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Water quality assessment using phytoplankton in a historical pond of Upper Assam

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Abstract:
A historical pond of more than 300 years old located now within an urban centre of Tinsusukia district (Assam) has been assessed for water quality and the pollution tolerant phytoplankton genrera. A total of 12 Palmer's genera were been reported from the pond having Palmar's score of 28. Correlation study revealed positive relationship with surface water temperature, electrical conductivity, turbidity, BOD, potassium, phosphate and nitrate with the total density values of Palmer's genera. The pollution index value as well as the water quality parameters along with the presence of some algal indicators indicated highly organically polluted status of the pond and need management interventions.

Keywords: Phytoplankton, water quality, pollution index, historical pond, Tinsukia, Assam

Introduction:

Organic pollution of water bodies is one of the most significant issues in present days. Almost all the freshwater bodies are under tremendous pressure from human population explosion and developmental activities in an around the water bodies. Excessive nutrient loading from the surrounding has been deteriorating water quality of those systems (Carpenter *et al.*, 1998; Smitha *et al.,* 1999). Physico-chemical parameters of any water body though, provide a good indication about the water chemistry and quality, that alone does not reflect the clear picture of the ecological condition of the water body due to lack of proper integration with ecological factors (Karr *et al*., 2000). Since a biotic community is the outcome of the integration and interaction of different physical, chemical and geo-morphological characteristics of any water body, biological assessment is a useful alternative in assessing those systems (Stevenson and Pan, 1999).

Phytoplankton is one of the potent groups of any water bodies. They are mainly responsible for net as well as the gross primary productivity of the system and are the source of base level energy in food webs maintaining in the water bodies. Habitat quality specificity of the different members of phytoplankton is seen to be reflected in their distribution and occurrence in relation to the quality of water where do they live (Bhatt, *et al*., 1999; Saha *et al*., 2000). They therefore, may be considered as a reliable tool for biomonitoring of water quality to assess the pollution status of the aquatic bodies (Palmer, 1959) where they use to flourish. Being one of the pioneer workers in algal biomonitoring, Palmer (1969) listed 60 genera and 80 species of algae tolerant to organic pollution and accordingly, proposed a pollution index scale based on algal genus to be used in rating water sample of high to low organically polluted water bodies. The scored pollution index of 20 or more indicate high organic pollution, 19 to 15 indicate probable organic pollution and less than 15 indicate less organic pollution (Palmer 1969).

Assam, one of the eastern most of states of India, has a huge number of historical ponds. Selukia Pukhuri is one among them and has been considered as sacred by the Matak community as it was dug by Matak king Sarbananda Singha in the seventeenth century (Dutta, 1985). The pond is located at the cross section of geo-coordinates of 27°29'34.3" N and 95°21'19.6" E in Tinsukia district of Assam. The pond is now squeezed to an area of 31824 m^2. Being situated within a human habitation, the pond has now been facing acute problem of encroachment and irregular dumping of garbage including idol immersions leading to change of water chemistry as well as inhabiting phytoplankton community. Since, no work have so far neither been done in enumerating phytoplankton nor in analysing water quality in the pond, the present endeavour made an attempt to analyses the water quality parameters and to assess pollution status of the pond using Palmer's scale.

Materials and Methods:

The water samples for physico- chemical as well as phytoplankton analysis were collected at monthly interval for a year from January 2012 to February 2013 from five collection points taking randomly at the pond. The data thus generated were

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summed up as average data on the basis of seasons *viz*. pre monsoon (March to May), Monsoon (June to September), post monsoon (October to November) and winter (December to February).

Surface water temperature, pH and electrical conductivity were measured on spot using Systronics digital water analyzer 371. Rest of the physico-chemical properties like turbidity, dissolved oxygen, free carbon dioxide, sodium, potassium, phosphate, nitrate and oil and grease content were analyzed in laboratory following Trivedy and Goel (1986) and APHA (2012).Both surface and subsurface samples of phytoplankton were collected by using Nansen sampler and preserved in Lugol's solution. Identification was done by consulting standard literature and monographs of Kutzing (1895), Fritsch (1935, 1961), Smith (1950), Desikachary (1959) and Prescott (1975).

