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LIMNOLOGY OF WASTEWATER TREATMENT LAGOONS AT PAGLA, NARAYANGANJ

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Abstract

Limnology of two wastewater treatment lagoons, (Lagoon numbers 1 and 10 are treated as L-1 and L-2, respectively) at Pagla, Narayanganj considering 15 water quality variables had been carried out for 10 months. Air and water temperature did not vary significantly. Secchi depth (Zs) showed gradual improvement from the lagoon 1 to lagoon 10 due to low loading of suspended matters. Improvement of water quality from L-1 to L-2 has also been observed in respect to alkalinity, conductivity and TDS. Similar trends were also seen for SRS and SRP. In L-1 anoxia occurred three times whereas it was absent in L-2. In the present study, improved DO prompted NO_3-N and TDS concentration. However in L-2, mean values of SRP dropped by about 13% than L-1. A significant positive correlation between the density of phytoplankton and SRP in L-2 at 5% level was obtained. A total of 105 species of phytoplankton belonging to 6 different algal classes were recorded from the lagoons. Highest number of species was obtained from Chlorophyceae followed by Euglenophyceae, Bacillariophyceae, Cyanophyceae, Cryptophyceae and Dinophyceae. The population density of phytoplankton and that of zooplankton in L-1 was low compared to L-2. Higher number of genera and species occurred in L-2 than L-1. Chl *a* and pheopigment concentrations were also higher in L-2. Results indicated that water quality has increased in the treatment pond number 10.

Introduction

Lagooning is one of the most common wastewater treatment systems in different countries (Onyema 2010, Oliveira 1995) where microalgae play multiple and complex roles. Microalgae release molecular oxygen during photosynthesis, which in conjunction with oxygen at the air-water interfaces, promote the aerobic conditions necessary for organic matter degradation by the aerobic bacteria. Also, small algae, predominant in wastewater treatment plant stabilization lagoons transform and accumulate organic matter degraded by the aerobic bacteria (Rodrigues and Santana 1993).

Water resource in the Dhaka city is most important and recently has been considered as a burning issue because of extreme degradation of water quality of its peripheral rivers (Hasan *et al*. 2006). When peripheral rivers of an urban area get polluted due to the release of municipal and industrial untreated wastewaters the surface water quality also deteriorates (Reynolds 1984, Subramanian 2004, Karn and Harada 2001). Domestic and industrial wastes of Dhaka City discharged into the river Buriganga by four main discharge pathways. Pagla Sewage Treatment Plant (PSTP) outfall is one of them, operated by Dhaka Water Supply and Sewerage Authority (DWASA). The plant treats wastes of about 7 million people at Dhaka city. The capacity of this treatment plant is only 0.12 million m^3/day while the total sewage generated by the city as estimated by DWASA is about 1.3 million m^3/day (Hasan *et al*. 2006). So far no published record is available on the limnology of wastewater lagoons of DWASA except some information on heterotrophic and nitrifying bacteria (Hasan *et al*. 2006). So, the present research was undertaken to study the improvement of water quality in the treatment lagoons operating at PSTP. Plankton diversity has also been studied to assess the water quality in the lagoons.

