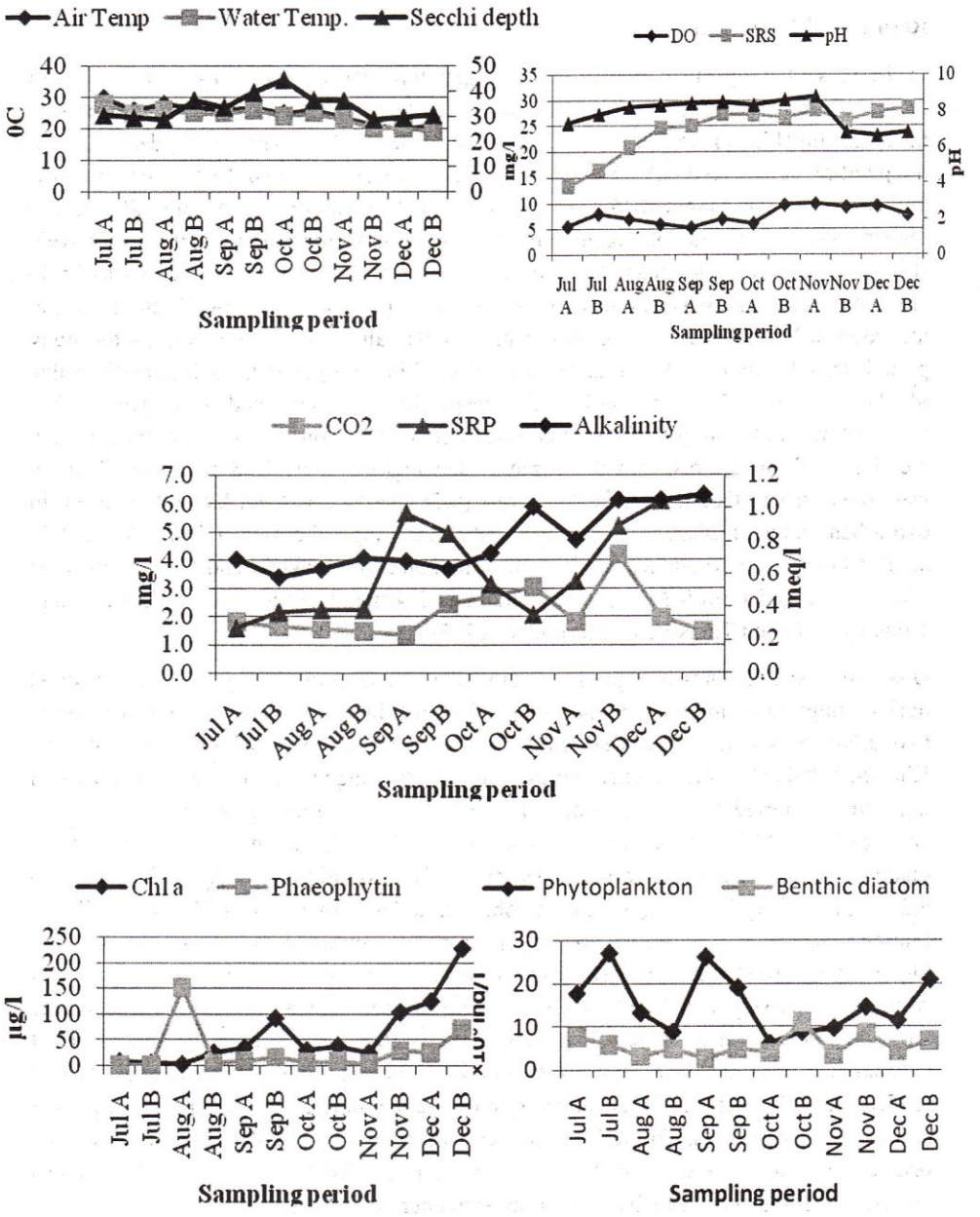

Fig. 1. Fluctuation of different limnological parameters of Samadnagar pond, recorded during the sampling period, July 2014 to December 2014. (Air temp.,Water temp. (^{0}C), Secchi depth (cm), Alkalinity (meq/l), DO, SRS, CO_2, SRP (mg/l), Chl *a*, Phaeophytin, phytoplankton, benthic diatom (µg/l) and pH).