In this present endeavor only the pollution tolerant genera (Palmer, 1969) with 50 and above individual per ml of water sample were considered for observation following Panigrahi *et al.* (2001). The numbers scored by each pollution tolerant genera as per Palmer (1969) were added and algal pollution index of the pond was thus evaluated. Density of pollution tolerant phytoplankton genera (hereafter used as PTPG) of the pond was determined by Sedgwick-Rafter cell method (Trivedy and Goel, 1986). The Pearson's correlation coefficients were evaluated between the studied physico-chemical properties of water with density of PTPG and were tabulated accordingly.

Results and discussion:

Pollution Tolerant Phytoplankton Genera:

Table-1 showed the list of 12 pollution tolerant phytoplankton Palmer's genera as identified and recorded during the year long study at Selukia Pukhuri historical pond. Of them, 5 genera belong to the Bacillriophyceae, 3 to the group Chlorophyceae and 2 each to Cyanophyceae and Euglenophyceae respectively. All the Bacillariophycean genera viz., *Nitzschia, Navicula, Synedra, Melosira* and *Gomphonema* were dominant throughout the year in all the four seasons. Overall high Palmer's index (28) and occurrence of *Euglena, Oscillatoria, Scenedesmus, Nitzschia* and *Navicula* again throughout the year indicated that the pond was organically polluted which in conformity with the study of Goel *et al.* (1986) who reported similar finding in few polluted fresh water bodies of Maharastra (India).

Table 1: Pollution tolerant phytoplankton genera recorded throughout the year in the Selukia Pukhuri during 2012-2013, in order of decreasing emphasis.

Genus	Group	Pollution Index
Euglena	Euglenophyceae	5
Oscilatoria	Cyanophyceae	4
Scenedesmus	Chlorophyceae	4
Nitzschia	Bacillariophyceae	3
Navicula	Bacillariophyceae	3
Synedra	Bacillariophyceae	2
Phacus	Euglenophyceae	2
Phormidium	Cyanophyceae	1
Melosira	Bacillariophyceae	1
Gomphonema	Bacillariophyceae	1
Pandorina	Chlorophyceae	1
Microcystis	Cyanophyceae	1
Total		**28**

A distinct seasonal change had also been noticed in densities of PTPG in this studied pond (Table-2). It was ranged from 23.65 ± 5.44 (x 10^3/l) during winter to 62.87 ± 8.81 (x 10^3/l) during monsoon season. It has been observed that the higher density of PTPG during monsoon season was associated with high concentration of phosphate and nitrate (Thomas *et al*., 2000) whereas during winter the PTPG density was low along with low nutrient concentration.

Table 2: Seasonal variation of physico chemical properties of Selukia Pukhuri during 2012-2013

Physico Chemical Parameters	**Seasons**			
	Pre-monsoon	**Monsoon**	**Post-Monsoon**	**Winter**
Surface Water temp. (^{0}C)	32.96 ± 1.73	30.66 ± 2.38	27.92 ± 1.13	21.52 ± 1.37
pH	3.24 ± 0.27	6.78 ± 0.91	7.6 ± 1.07	7.62 ± 0.40
Conductivity(µS/cm)	564 ± 2	330.2 ± 5.54	151.2 ± 1.09	153 ± 1.22
Turbidity (NTU)	180 ± 4.84	134.8 ± 2.16	91.6 ± 1.67	62.4 ± 2.73
DO (mg/l)	7.6 ± 1.25	3.52 ± 0.83	4.68 ± 1.11	8.44 ± 2.32
Free CO_2 (mg/l)	21.6 ± 2.55	25.37 ± 3.81	23.51 ± 1.33	14.34 ± 1.75
BOD (mg/l)	2.22 ± 0.72	2.66 ± 0.39	1.83 ± 0.41	1.12 ± 0.22
Oil & Grease (mg/l)	1.30 ± 0.38	0.79 ± 0.81	1.43 ± 0.68	1.82 ± 0.57
Na (mg/l)	17.46 ± 1.10	15.5 ± 1.01	13.32 ± 1.31	19.7 ± 2.03
K (mg/l)	13.18 ± 1.22	12.70 ± 1.06	10.48 ± 1.19	9.78 ± 1.02
PO_4 (mg/l)	1.16 ± 0.84	2.76 ± 0.27	0.93 ± 0.39	1.43 ± 0.63
NO_3 (mg/l)	0.44 ± 0.11	0.68 ± 0.37	0.53 ± 0.19	0.45 ± 0.45
Density of PTPG (x 10^3/l)	44.63 ± 2.9	62.87 ± 8.81	32.29 ± 3.88	23.65 ± 5.44

