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EFFECT OF SOIL PHYSICOCHEMICAL PROPERTIES ON WETLAND HYDROPHYTIC DIVERSITY OF SAVAR AND DHANMONDI LAKE

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ABSTRACT

A study of soil physicochemical characteristics and hydrophytic diversity in four wetlands of Savar Thana and Dhanmondi Lake was performed during January to March 2007. The pH and the contents of soil moisture, organic carbon, organic matter (OM), available nitrogen in ammonium (NH_4^+) and nitrate (NO_3^-) forms, available phosphorus, sulphur, potassium (K^+), calcium (Ca^{2+}) and cation exchange capacity (CEC) were determined. A total of 20 hydrophytic species were recorded. *Nymphaea nouchalli, Nymphaea pubescens, Nymphaea rubra, Alternanthera paronychiodies, Cyperus killinga, Cyperus platystylis, Limnophila heterophylla, Schoenoplectus juncodies* and *Paspalidium punctatum* were the rooted attached hydrophytes. *Paspalidium punctatum* was the most dominant (abundance = 425.0) hydrophytic species. Soil pH, organic matter, available nitrogen in ammonium (NH_4^+) form and CEC showed strong positive correlation with available nitrogen in nitrate (NO_3^-) form (r = 0.762), organic carbon (r = 1.00** at 0.01 level of significance), Ca^{2+} (r = 0.973), available nitrogen in ammonium (NH_4^+) form (r = 0.66), respectively. Soil pH and organic matter showed strong negative correlation with CEC (r = -0.973* at 0.05 level of significance) and available nitrogen in ammonium (NH_4^+) form (r = -0.820), respectively. Dhanmondi Lake was totally devoid of rooted attached hydrophytic species.

Key words: Soil, physicochemical properties, wetland, hydrophytic diversity

INTRODUCTION

Wetlands are dynamic and complex habitat. The total wetland areas during wet season in Bangladesh have been estimated about 7.5 million hectares. The existing water bodies approximately reach to a total of 6.71 million hectares area (Akond, 1989). Wetlands cover an area of 6% of the earth surface and are found in all climates and region. Despite this coverage, wetlands everywhere are under threat from agricultural intensification, pollution, urban development and engineering schemes (Abbasi, 1997).

The growth and development of aquatic plants in wetlands are largely dependent on soil nutrient status, water quality and other meteorological condition. According to Moorman and Watering (1985), wetland soils can be defined as soils whose development and properties are strongly influenced by topography and permanent saturation in the upper part of the land. The wetland soils in Bangladesh can be grouped into two broad classes as organic and mineral. The organic group (peat) consists of around 74,000 ha. Mineral soils forming under the wetland conditions are the most extensive in Bangladesh (SRDI, 1965-87). Kyuma (1985) reported that wetland soils are quite variable in material nature, but are always high in clay activity. However, submerged aquatic vegetation has been pointed out as a key structural component and regulator in ecosystem (Cathleen *et al.*, 2000). Frisk *et al.* (1999) reported that the low water periods were hazardous to the ecosystem and cause an increase of resuspension, accelerate nutrient cycling and improve the water column illumination and this leads to massive growth of planktonic algae and submerged hydrophytes. The present study was undertaken to evaluate the major physicochemical properties of soils and hydrophytic diversity of some freshwater wetlands of Savar and Dhanmondi Lake.

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MATERIALS AND METHODS

The study was carried out during January to March 2007. A total of four sites were selected for the study. The selected three sites are located at Savar Thana - Wetland of Jahangirnagar University (JU), Wetland of National Martyrs' Memorial (NM) and Wetland near Pakija dyeing industry (PA) and remaining one is located in Dhanmondi Thana (DH) of Dhaka district.

Soil samples were collected from 0 – 15 cm depth with the help of "Eijkelkamp Agrisearch Equipment" (The Netherlands) and taken in polybags. Moist soil samples were used to determine soil pH and available nitrogen. Dry soil samples after sieving (2 mm sieve) were preserved in polybag to determine other physicochemical properties.