27.53 mg/l and 27.43mg/l, respectively (Table 1). According to Welch (1952) much of the dissolve silicate becomes utilized by diatoms resulting the lower silicate in water. In the study pond, Bacillariophyceae was represented by 13.64% of the total phytoplankton population. Mean concentration of SRS fluctuated in the same order of magnitude as those observed from northern part of Bangladesh and Dhaka metropolis (Khondker and Kabir 1995 and Sultana and Khondker 2009a).

Table 1. Seasonal variation (according to Rashid 1991) of the limnological variables in Samadnogor pond during the study period (mean value).

	Monsoon	Autumn	Winter
Limnological variables	Jun- early Oct 2014	Late Oct- Nov 2014	Late Nov- Feb 2014
Air Temp. (°C)	27.0	25.0	20.67
Water Temp. (°C)	25.57	24.0	19.67
Secchi depth (cm)	35.36	36.41	29.67
pH	8.11	8.70	6.73
Alkalinity (meq/l)	0.66	0.91	1.06
Free CO_2 (mg/1)	1.83	3.01	1.69
DO (mg/l)	6.43	9.87	8.89
SRP (mg/l)	3.15	2.67	5.89
SRS (mg/l)	22.17	27.43	27.53
Chl *a* (µg/l)	30.16	33.75	153.53
Phaeophytin (µg/l)	223.39	7.44	43.13
Phytoplankton density ($\times 10^6$ ind/l))	16.78	11.0	16.1
Benthic diatom density ($\times 10^6$ ind/l)	4.65	7.26	6.45

The phytoplankton diversity in the Samadnagar pond was represented by 33 species (Table 2) of which 54.55% belonged to Chlorophyceae followed by Bacillariophyceae (13.64%), Cyanophyceae (13.64%), Euglenophyceae (13.64%) and Dinophyceae (4.55%). Begum (2008) identified a total number of 69 taxa from an urban pond belonging to the classes of Cyanophyceae, Chlorophyceae, Chrysophyceae, Xanthophyceae, Cryptophyceae and Dinophyceae. Among them Chlorophyceae was the most abundant (48 out of 69 taxa). The dominance of Chlorophyceae was also observed in a pond of Kanyakumari, Tamil Nadu (Balasingh 2010).

Table 2. List of the phytoplankton and benthic diatom recorded from the Samadnagar Pond.

Phytoplankton	Bacillariophyceae
Cyanophyceae	*Euglena acus var longissima* Defl.
Anabaenopsis circularis (G.S.West) Wolosz et Millar	*Euglena archaeoplastidiata* Chadefaud
Aphanocapsa biformis A.Br.	*Phacus acutus* Pochm
Aphanocapsa koordersi Strom	*Phacus acuminatus* Stokes var *acuminatus*
Arthrospira platensis (Nordst.) Gomont	*Trachelomonas hispida* var *cornata* Lemm.
Crucigenia quadrata Morren	*Trachelomonas hispida* (Perty) Stein
Crucigenia *rectangularis* (Nag.) Gay	Euglenophyceae
Crucigenia tetrapedia (kirchner) W.West and G.S. West	*Navicula anglica* Ralfs in Pritchard
Coelospherium kuetzingianum Nag.	*Navicula laevissima* Kützing
Merismopedia punctata Mayen	*Nitzschia alpina* (Nag) Hustedt
Merismopedia glauca (Ehrenb) Nag.	Dinophyceae
Chlorophyceae	*Peridinium* sp. Ehrenberg
Actinastrum gracillimum var *gracillimum* G .M Smith	Benthic diatom
Actinastrum hantzschi Lagerheim	*Melosira granulate (*Ehrenberg) Ralfs in Pritehard
Ankistrodesmus densus kors	*Fragillaria virescens* Ralfs
Ankistrodesmus falcatus (Corda) Ralfs	*Pinnularia major* (Kütz) Rabenhorst
Coelastrum indicumm W.B Turner	*Gomphonema acuminatum* Ehrenberg
Chlamydomonas angulosa Nyg.	*Nitzschia fruticosa* Hust
Chlamydomonas gloeogama Kors in Pascher.	*Nitzschia acicularia* (Kützing) W.Smith
Pediastrum duplex Mayen	*Synedra rumpens* var *familiaris* (Kütz.)[Poretzky]
Pediastrum duplex var calthratum (Ag.Br) Lagerheim	*Navicula cuspidata* Kützing
Pediastrum tetras (Ehrenberg) Ralfs	*Navicula americana* Ehrenberg
Scenedesmus acutus var *acutus* Mayen	*Navicula popula* Kütz
Scenedesmus acuminatus var *minor* G.M.Smith	*Cymbella* sp. (C. Agardth) Endlicher
Scenedesmus dimorphus (Turp) Kütz.	*Surirella robusta* var *splendida* (Ehrenberg) van Heurck. in Hustedt