Materials and Methods

The PSTP is situated about a kilometer from Pagla Bazar (23° 40' 0" N, 90° 27' 0" E) and is about 10 km south of Dhaka metropolis. PSTP consists of 16 lagoons for the tertiary treatment of sewage water. All these lagoons are connected to each other with a narrow channel. Sampling for the present investigation was carried out in lagoon Nos. 1 and 10 of PSTP, hereinafter designated as L-1 and L-2, respectively. Samples were collected from October, 2009 to July, 2010 fortnightly except October, January and May when monthly collections were made. So a total of 17 samples were collected. On each occasion of sampling, air and water temperature were measured with the help of a mercury centigrade thermometer. The transparency of water was measured with the help of a Secchi disc (20 cm dia). pH was measured with the help of a Griffin pH meter (PHJ-260-V-pH-meter, Model 50, UK). TDS (total dissolved solids) and conductivity were measured with the help of field meters (Hanna instruments, HI9034 and HI9034, Singapore). Methods described in Wetzel and Likens (1979) were used to determine the dissolved oxygen (DO) and soluble reactive silicate (SRS). Alkalinity was measured after Mackereth *et al*. (1978) while Müller and Wiedemann (1955) was followed for the determination of nitrate-nitrogen (NO_3-N). SRP was measured using the methodology described in Murphy and Riley (1962). Chlorophyll *a* and phaeopigment concentrations were measured following Marker *et al*. (1980). Pearson correlation analysis was made (SPSS program) to find the relationships between the measured limnological variables and phytoplankton (Table 3).

Results and Discussion

Air and water temperature of L-1 and L-2 lagoons did not vary significantly in a particular months. The Secchi depth (Zs) ranged from 6 - 34 cm in L-1 and 5 - 43 cm in L-2 though not significant. An improvement in the Secchi reading has been observed in L-2. Results on the water quality variables show that TDS and conductivity decreased in L-2 compared to L-1. An increase in pH and decrease in alkalinity have been observed in L-2 (Table 1). Dissolved oxygen showed at least three occasions of anoxia in L-1 but no anoxia was recorded in L-2. Little difference has been observed in the SRP and nitrate concentrations of the lagoon waters. In L-2, mean values of SRP dropped by about 13% than L-1 (Table 1). With the improvement of oxygen concentration in L-2 than L-1 a slight fall in the value of SRP and increase in the nitrate concentration did occur. Under the anoxic condition, leaching of SRP from bottom into the surface water and prevalence of nitrate may occur. However, no significant change in the concentration of SRP has been observed in the two lagoons.

Chlorophyll *a* fluctuated more in L-1 compared to L-2 where higher concentration was found. Phaeopigment concentration was lower in L-1 than in L-2. Significant increase in the concentration of both phyto- and zooplankton has been observed in L-2 than L-1(Table 1).

The monthly highest density of phytoplankton was found at L-1 in April and at L-2 in February (Table 1). This may happen due to increase in water quality parameters such as alkalinity, conductivity, TDS, DO, SRP and SRS. Phytoplankton belonging to blue-green algae and euglenoids were found to be dominant in most of the occasions at two sampling points except mid July when the members of Bacillariophyceae and blue-green algae showed their dominance. A large density of blue-greens in the maturation wastewater treatment pond and in the effluent ready to be discharged into the receiving river Lambo (Nigeria) was found by Pereira *et al*. (2001). The Esmoriz wastewater treatment plant may be considered as an optimal habitat for the development of blue-green and members of Euglenophytes (Chindah *et al.* 2005, 2007 and Oliveira 1995).

A comparative analysis of the two lagoons in respect to mean values (n = 17) of 15 environmental variables is shown in Fig. 1. Prevailing air temperature and water temperature of the lagoons ran parallel to each other. But Secchi depth increased in L-2 by 13.49 cm compared to

Table 1. Physical, chemical and biological parameters of the lagoon L-1 and L-2 from October 2009 to July 2010. Variations of parameters in each month are roughly for 1st and last week of that month except October, January and May.