Physico-chemical properties of the pond water:

Water quality data of the studied pond Selukia Pukhuri were showed in the Table 2. The surface water temperatures recorded during the study period was between the range from 21.52(± 1.37) ^{0}C to 32.96 (±1.73)^{0}C. The maximum temperature was observed during pre-monsoon season while the minimum was found during winter season. Kannan and Job (1980), Yadav *et al.* (2013), Niroula *et al*. (2010) also recorded similar observations in urban ponds of India.The pH value of the pond during the study period was in between 3.24 (± 0.27) to 7.62 (± 0.40). Though the pH values were slightly higher towards alkaline range, It is extremely acidic during pre monsoon season. Electrical conductivity was varied 564 (± 2) to 151.2 (± 1.09) µS/cm. The highest value was recorded during pre-monsoon and the lowest was observed during post- monsoon period. The turbidity values of the water samples were observed from 180 (± 4.84) to 62.4 (± 2.73) NTU. The highest turbidity was found during pre-monsoon months and the least values were found in the months of winter season.

In this present investigation dissolved oxygen concentration of the pond was varied from 8.44 (± 2.32) mg/l during winter to 3.52 (± 0.83) mg/l during monsoon. Concentration of free carbon dioxide of the pond during the study period was recorded between 25.37 (± 3.81) mg/l during monsoon to 14.34 (± 1.75) mg/l during winter. The higher free CO_2 value indicates increase in pollution load of the pond (Koshy and Nayar, 1999). The BOD values of the water samples were varied from 1.12 (± 0.22) during winter to 2.66 (± 0.39) mg/l during monsoon season. The concentration of oil and grease was varied from 0.79 (± 0.81) to 1.82 (± 0.57) mg/l. The lowest value oil and grease was noticed during the monsoon as the rain water dilutes its concentration and highest during winter season when the water was minimum in the pond. Four nutrients *viz.* sodium, potassium, phosphate and nitrate were also estimated in water samples during the investigation (Tab- 2). Concentration of sodium and potassium varied from 13.32 (± 1.31) to 19.7 (± 2.03) mg/l and 9.78 (± 1.02) to 13.18 ± 1.22 mg/l respectively. The highest amount of sodium and lowest value of potassium was recorded during winter season. Both phosphate and nitrate are the key nutrients that cause extensive algal growth, *i.e*. eutrophication in water bodies. Phosphate and nitrate contents of the water samples were ranged from 0.93 (± 0.39) to 2.76 (± 0.27) mg/l and 0.44 (± 0.11) to 0.68 (± 0.37) mg/l respectively.

From the observations made during this investigation it was noticed that the pre-monsoon and monsoon rain play key role in seasonal dynamics of studied physicochemical properties of the water samples. The rain water carried large amount of organic matter in the form of municipal and domestic waste to the pond. As the runoff water were rich in clay, silt and colloidal organic matter which also attributed for excessive plankton growth and thus increase turbidity during pre-monsoon and monsoon season (Radhika *et al*. 2004, Pathak and Limaye, 2012 and Dhanalakshmi *et al.* 2013). Raised ionic concentration due to nutrient deposition and organic pollution attributed highest electrical conductivity during pre-monsoon season (Fokmare and Musaddique, 2001).High water temperature could raise the rate of microbial decomposition of the rain water carried organic load resulting reduction of dissolved oxygen content in water sample (Prasad *et al.*, 1985; Hulyal and Kaliwal, 2011; Ramulu and Benarjee, 2013) and on the other hand, excessive production of CO_2 due to microbial decomposition increased amount of free CO_2 in water which in turn reduced the pH of water (Dhanalakshmi *et al*., 2013) particularly during monsoon.

Due to the accelerated microbial decomposing activity the requirement of oxygen was increased (Anitha *et al.*,2005) resulting higher value of BOD during monsoon.The maximum concentration of phosphate and nitrate was also observed during monsoon season. Runoff from the surrounding human settlement consisting domestic sewage rich in organic matters was the main cause of phosphate and nitrate enrichment of the pond (Khurshid *et al.,* 1997; Verma *et al.,* 2012).

