STUDIES ON LIMNOLOGY AND MACROPHYTES IN SELECTED WATER BODIES OF DURGAPUR, WEST BENGAL, INDIA

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ABSTRACT

Background: Water quality directly affects distribution, abundance, and diversity of aquatic macrophytes in lakes because it controls the amount of algae and light availability. **Objective:** The present investigation was carried out in order to assess the influence of water quality on macrophyte distribution and abundance in the lentic and lotic water bodies. **Material and methods:** Limnological investigation along with macrophyte distribution, diversity and abundance were studied for lentic and lotic ecosystem following standard methods during 2009-2010. **Results and conclusion:** Water and air temperature, solar intensity, humidity, dissolved oxygen content showed significant seasonal variation between two studied sites. The total dissolved solid, conductivity, total alkalinity, hardness, chloride, phosphate, nitrate value of water samples significantly varied in the two studied sites at different seasons throughout the study period. 45 species of macrophytes in site A and 20 such species in site B were collected and their growth forms were observed and recorded. Site A reflecting higher level of productivity, dissolved oxygen content appears to be a valuable resource which needs prior conservation efforts for its sustainable use.

KEYWORDS: *growth form, macrophyte, water quality, species composition.*

1. INTRODUCTION

Physico-Chemical parameters are highly important with regard to the occurrence and abundance of species. Eutrophication has become a widely recognized problem of water quality deterioration [1]. Water quality directly affects distribution, abundance, and diversity of aquatic macrophytes in lakes because it controls the amount of algae and light availability [2].

Therefore, aquatic macrophytes can be an index of water quality. The aims of this present investigation were to examine the quality of the physical and chemical environment of water courses in Durgapur by assessing the distribution and abundance of macrophytes in watercourses and to get an insight into the relationship between the quality of environment and macrophyte presence and abundance. Distribution and abundance of macrophytes are affected by several environmental and antropogenic factors and their interactions [3]. Parameters exerting impact on macrophyte growth and abundance in running waters are the following: climate, hydrology, geomorphology, nutrients and other chemical factors, biological interactions and human activities [4]. Plants growth form schemes constitute a way of classifying plants alternatively to the ordinary species-genus-family scientific classification. The scientific use of growth form schemes emphasizes plant function in the ecosystem and that the same function or adapted ness to the environment may be achieved in a number of ways. The study area has been surveyed and a brief account of wetland vegetation is enumerated with their diversity, ecotype, and growth form. In view of this, overall assessment of the influence of water quality on macrophyte distribution and abundance in the lentic and lotic water bodies were undertaken.

2. MATERIALS AND METHODS

2.1 STUDY SITES: The present work is an outcome of a field study undertaken during December 2009 to November 2010. Site A is Borobandh (lat: 23°30'13.23"N/long: 87°21'36.30"E) at Muchipara, which is a constructed freshwater wetland which is connected with another wetland nearby and Site B were DPL housing complex (lat: 23°30'13.01"N/long: 87°21'40.99"E) is a polluted water body as it receives effluent from Durgapur Project Limited (DPL) and Alloy Steel Plant.

2.2 METHODS OF THE STUDY

2.2.1 Sampling: All the collections and observations were made between 9:00 am to 3:00 pm in different seasons from different study sites throughout the study period. The collected water samples were brought to the laboratory for the estimation of various parameters.

2.2.3 Limnological Investigations: Standard methods were employed for the estimation of parameters such as pH, DO, alkalinity, total hardness, chloride, phosphate, total dissolve solids, NPP, GPP [5]. The pH of water samples were determined potentiometrically. Dissolved Oxygen, NPP and GPP content were measured by Winkler's Iodometric method, alkalinity, total hardness, chloride content of water samples were measured titrimetrically, phosphate content were measured spectrophotometrically and total dissolve solids of water samples were measured gravimetrically.

2.2.4 Macrophyte Study: Adequate plant specimens of vascular macrophytes were collected and relevant observations on them were recorded in field note book. The plant specimens were then properly dried and processed for herbarium preservation. For correct identification of each species, they were referred voucher specimens were matched with the authentic specimens preserved in the Central National Herbarium, Shibpur, Howrah and in the Herbarium of Burdwan University.