Date	Air Temp. (° C)		Water Temp. (° C)		Secchi Depth (cm)		TDS (mg/l)		Conductivity (µs/cm)		pH		Alkalinity (meq/l)		DO (mg/l)	
	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2
Oct.	27	30	21	25	28.2	31.5	421	317	787	585	7.93	7.82	6.7	4.40	6.6	9.50
Nov.	29-20	33-19	26-22	28-22.5	31-25	33-26	428-462	273-336	836-806	512-625	7.72-7.41	7.33-7.63	7.4-8.3	3.57-5.27	1.8-7.2	8.94-7.15
Dec.	22-17	23-15.5	20.5-18	22.5-19	27-16.5	19	627-732	376-400	1143-1290	669-703	7.12-6.95	7.29-7.53	11.0-14.5	6.10-6.67	6.3-6.0	4.88-5.69
Jan.	16.5	16	17.5	20	20	20	856	435	1473	776	6.78	7.40	15.8	6.40	2.6	2.24
Feb.	22-25	21-22	21.5-22	20-24	17-34	43-28	986-477	416-423	1586-865	754-775	6.94-7.3	7.71-8.50	21.5-7.3	7-7.5	2.3-6.3	6.91-8.54
Mar.	29-31	27-32	26.5-26	26.5	16-6	23.5-6	454-591	370-299	776-1137	625-592	7.83-7.65	8.49-8.94	7.15-9.20	8.49-6.60	4.5-0	6.25-6.10
Apr.	31.5-34	30-34	29.5-31	29-30.5	7-16	5-16	480-674	359-336	791-1252	611-666	7.46-7.62	8.55-8.83	7.75-13.90	7.05-5.75	0-3.1	5.49-11.50
May	33	32	31	31	14	13	591	299	1137	592	7.65	8.94	11.80	5.05	0	3.94
June	32-33	32	30-31.5	30.5-29	17-6	26-18	370-469	284-272	778-960	586-578	7.50-7.68	7.83-8.25	7.15-8.50	4.20-4.15	1.9-4.6	5.18-6.71
July	29	30	29-29.5	29	13-15	19-22	472-240	255-523	1022-510	543-1376	7.7-7.9	8.80-9.00	9.10-9.60	4.05-4.30	3.5-8.9	5.16-6.79

(Contd.)

Date	SRP (µg/l)		SRS (mg/l)		No_3-N (mg/l)		Chl *a* (µg/l)		Phaeopigment (µg/l)		Phytoplankton ($\times 10^6$ ind/l)		Zooplankton ($\times 10^6$ ind/l)	
	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2	L-1	L-2
Oct.	724	657	29.18	20.65	0.23	3.66	154	112	30.46	37.12	17.82	115	0.49	0.72
Nov.	139-1450	115-1309	30.13-10.29	20.23-10.29	0.41-3.71	9.41-8.97	199-52.98	88.5-187	105-81.88	97.24-242	18.89-8.76	341-367	0.44-0.18	0.27-0.66
Dec.	928-1506	71.28-533	32.64-22.91	28.84-21.01	0.893-0.823	0.59-0.68	15.98-7.24	524-429	14.38-4.32	120-69.55	2.87-7.26	313-189	0.15-0.52	0.42-4.50
Jan.	1342	912	31.20	29.92	7.565	0	14.21	1375	16.85	1364	9.38	215	0.06	2.5
Feb.	1936-2223	1807-1686	31.27-26.21	32.87-31.09	1.47-18.23	0.63-9.02	19-186	128-719	20.46-74.78	107-229	6.12-30.20	40.02-1574	0-0.28	0.92-0
Mar.	1449-2070	1609-2068	27.96-170	28.19-169	0.69-1.47	0.48-1.83	160-31.43	258-4388	217-1.85	623-5912	1.91-1.88	50.66-293	0.25-0	1.39-0.08
Apr.	2389-2377	2389-2377	1216-335	1268-331	0-0.423	0-0.41	21.48-12.19	2751-2561	3.88-10.76	4119-4380	7.35-205	15.53-229	0.13-0.02	1.35-0.02
May	917	917	49.50	35.08	0.94	0	8037	4303	337	6853	98.6	654	1.70	3.41
June	6516-3490	5439-3488	27.36-40.99	31.42-28.69	0.53-2.07	0.27-0.47	348-3690	301-3569	127-744	53.69-1492	30.13-17.36	20.46-8.87	1.44-0.32	0.12-0
July	3257-3623	3243-3536	42.8-46	28.27-28.79	0.23-0.31	0.22-0.34	3787-4500	3434-357	629-1024	3948-90.87	21.90-22.76	8.07-28	0.15-0.17	0-0.28

L-1. Chlorophyll *a*, phaeopigment, pH, DO, density of phytoplankton and density of zooplankton in L-2 increased. Concentration of dissolved silicate (SRS) did not change at all in L-2 compared to L-1 (Fig. 1). TDS, conductivity, nitrate, SRP and alkalinity were higher in L-1 than in L-2.