The highest density of phytoplankton was counted 26.84×10^6 ind/l in late July followed by 25.96×10^6 ind/l in early September and 20.76×10^6 ind/l in late December whereas, the lowest density (6.16×10^6 ind/l) was counted in early October (Fig. 1). Sultana *et al.* (1999) found three picks of phytoplankton (August, November and April) during their study of urban ponds and phytoplankton density ranged from 2×10^6 cells/l to 31×10^6 cells/l. Benthic diatom density varied from 2.64×10^6-11×10^6 ind/l. The total benthic diatom population was highest (11×10^6 ind/l) in late October. The lowest number was recorded in early September (2.64×10^6 ind/l) (Fig. 1). A total 12 species of benthic diatoms was identified (Table 2) and *Nitzschia* and *Navicula* were found to be most abundant benthic diatoms in the pond.

Determination of Chl *a* concentration from water sample is a useful tool for the prediction of phytoplankton biomass (Sandu *et al.* 2003 and Kasprzak *et al.* 2008). During the study period Chl *a* concentration ranged from 5.10 to 228.51µg/l (Fig. 1). Results showed that Chl *a* concentration didn't corresponds to the phytoplankton density, this might be due to the presence of microplankton in the sample. So far highest concentration of chl *a* (8037 µg/l) was reported by Gani *et al.* (2011) from wastewater treatment lagoons. Phaeophytin concentration varied from 2.05 - 1519.36µg/l. The highest phaeophytin concentration was obtained in early August and the lowest value was recorded in late July (Fig. 1). The mean seasonal concentration in monsoon and winter were 223.39 µg/l and 43.13 µg/l, respectively (Table 1).

Aquatic macrophyte communities were represented by a total of 23 species under 11 families, which considered as an important biological element in pond ecosystem. Among them 14 species were amphibians, 5 were hygrophytes and 4 were free floating macrophytes. The distribution of aquatic macrophytes differed in various seasons like the investigation conducted in Gumti flood plain where 40 species were recorded (Khondker and Talukder 1995). *Eichhorina crassipes* (Mart.) Solms., *Ipomoea aquatica* Forsk., *I. fistulosa* Mart., *Telanthera philoxeroides* Moq., *Eclipta* prostata (L.) L., *Rumex maritimus* L. and *Salvinia natans* L. were observed throughout the study period (Table 3). The distribution of *Cyperus michelianus* (L.) Delile., *Lemna perpusilla* Torry and *Pistia* stratiotes L. was observed during monsoon period. After that period these species had been declined. However, *Heliotropium indicum* L. and *Grangea maderaspatana* L. were observed only during the winter season (Table 3).

Table 3. List of aquatic macrophytes and seasonal variation (according to Rashid 1991) observed during study period in the Samadnagar Pond ("+" = Noticed and "–"= Unnoticed).

Name of species	Family	Types	Monsoon Jun-Early Oct 2014	Autumn Late Oct-Nov 2014	Winter Late Nov-Feb 2014
Eichhornia crassipes (Mart.) Solms.	Pontederiaceae	Free floating	+	+	+
Rumex maritimus L.	Polygonaceae	Hygrophytes	+	+	+
Heliotropium indicum L.	Boraginaceae	Amphibian	-	-	+
Telanthera philoxeroides Moq.	Amaranthaceae	Amphibian	+	+	+
Lemna perpusila Torry	Araceae	Free floating	+	-	-
Pistia stratiotes L.	Araceae	Free floating	+	-	-
Lippia nodiflora (L.) Greene	Verbenaceae	Amphibian	+	-	+
Monochoria vaginalis (Burm.f.) Presl.	Pontederiaceae	Hygrophytes	-	+	+
Commelina benghalensis L.	Commelinaceae	Hygrophytes	-	+	+
Xanthium strumarium L.	Asteraceae	Amphibian	-	+	+
Panicum repens L.	Poacea	Amphibian	-	+	+
Eleusine indica (L.) Gaertn	Poaceae	Hygrophytes	-	+	+
Polygonum orientale L.	Polygonaceae	Hygrophytes	-	+	+
Grangea maderaspatana L.	Asteraceae	Amphibian	-	-	+
Ipomoea aquatica Forsk.	Convolvulaceae	Amphibian	+	+	+
Echinochloa colona L.	Poaceae	Amphibian	-	+	+
Vetiveria zizanioides (L.) Nash	Poaceae	Amphibian	-	+	+
Setaria viridis (L.) P. Beauv.	Poacceae	Amphibian	-	+	+
Eclipta prostata (L.) L.	Asteraceae	Amphibian	+	+	+
Ipomoea fistulosa Mart.	Convolvulaceae	Amphibian	+	+	+
Cyperus michelianus (L.) Delile	Asteraceae	Amphibian	+	-	-
Gnaphalium pulvinatum Delile	Asteraceae	Amphibian	-	+	+
Salvinia natans L.	Salviniaceae	Free floating	+	+	+