2.2.4 Growth form analysis: The growth forms are categorized on the basis of their morphological dependence on the atmosphere, aquatic, edaphic conditions, their relative sizes and their anatomical structures. A particular growth form comprises plants of comparable structures and similar relations to their physical environment. Various characteristics comprising the horizontal and vertical distribution has been assessed viz., (a) relationship of the plants to the substratum (soil surface) (b) relationship to the aquatic environment (c) habits etc.

3. RESULTS AND DISCUSSION

Table 1: the table presents the hysicochemical parameters of water for site A (Borobandh at Muchipara) and site B (Durgapur Project Limited housing complex).

	DO	SI	AT	WT	pH	TDS	COND	HARD	ALK	CHL	P	N
SITEA: Min±SD	3.37±0.15	396.23±0.21	23.23±0.15	17.30±0.10	7.2±0.10	0.12±0.0	0.29±0.0	0.47±0.15	1.20±0.10	20.13±0.15	3.10±0.10	0.51±0.01
Max±SD	5.47±0.15	990.20±0.20	39.63±0.15	31.20±0.20	7.8±0.10	0.19±0.0	0.42±0.0	1.27±0.21	1.75±0.10	42.23±0.15	3.33±0.15	0.53±0.01
SITEB: Min±SD	1.30±0.10	560.13±0.15	23.20±0.10	16.70±0.10	6.4±0.14	0.14±0.00	0.37±0.00	1.20±0.10	0.63±0.15	28.10±0.10	10.13±0.15	0.51±0.01
Max±SD	2.50±0.10	850.23±0.21	34.40±0.10	37.23±0.15	9.6±0.12	0.19±0.00	0.44±0.00	2.23±0.15	3.47±0.15	42.17±0.15	10.52±0.15	0.54±0.02

Dissolve oxygen(mgL^{-1})-DO,Solar Insolation (lux)-SI, Air Temperature(oC)-AT, Water Temperature(oC)-WT, Conductivity(mS)-COND, Total Dissolved solid (mgL^{-1})-TDS, Ph-pH, Alkalinity(mgL^{-1})-ALK, Hardness(mgL^{-1})HARD ,Nitrate(mgL^{-1})-N, Phosphate(mgL^{-1})-P, Chloride(mgL^{-1})-CHL

Table 1 represents the limnological characteristics of two study sites of Durgapur. In the present investigation, solar intensity gradually decreased from the month of December to July in site A and to May in site B, then increased during the winter months for following two study sites. Higher atmospheric temperatures were recorded during the summer months and lower atmospheric temperature was recorded in winter months. The atmospheric temperature was maximum in month of May for both the study sites. The variation in water temperature might be attributed towards the normal climatic fluctuations and effect of seasons as well as the effect of atmospheric temperature as reported by respectively [6]. The surface water temperature showed an increasing trend during summer months as influenced by the intensity of solar radiation, evaporation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters [7]. In the present study, the pH was found alkaline in site A throughout the entire study period, but in site B pH value was acidic in winter season and alkaline in summer. The recorded high summer pH might be due to the influence of high biological activity [8] and due to the occurrence of high photosynthetic activity [9] at both the study sites. The acidic nature of the water quality during winter months for site B may be attributed towards heavy release of toxic substances from the nearby factories like Durgapur Project Limited and Alloy Steel Plant. TDS values were found to be higher in summer followed by winter and monsoon. Similar observation were reported higher level of TDS during summer from two ponds of Uttar Pradesh [10]. Both the study sites showed a gradual increase in conductance value from winter to premonsoon The lower value of conductance might be due to the presence of lower inorganic material and lower ionic state and inversely, higher value due to higher ionic load derived from edaphic sources that reached that site. Similar findings were reported [11] in study on water quality. During the present investigation, it was observed that hardness is higher in the pre monsoon period in both the studied sites, possibly due to the influx of water and lower hardness value were recorded in both the studied sites during monsoon rains which might be attributed towards the dilution effect of the water [12]. Total alkalinity showed a declining trend from winter to summer and monsoon for site A and site B, might be due to high pH which may be due to the presence of hydroxide carbonates and bicarbonate salts, photosynthetic activity of aquatic plant which reduces alkalinity. High alkalinity was recorded for site B in comparison to site A may be due to the addition of waste from organic matter. Chloride content of water samples of two studied sites were found to be higher in summer in comparison to other seasons. Chloride content of water is one of the important ecological factors, which influences the functional physiology and reproductive activity of organisms [13] there by affecting distribution of planktons and animals .The higher level of chloride content during summer months may be attributed towards continuous evaporation of water especially during summer season [14].