The statistical analysis of Pearson's correlation coefficient is presented in the Table 3. The surface water temperature was significantly positively correlated with electrical conductivity, turbidity, free carbon dioxide, BOD, potassium and density of PTPG. On the other hand, surface water temperature showed strict negative relation pH, sodium and oil and grease in water body. The pH showed significant negative correlation with conductivity, turbidity, BOD and potassium. The increase in electrical conductivity increases turbidity, BOD, K and density of PTPG. Turbidity showed significant positive correlation with free carbon dioxide, BOD, potassium and density of PTPG and significant negative correlation with oil and grease content in water. Dissolved oxygen has positive correlation with sodium and oil and grease and showed negative correlation with free carbon dioxide, phosphate, nitrate and with density of PTPG. Result revealed a positive correlation of free CO_2 with BOD, potassium and nitrate in the studied pond. But free CO_2 has negative correlation with sodium and oil and grease content. BOD was positively correlated with potassium and density of PTPG, however, it showed negative correlation with oil and grease content. Sodium was positively correlated with oil and grease and negatively correlated with nitrate in this study. Potassium on the other hand showed negative correlation with oil and grease content. The increase in potassium content also increases the density of PTPG. Increasing phosphate in the pond also increases nitrate content as well as density of PTPG. Phosphate has negative correlation with oil and grease content. The result also revealed that oil and grease were highly responsible for significantly reduction in density of PTPG in the pond.

Conclusion:

From the results of physico chemical properties and as well as from the Palmer's score (28) of Selukia Pukhuri, it may be conclude that the pond is highly organically polluted. Dominance of pollution tolerant genera *Euglena, Oscillatoria, Scenedesmus, Nitzschia* and *Navicula* round the year also supports the view to categorize the pond as eutrophic in nature as also reported by Nandan and Aher (2005) and Shekhar *et al*.(2008). The pond also showed an interesting observation during pre monsoon and monsoon seasons. Higher densities of PTPG during these seasons may be attributed for mixing of pond water and mobilisation of nutrients due to rain and surface runoff water that dictates towards the pond. Algal analysis thus showed that water quality of the pond has reached at threshold level and therefore, it need some corrective measures to maintain the water chemistry of the pond to save that historical site heritage from further deterioration. Regular monitoring of densities of PTPG is also to be done.

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Table 3: Correlation matrix of studied physico chemical properties and PTPG density of Selukia Pukhuri during 2012-2013

	SWT	pH	EC	Turb	DO	F CO_2	BOD	Na	K	PO_4	Nitrate	O & G	PTPG
SWT	1	-0.727*	0.812*	0.936*	-0.413	0.711*	0.951*	-0.452*	0.918*	0.166	0.269	-0.726*	0.640*
pH		1	-0.965*	-0.896*	-0.311	-0.119	-0.770*	-0.194	-0.783*	0.157	0.352	0.223	-0.279
EC			1	0.961*	0.134	0.194	0.840*	0.141	0.905*	0.086	-0.129	-0.433	0.464*
Turb				1	-0.116	0.439*	0.929*	-0.120	0.958*	0.148	0.061	-0.604*	0.578*
DO					1	-0.780*	-0.300	0.831*	-0.270	-0.529*	-0.887*	0.743*	-0.576*
F CO_2						1	0.596*	-0.925*	0.446*	0.074	0.504*	-0.683*	0.442
BOD							1	-0.342	0.905*	0.127	0.157	-0.632*	0.623*
Na								1	-0.134	0.284	-0.533*	0.491*	-0.293
K									1	0.393	0.274	-0.743*	0.707*
PO_4										1	0.782*	-0.683*	0.694*
Nitrate											1	-0.765*	0.586*
O & G												1	-0.747*
PTPG													1

*= significant at 0.05 level (2-tailed)

SWT=surface water temperature, EC=electrical conductivity, Turb=turbidity, DO=dissolved oxygen, F CO_2= Free carbon dioxide, BOD=biochemical oxygen demand, Na=sodium, K=potassium, PO_4= phosphate, O & G=oil and grease, PTPG=density of pollution tolerant phytoplankton genera.