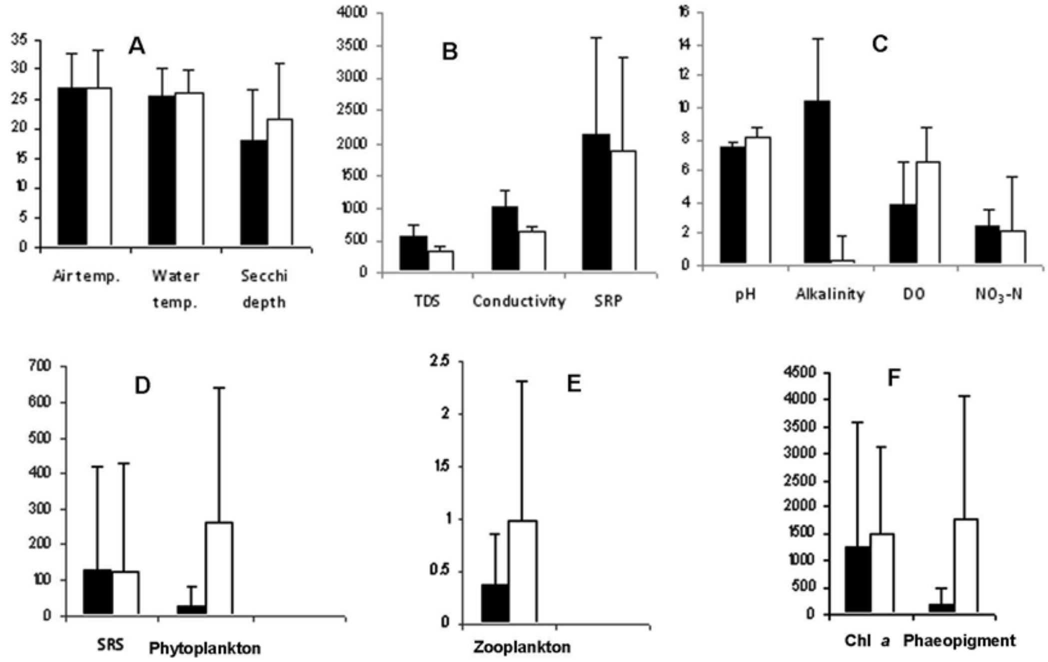

Fig. 1. Comparison of different variables in L-1 (■) and L-2 (□) from Oct. 2009 to July 2010. A. Air and water temperature (º C) and Secchi depth (cm), B. TDS (mg/l), conductivity (µS/cm)) and SRP (µg/l)), C. pH, alkalinity (meq/l), DO and $N0_3$-N (mg/l), D. SRS (mg/l) and density of phytoplankton ($\times 10^6$ ind/l), E. Density of zooplankton ($\times 10^6$ ind/l) and F. Chlorophyll *a* and phaeopigment(µg/l)).

Highest chl *a* concentration at L-1 in May 2010 and at L-2 in March 2010 was observed. Those peak phytoplankton biomass were contributed by *Euglena acus* and *Euglena* spp., respectively. Pereira *et al*. (2001) obtained maximum chl *a* concentration 2055 µg/l in the facultative pond. In the present experiment, maximum algal abundance coincided with the maximum concentration of chl *a*. Blue-green contributes less chl *a* than diatoms, greens and especially, euglenophytes (Reynolds 1984). Increases in chlorophyll *a* concentration in the water and pH were related to euglenoid population, whereas oxygen concentration changes were related to changes in density of both diatoms and euglenophytes (Pereira *et al*. 2001).