In the present study, phosphorus showed higher values in premonsoon and lower in winter months. Slow flow rate and settled and stagnant water might be the reason for the high values observed during premonsoon. These findings supported the observations made by several previous workers [15]. The nitrate concentration of water of all the study sites showed significant fluctuation throughout the study period. The maximum value was recorded in summer and minimum value during winter. The recorded highest monsoonal nitrate value could be through oxidation of ammonia form of nitrogen to nitrite formation [16]. The recorded low values during non-monsoon period may be due to its utilization by phytoplankton as evidenced by high photosynthetic activity [17]. There is a gradual decline in dissolved oxygen concentration from winter to summers in all the two sites [18] (Table1). The correlation coefficient values were, in most cases, above 0.3 and significant at $P < 0.05$, thus justifying the use of multivariate statistics (PCA). Table 2 shows that factor analysis extracts three factors according to eigen values (>1) for the two studied sites. For site A the first, second and third factor accounts for 32.841%, 26.279% and 13.357% of variability in the water quality respectively. Parameters such as water temperature, TDS and chloride were found to be significantly loaded in factor I, humidity was significantly loaded in factor 2, nitrate-nitrogen in factor 3. For site B the first, second and third factor accounts for 52.116%, 17.382% and 10.727% of variability in the water quality. Parameters such as humidity, air temperature, water temperature, water pH, conductivity, TDS and chloride were found to be significantly loaded in factor 1; nitrate-nitrogen was significantly loaded in factor 2, dissolved oxygen in factor 3.

Table 2: The table presents rinciple component analysis (3 components counted) with varimax rotation for physico-chemical parameters of water in site A and B

	Component		
	1	2	3
HUM	0.839	-0.341	-0.165
S_I	-0.879	0.223	0.197
ATM. TEMP	0.818	0.175	-0.171
W.TEMP	0.866	0.223	4.97E-03
W_PH	0.955	-0.114	-2.84E-02
TDS	0.811	0.323	-7.90E-03
CONDT	0.896	7.21E-02	-9.95E-02
HRD	-2.43E-02	-0.682	7.73E-02
ALK	-0.865	-0.135	0.297
CHL	0.76	0.261	-0.512
PHOS	0.319	0.725	-3.05E-02
NI	-0.115	0.826	0.22
DO	-0.136	6.27E-03	0.942
NPP	0.441	0.686	-0.49
CR	-0.962	-8.16E-02	-6.68E-02
GPP	-0.968	5.56E-03	-4.83E-02
Eigenvalue	8.86	2.955	1.824
% of Variance	52.116	17.382	10.727
Cumulative %	52.116	69.498	80.225

Extraction Method: Principal Component Analysis.
Varimax with Kaiser Normalization
A Rotation converged in 6 iterations.

	Component		
	1	2	3
HUM	.344	.850	.138
S_I	-.693	-8.641E-02	-.115
ATM. TEMP	.541	.687	.234
W.TEMP	.896	.357	-4.056E-02
W_PH	-.692	-1.419E-03	.137
TDS	.847	.429	-.124
CONDT	.579	.366	.498
HRD	-.299	-.598	-8.457E-02
ALK	-.175	-.509	3.184E-02
CHL	.909	.343	-8.374E-02
PHOS	.212	.593	.435
NI	.231	6.812E-02	.839
DO	-.904	-.215	-.210
NPP	-.369	-.708	.506
CR	.304	-.824	6.734E-02
GPP	-.279	-.695	.459
Eigenvalue	5.583	4.467	2.271
% of Variance	32.841	26.279	13.357
Cumulative %	32.841	59.12	72.477