In the present investigation, among the biological parameters chl *a* showed negative correlation with air temperature (r= -.749), water temperature (r= -.801) and pH (r= -

.632) while it exhibited positive correlation with alkalinity (r= .721) and SRP (r= .809). Relatively higher concentration of Chl *a* was observed during the sampling periods of early November (Nov A) and December (Dec A & B) when the air temperature, water temperature and pH value were lower.During these sampling periods the value of alkalinity and SRP was comparatively higher (Fig. 1). Abundance of benthic diatom showed positive correlation only with CO_2 (r=.586) at 5% significant level. No correlation was found for phytoplankton density and phaeophytin concentration.

References

Ahmed, Z. U., Z. N. T. Begum, M. A. Hasan, M. Khondker, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E. U. Haque (eds.). 2008. *Encyclopedia of Flora and Fauna of Bangladesh*, vol.4.Algae, Chlorophyta (Aphanochaetaceae-Zygnemataceae). Asiatic Society of Bangladesh, Dhaka. 812pp.

Ahmed, Z.U., Z.N.T. Begum, M. A. Hasan, M. Khondker, S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman and E.U. Haque (eds.). 2009. *Encyclopedia of Flora and Fauna of Bangladesh.* vol.4.Algae, Charophyta-Rhodophyta (Achnanthaceae-Vaucheriaceae). Asiatic Society of Bangladesh. Sci. 543pp.

Alfasane, M. A., M. S. Islam and Z. N. T. Begum. 2003.The relationship between Phytoplankton and some physicochemical variables in two ponds of Bakerganj. Bangladesh J. of Asiat. Soc. Bangladesh, Sci. **29**(1):93-102.

Balasingh, G. S. R. 2010. Studies on phytoplankton diversity and seasonal abundance of perennial pond in Kanyakumari–Tamil Nadu, India. Journal of Basic and Applied Biology. **4**(3): 188-193.

Begum, Z. N. T. and M. J. Alam . 1987. Plankton abundance in relation to physic-chemical variables in two ponds in Maijdee Court.Noakhali. J Asiatic Soc. Bangladesh. Sci. **13**:55-63.

Begum, Z. N. T. 2008. A Taxonomic account of the phytoplankton of a pond receiving textile industrial effluents.Bangladesh J. Plant Taxon. **15**(2): 129-139.

Bhuiyan, J. R. and S. Gupta. 2007. A comparative hydrobiology study of a few ponds of Barak Valley, Assam and their role as sustainable water resources J. Environmental Biol. **28**(4): 799-802.

Cabecinha, E., R. Cortes, J. Cabral, T. Ferreira, M. Lourenço and M. Pardal. 2009. Multi-scale approach using phytoplankton as a first step towards the definition of the ecological status of reservoirs. Ecological Indicators. **9**: 240-255.

Chowdhury, A. H. and A. A. Mamun. 2006. Physio-chemical conditions and plankton population of two fishponds in Khulna. Univ. J. Zool. Rajshahi Univ. **25**: 41-44.

Domingues, R. and H. Galvão. 2007. Phytoplankton and environmental variability in a dam regulated temperate estuary. Hydrobiologia. **586**:117-134.

Gani, M. A., M. A. Alfasane and M. Khondker. 2011. Limnology of wastewater treatment lagoons at Pagla, Narayanganj. Bangladesh J. Bot. **40**(1): 35-40.

Hossain, M. Y., S. Jasmie, A. H. M. Ibrahim, Z. F. Ahmed and J. Ohtomi. 2007. A preliminary observation of water quality and plankton of an earthen fish pond in Bangladesh: Recommendation for future studies. Pak. J. Biol. Sci. **10**: 868-873.

Hötzel, G. and R. Croome. 1999. A Phytoplankton Methods Manual for Australian Freshwaters. LWRRDC Occasional Paper. 22/99.