In the present investigation 46 and 54 genera were recorded in L-1 and L-2, respectively. The genera recorded from lagoon L-1 to L-2, belonged to six classes (Cyanophyceae, Chlorophyceae, Euglenophyceae, Bacillariophyceae, Cryptophyceae and Dinophyceae, Table 2). *Arthrospira platensis* was found to be most dominant blue-green alga followed by *Microcystis* and *Merismopedia* for L-2. Similarly for L-1, *A. platensis* was also dominant. *Coelastrum* and *Scenedesmus* were found to be abundant in number rather than other green algae in L-2. For L-1, the dominant green alga was *Chlorella*. *Cyclotella* and *Navicula* were found to be the dominant diatoms in L-1 and L-2. *Euglena* was found to be in large number in L-1 and L-2 other than any other genera of this group.

Chlorophycean members dominated in the two lagoons followed by Cyanophyceae, Bacillariophyceae, Euglenophyceae, Cryptophyceae and Dinophyceae (Table 2) Generic and species diversity was higher in the L-2 where 105 species compared to 98 in L-1 was observed due to improved water quality and DO (Table 1).

In the wastewater treatment plant, phytoplankton was mainly composed by chlorophytes in agreement with data reported by Pereira *et al*. (2001) and Oliveira (1995). Phytoplankton community is dominated by the members of chlorococcoid and volvocalean forms. In the present investigation *Peridinium cinctum*, *Ceratium.hirundinella*, *Gymnodinium* sp. and *Gonyaulax* sp. of Dinophyceae were recorded. Onyema *et al.* (2010) also reported 3 species of Dinophyceae namely, *Ceratium macroceros*, *Ceratium tripos* and *Peridinium africana* in the Iyagbe lagoon, Nigeria.

Table 2. Number of genera and species recorded from different classes of algae from the two lagoons of the PSTP.

Class	L-1		L-2	
	Genera	Species	Genera	Species
Chlorophyceae	18 (39.13%)	33 (33.67%)	21 (38.89%)	41 (39.05%)
Cryptophyceae	03 (6.52%)	03 (3.06%)	03 (5.56%)	05 (4.76%)
Bacillariophyceae	09 (19.57%)	19 (19.39%)	09 (16.67%)	17 (16.19%)
Euglenophyceae	05 (10.87%)	26 (26.53%)	05 (9.26%)	19 (18.09%)
Cyanophyceae	10 (21.74%)	16 (16.33%)	12 (22.22%)	19 (18.09%)
Dinophyceae	01 (2.17%)	01 (1.04%)	04 (7.42%)	04 (4.08%)
Total	46	98	54	105

According to Vasconcelos and Araujo (1994) *Microcystis aeruginosa* is one of the most common species in wastewater treatment plant and other species of blue-green, namely, *Synechoccocus* and *Synechocystis* were also common in wastewater treatment plant (Oudra 1990, Chindah *et al*. 2007). Oliveira (1995) also reported dominance of chlorophytes found in wastewater stabilization ponds.

In most cases the relationships of variables were non-significant (Table 3). However, a significant positive correlation between the density of phytoplankton and SRP in L-2 at 5% level was obtained. Pereira *et al*. (2001) conducted similar studies and also obtained non-significant relationships between the phytoplankton and physicochemical variables except a significant negative correlation between diatom and pH.

Table 3. Result of the Pearson's product moment correlation analysis between the physicochemical variables and the density of phytopolankton in L-1 and L-2.