Extraction Method: Principal Component Analysis. Rotation Method:
Rotation Method: Varimax with Kaiser Normalization
B Rotation converged in 4 iterations

(*AT-Atmospheric temperature, WT-Water temperature, pH-Water, LI-Light intensity, HMD-Humidity, CONDT -Conductivity, TDS-Total dissolved solids, ALK-Alkalinity, HRD-Total Hardness, CL-Chloride, PHOS-Phosphate, NI-Nitrate, DO-Dissolved oxygen, NPP-Net primary productivity, CR-community respiration, GPP-gross primary productivity)

From the correlation study, it was observed that, a positive correlation exists between community respiration and gross primary productivity with solar intensity for site B. Atmospheric temperature is positively correlated with water temperature, TDS, chlorine and conductivity in site A and in site B respectively. Atmospheric temperature is positively correlated with water pH in site B. Water temperature is positively correlated with TDS (r=0.92) and chloride in site A. In this site TDS is positively related with chloride and NPP is also relating positively with GPP. In site B water pH is positively correlated with TDS, conductivity and chloride. Alkalinity shows positive correlation with CR and GPP. In this site chloride is positively related with NPP and CR with GPP (Table 3 and 4).

Table 3: The table presents the correlation between different physico-chemical factors of water in site-A.

	HUM														
S_I	-0.43	S_I													
ATM_TEMP	0.69	-0.31	ATM_TEMP												
W_TEMP	0.6	-0.78	0.7	W_TEMP											
W_PH	-0.06	0.27	-0.59	-0.62	W_PH										
TDS	0.54	-0.54	0.79	0.92	-0.72	TDS									
CONDT	0.66	-0.44	0.52	0.58	-0.02	0.54	CONDT								
HRD	-0.69	-0.06	-0.57	-0.3	0.16	-0.45	-0.59	HRD							
ALK	-0.63	0.2	-0.5	-0.28	0.33	-0.26	-0.06	0.54	ALK						
CL	0.55	-0.54	0.76	0.89	-0.69	0.95	0.61	-0.58	-0.33	CL					
PHOS	0.64	-0.24	0.64	0.46	-0.11	0.35	0.55	-0.23	-0.14	0.31	PHOS				
NI	0.17	-0.27	0.38	0.21	-0.13	0.21	0.54	-0.19	0	0.18	0.24	NI			
DO	-0.61	0.71	-0.63	-0.88	0.45	-0.76	-0.79	0.42	0.27	-0.85	-0.48	-0.28	DO		
NPP	-0.59	0.2	-0.58	-0.58	0.28	-0.74	-0.29	0.5	0.25	-0.65	-0.22	0.23	0.36	NPP	
CR	-0.52	0.04	-0.39	-0.12	-0.09	-0.16	0.04	0.15	0.3	0.03	-0.42	-0.05	-0.19	0.49	CR
GPP	-0.54	0.3	-0.52	-0.57	0.16	-0.66	-0.22	0.25	0.13	-0.52	-0.28	0.21	0.29	0.93	0.59

Table 4: The table presents the Correlation between different physico-chemical factors of water in site-B.