Kasprzak, P., J. Padisa'k, R. Koschela, L. Krienitz and F. Gervais. 2008. Chlorophyll *a* concentration across a trophic gradient of lakes: An estimator of phytoplankton biomass? Limnologica. **38**: 327–338.

Khan, M. S. and M. Halim. 1987. Aquatic angiosperms of Bangladesh. Bangladesh National Harbarium, Dhaka, Bangladesh. 120 pp.

Khondker, M. and M. A. Kabir. 1995. Phytoplankton primary production in a mesotrophic pond in sub-tropical Bangladesh.Hydrobilogia. **304**: 39-47.

Khondker, M. and A. K. M. H. Talukder. 1995. Limonological assessment of some water bodies within Gumti flood plain, Comilla. Dhaka Univ. J. Biol. Sci. **4**(1): 51-58.

Khondker, M., A. K. M. N. Islam, Z. N. T. Begum and S. Haque. 1990. Limnological studies of four polluted ponds in and around Dhaka city with reference to indicators species. Bangladesh J. Bot. **19**(1): 51-63.

Mackereth, F. J. H., J. Heron and J. F. Talling. 1978. *Water analysis: some revised methods for limnologists*. Freshwater.Biol. Assoc. Publ. 120 pp.

Marker, A. F. H., E. A. Nusch, H. Rai and B. Riemann. 1980. The measurement of photosynthetic pigments in freshwaters and standardization of methods: conclusions and recommendations. Arch. Hydrobiol. Belih.Ergebn.Limnol.**14**: 91-106.

Murphy, J. and J. P. Riley. 1962. A modified single solution method for thedetermination of phospahte in natural waters. Analyt. Chem. Acta. **27**: 31-36.

Oppenheimer, J. R, M. G Ahmed, A. Huq, K. A. Haque, A. K. M. A. Alam, K. M. S. Aziz, S. Ali and A. S. M. M. Haque. 1978. Limnological studies of three ponds in Dhaka, Bangladesh. Bangladesh J. Fish. **1**(1): 1-28.

Rashid, H. 1991. *Geography of Bangladesh.* The University Press Limited. Dhaka, Bangladesh.

Sandu, C., R. Iacob and N. Nicolescu. 2003. Chlorophyll-a determination—a reliable method for phytoplankton biomass assessment. Acta Botanica Hungarica. **45**(3): 389-397.

Siddiqui, K. U., M. A. Ahmed, Z.U. Ahmed, Z. N. T. Begum, M. A. Hassan, M. Khodker., S. M. H. Kabir, M. Ahmad, A. T. A. Ahmed, A. K. A. Rahman And E.U. Haque (eds.). 2007. Encyclopedia of Flora and Fauna of Bangladesh.Vol.2.Cyanobacteria, Bacteria and Fungi.Asiatic Society of Bangladesh, Dhaka.

Sultana, M., M. Khondker and A. Aziz. 1999. Plankton composition and its seasonal dynamics in two urban ponds. Dhaka Univ. J. Biol. Sci. **8**(1): 35-43.

Sultana, M. and M. Khondker. 2009a. A comparative limnology of two urban pond ecosystems: physical & chemical features. J. Asiat. Soc. Bangladesh, Sci. **35**(1): 65-71

Sultana, M. and M. Khondker. 2009b. Assessment of phytoplankton primary productivity of two urban pond ecosystems of Bangladesh. Dhaka Univ. J. Bio. Sci. **18**(2): 127-135, 2009.

Talukder, A. K. M. H and M. Khondker. 1995. Limnological study of some water bodies in the Noakhali North flood prone areas of Bangladesh. Dhaka Univ. J. Biol. Sci. **4**(1): 59-65.

Taylor, J. C., P. A. de la Rey and L. van Rensburg. 2005. Recommendations for the collection, preparation and enumeration of diatoms from riverine habitats for water quality monitoring in South Africa. African Journal of Aquatic Sciences. **30**: 65–75.

Thomaz, S. M. and E. R. da Cunha. 2010. The role of macrophytes in habitat structuring in aquatic ecosystems: methods of measurement, causes and consequences on animal assemblages' composition and biodiversity. Acta Limnologica Brasiliensia. **22**(2): 218-236.

Welch, P. S. 1952. *Limnological Methods*. Blakiston Co., Philadelphia.538 pp.

Wetzel, R.G. and G.E. Likens. 1979. *Limnological analysis*.W.B. Saunders Co. Philadelphia.357 pp.

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