Variables	L-1		L-2		Variables	L-1		L-2	
	r	p	r	p		r	p	r	p
Air temp.	0.457	ns	–0.203	ns	DO	–0.177	ns	0.167	ns
Water temp.	0.456	ns	–0.126	ns	SRS	0.050	ns	–0.307	ns
Secchi depth	–0.060	ns	0.071	ns	SRP	0.103	ns	0.594*	0.05
TDS	0.090	ns	0.146	ns	NO_3-N	–0.073	ns	–0.166	ns
Conductivity	0.170	ns	0.007	ns	Chl *a*	0.231	ns	–0.008	ns
pH	0.203	ns	0.100	ns	Phaeopigment	–0.030	ns	–0.028	ns
Alkalinity	0.177	ns	0.264	ns					

* Correlation significant at 5% level, r = correlation coefficient, p = probability, ns = not significant.

It is revealed that the water quality in the treatment plants has increased as indicated by low conductivity, alkalinity, SRP, NO_3-N, and high DO and Plankton.

References

Chindah AC, SA Braide and E Izundu 2005. Treatment of Municipal wastewater quality using sunlight. Caderno de Pesquisa **17**(2): 27-45.

Chindah AC, SA Braide, J Amakiri and E Izundu 2007. Succession of phytoplankton in a municipal waste-water treatment system under sunlight. Revista UDO Agrícola **7**(1): 258-273.

Hasan MM, MK Ahmed, F Hafiz, AMI Hussain, S Parveen and SR Tinni 2006. Heterotrophic and nitrifying bacteria in the lagoon and the receiving river Buriganga, Bangladesh. J. Microbiol. **23**: 93-97.

Karn SK and H Harada 2001. Surface water pollution in three urban territories of Nepal, India and Bangladesh. Environ. Manage. **28**(4): 483-496.

Mackereth FJH, J Heron and JF Talling 1978. Water analysis: some revised methods for limnologists. Freshwat. Biol. Assoc. Publ. 120 pp.

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

Müller R and F Wiedemann 1955. Die Bestimmung des Nitrats in Wasser. Jahrbuch für Wasserchemie und Wasserreinigungstechnik. Verlag Chemie, Reinbek **12**: 247-271.

Murphy J and JP Riley 1962. A modified single solution method for the determination of phosphate in natural waters. Anal. Chem. Acta **27**: 31-36.

Oliveira TFS 1995. A lugunagem eniportugal conceitos busicos e aplicagees pruticas. Ed. Universitarias Lusofonas, Lda. 516 pp.

Onyema IC 2010. Phytoplankton diversity and succession in the Iyagbe lagoon. Lagos. **43**(1): 61-74.

Oudra B 1990. Bassins de stabilization anairobie facultatifpour le traitement des eaux usees d.Marrakesh: Dynamigue du phytoplankton (microplankton *et* picoplankton) *et* evaluation de lu biomane primaire. These de 3eme cycle. Univ. Cady Ayyad. Fac. Sci. Marrakesh. 144 pp.

Pereira AI, ML Fidalgo and V Vasconcelos 2001. Phytoplankton and nutrient dynamics in two ponds of the Esmoriz wastewater treatment plant (Northern Portugal). Limnetica **20**(2): 245-254.

Reynolds C 1984. The ecology of freshwater phytoplankton**.** Freshwater Biol. Assoc., Cambrigde Univ. Press, Cambrigde. 384 pp.

Rodrigues AMF and FJP Santana 1993. Tratamento de aguas residuais por microalgas. Bol. UCA. Uni. Algarve, UCTM **1:** 82-599.

Subramanian B 2004. Water quality in South Asia. Asian J. Water Environ. Pollut. **1**(1-2): 41-54.

Vasconcelos VM and EO Araujo 1994. Cianobacteriastrurn risco para o umbiente epara a Saude Humana. lnstituto da Agua, Ministerio da Saude, Ministerio do Ambiente e Recursos Humanos e Direcqiio-Geral da Saude. 24 pp.

Wetzel RG and GE Likens 1979. Limnological analysis. Saunders Co., Philadelphia. 357 pp.

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