	HUM														
S_I	-0.92	S_I													
ATM_TEMP	0.57	-0.59	ATM_TEMP												
W_TEMP	0.52	-0.61	0.92	W_TEMP											
W_PH	0.81	-0.91	0.77	0.8	W_PH										
TDS	0.68	-0.7	0.54	0.62	0.7	TDS									
CONDT	0.64	-0.72	0.88	0.85	0.86	0.65	CONDT								
HRD	0.04	-0.15	-0.11	-0.05	0.22	-0.36	-0.07	HRD							
ALK	-0.8	0.75	-0.75	-0.75	-0.73	-0.82	-0.74	0.35	ALK						
CL	0.53	-0.67	0.76	0.76	0.73	0.65	0.82	-0.16	-0.8	CL					
PHOS	0.09	-0.31	0.32	0.38	0.27	0.47	0.29	-0.48	-0.3	0.38	PHOS				
NI	-0.48	0.43	0.11	0.2	-0.19	0.07	-0.06	-0.39	0.07	0.08	0.37	NI			
DO	-0.26	0.24	-0.35	-0.19	-0.11	-0.06	-0.22	0.12	0.44	-0.59	-0.01	0.13	DO		
NPP	0.16	-0.35	0.55	0.53	0.43	0.57	0.52	-0.34	-0.53	0.81	0.65	0.47	-0.49	NPP	
CR	-0.82	0.81	-0.74	-0.81	-0.87	-0.86	-0.8	0.16	0.9	-0.69	-0.31	0.03	0.07	-0.4	CR
GPP	-0.8	0.87	-0.7	-0.81	-0.95	-0.83	-0.82	-0.07	0.81	-0.73	-0.27	0.08	0.05	-0.43	0.96

The present study reveals the presence of 45 macrophytes in site A and 20 in site B (Table 5). In present enumeration a total number of 45 species of 33 genera which belongs 22 families in site A and 20 species of 17 genera which belongs to 12 families in site B are identified. Out of these in site A 26 species are Halophyte, 7 species Pleustophyte, 5 species Tenagophyte, 3 species Vittate, 2 species Epihydate, 1 species Hyperhydate and 1 species Rosulate and in site B 13 species are Helophyte, 3 species Pleustophyte, 2 species Hyperhydate, 1 species Tenagophyte and Rosulate in each, Vittate and Epihydate form are absent.The dominant family is Poaceae in both sites (6 in site A and 5 in site B respectively).Generally the vegetation of wetland has been classified into four classes viz., i) Submerged, ii) Rooted with floating leaves, iii) Free floating, iv) Emergent and v) Floating. Emergent plants are abundant in both studied sites. In both cases the growth of the submerged, free -floating, floating and rooted with floating leaves are high in site A rather than site B.

Table 5: The table presents the list of macrophytes observed at the site A along with their ecotype and growth form.

Site-A				Site-B			
Name of the plant	**Family**	**Eco-type**	**Growth form**	**Name of the plant**	**Family**	**Eco-type**	**Growth form**
Alternanthera sessilis	Amaranthaceae	Emergent	Hel.	*Alternanthera sessilis*	Amaranthaceae	Floating	Hel.
Azolla pinnata	Azollaceae	Free floating	Ple.	*Azolla pinnata*	Azollaceae	Free floating	Ple.
Bacopa monnieri	Scrophulariaceae	Floating	Hel.	*Echinochloa crus-galli*	Poaceae	Emergent	Hel.
Brachiaria ramosa	Poaceae	Emergent	Hel.	*Eichornia crassipes*	Pontederiaceae	Free floating	Ple.
Brachiaria reptans	Poaceae	Emergent	Hel.	*Ipomoea fistulosa*	Convolvulaceae	Emergent	Hel.

Centella asiatica	Apiaceae	Floating	Hel.	*Leersia hexandra*	Poaceae	Emergent	Hel
Ceratophyllum demersum	Ceratophyllaceae	Sub-merged	Vit.	*Lindernia anagallis*	Scrophulariaceae	Emergent	Hel.
Coix lacryma-jobi	Poaceae	Emergent	Hel.	*Monochoria vaginalis*	Pontederiaceae	Emergent	Hel.
Coldenia procumbens	Boraginaceae	Emergent	Hel.	*Ottelia alishmoides*	Hydrocharitaceae	Submerged	Ros.
Commelina benghalensis	Commelinaceae	Emergent	Hel.	*Panicum repens*	Poaceae	Emergent	Hel.
Cyperus exaltatus	Cyperaceae	Emergent	Ten.	*Phragmites karka*	Poaceae	Emergent	Hyp.
Cyperus iria	Cyperaceae	Emergent	Ten.	*Phyla nodiflora*	Verbenaceae	Emergent	Hel.
Cyperus rotundus	Cyperaceae	Emergent	Hel.	*Pistia stratiotes*	Araceae	Free floating	Ple.
Echinochloa colona	Poaceae	Emergent	Hel.	*Polygonum barbatum*	Polygonaceae	Emergent	Hel.
Echinochloa crusgalli	Poaceae	Emergent	Hel.	*Polygonum hydropiper*	Polygonaceae	Emergent	Hel.
Eichornia crassipes	Pontederiaceae	Free floating	Ple.	*Polygonum orientale*	Polygonaceae	Emergent	Hel.
Enydra fluctuans	Asteraceae	Free floating	Hel.	*Polygonum plebeium*	Polygonaceae	Emergent	Hel.
Evolvulus alsinoides	Convolvulaceae	Emergent	Hel.	*Rotala indica*	Lythraceae	Emergent	Ten.
Fimbristylis dichotoma	Cyperaceae	Emergent	Ten.	*Saccharum spontaneum*	Poaceae	Emergent	Hel.
Heliotropium strigosum	Boraginaceae	Emergent	Hel.	*Typha elephantina*	Typhaceae	Emergent	Hyp.
Heliotropium indicum	Boraginaceae	Emergent	Hel.				
Hydrilla verticillata	Hydrocharitaceae	Submerged	Vit.				
Hydrolea zeylanica	Hydrophyllaceae	Sub-merged	Hel.				
Hygrophila difformis	Acanthaceae	Emergent	Hyp.				
Ipomoea aquatica	Convolvulaceae	Floating	Hel.				
Ipomoea fistulosa	Convolvulaceae	Emergent	Hel.				
Lemna perpusila	Lemnaceae	Free floating	Ple.				
Leptochloa chinensis	Poaceae	Emergent	Ten.				
Marsilea minuta	Marsileaceae	Floating	Ten.				
Monochoria hastata	Pontederiaceae	Emergent	Hel.				
Monochoria vaginalis	Pontederiaceae	Emergent	Hel.				
Nymphaea pubescens	Nymphaeaceae	Emergent with floating leaves	Eph.				
Nymphoides hydrophylla	Menyanthaceae	Emergent	Ple.				
Nymphoides indica	Menyanthaceae	Free floating	Ple.				
Polygonum barbatum	Polygonaceae	Emergent	Hel.				
Polygonum hydropiper	Polygonaceae	Emergent	Hel.				
Polygonum	Polygonaceae	Emergent	Hel.				

orientale							
Polygonum plebeium	Polygonaceae	Emergent	Hel.				
Potamogeton crispus	Potamogetonaceae	Submerged	Vit.				
Potamogeton nodosus	Potamogetonaceae	Submerged	Eph.				
Salvinia cuculata	Salviniaceae	Floating	Ple.				
Sphaeranthus indicus	Asteraceae	Sub-merged	Hel.				
Spilanthes paniculata	Asteraceae	Sub-merged	Hel.				
Spirodela polyrhiza	Lemnaceae	Emergent	Ple.				
Vallisneria spiralis	Hydrocharitaceae	Submerged	Ros.				

Epihydate- Eph.; Helophyte- Hel.; Hyperhydate- Hyp.; Pleustophyte- Ple.; Rosulate- Ros.; Tenagophyte- Ten.; Vittate- Vit

Although the present investigation has got sufficient new information from wetland biology perspectives but it has got some inherent limitations. As the study was conducted under tropical condition< the results may not be same for other climatic condition inall places.Therefore representative works needs to be conducted at various conditions. Again from ecological niche perspective the distribution abundance of the respective macrophytic species needs further indepth investigation with respect to limnology.

4. CONCLUSIONS

From the present investigation it can be concluded that Site A is highly productive (Gross Primary Productivity, Net Primary Productivity, Community Respiration). The Dissolved Oxygen content is well within the acceptable range for supporting aquatic diversity in site A. The macrophyte diversity was found to be greater in site A. This therefore can be utilized as biological resource and maintenance of the sustainability of the freshwater habitat. The overall limnological attributes along with associated macrophytic diversity necessitates prior conservation of site A (Borobandh- a wetland).From the results it can further be concluded that constructed wetlands can be effectively utilized in comparison to a polluted water body for maintaining the sustainability of the wetland ecosystem.

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