Textural classes of soils were determined by Marshall's Triangular Co-ordinate (USDA). The pH of freshly collected moist soil was determined by using Griffin pH meter (Model No. 40). The soil to water ratio was 1: 2.5. Soil organic carbon content was estimated by Walkley and Black's (1934) wet oxidation method as described by Jackson (1973).The organic matter content of the soil was determined by multiplying the percentage of organic carbon with conventional Van Bemmelen's factor of 1.724 (Piper, 1950). Available nitrogen from the soil was extracted by 2M potassium chloride solution and the nitrogen content of the extract was determined by Micro-Kjeldahl distillation method, as described by Jackson (1973). The phosphorus content of the soil sample was determined by ascorbic acid blue colour method (Murphy and Riley, 1962). Available soil sulphur was extracted with 500 ppm phosphorus from Ca $(H_2PO_4)_2$. $2H_2O$ (Fox *et al.*,1964). The amount of sulphur was measured turbidimetrically (Hunt, 1980). Cation exchange capacity of the soil was determined by using neutral 1N NH_4OAc solution as described by Black (1965). Available soil potassium and calcium were extracted with 1N neutral ammonium acetate solution (Schollenberger and Simon, 1945).

Determinations of the density of hydrophytes in different wetlands were estimated by quadrate method (Shukla and Chandela, 2000). Analyzing data from the study using Statistical Package for Social Sciences (SPSS) for windows did relationship between variables i.e. statistical correlation analysis Pearson Correlation with (2 Tailed) bivariate analysis were done.

RESULTS AND DISCUSSION

The textures of soils of JU and DH wetlands were clay loam, the soil of NM wetland was sandy loam and soil of PA was silty loam (Table 1).

Table 1. Textural classes of four wetland soils

Site	Sand fraction	Silt fraction	Clay fraction	Textural class
JU	7.05	47.5	45.45	Clay loam
NM	42.05	32.5	25.45	Sandy loam
PA	19.52	52.53	27.95	Silty loam
DH	39.55	25.0	35.45	Clay loam

Chemical properties of soils have profound influence on Lake Environment, hydrophytes growth and development. The physico-chemical properties of soil varied from one wetland to another (Table 2). The moisture content of soils in four wetlands ranged from 35.97% to 88.4%. The maximum moisture content was found at Pakija Dyeing Lake and minimum at JU.

The maximum pH (7.18) was recorded in wetland PA and minimum pH (6.82) in wetland JU. Soil pH is more or less basic. Organic carbon content present in soils of different wetlands ranged between 0.39% and 1.36% in various wetlands. The maximum organic carbon content of soil was found in PA and the minimum in DH.

The organic matter ranged between 0.67% and 2.34% in different wetlands. The highest amount of organic matter content was found in PA and the lowest in DH.

Among studied sites, the highest amount of available ammonium (NH_4) was obtained in DH (62.88 µg/g) and the minimum was found in PA (15.72 µg/g).

Among four sites, the highest amount of available nitrate was found in PA (56.59 µg/g) and the lowest was found in JU (3.14 µg/g). Available phosphorus of soil of four freshwater wetlands varied from 65.0 µg/g to 17.5 µg/g. The highest amount of phosphorus was found in DH and the lowest value was found in NM.

The fluctuation of available soil sulphur content indicates that the range of soil sulphur varied from 75.0 µg/g to 150.0 µg/g. The maximum amount of soil sulphur was found in PA and the minimum was found in NM.

Available potassium of soils of four freshwater wetlands varied from 90.0 µg/g to 155.0 µg/g. with the changes of wetlands. The highest amount of potassium was found in DH and the lowest value was found in NM.

Table 2. Physico-chemical properties of four wetland soils

Site	Moisture content (%)	pH	Organic carbon (%)	Organic matter (%)	Available Nitrogen (NH_4^+) (μgg^{-1})	Available Nitrogen (NO_3^-) (μgg^{-1})	Available Phosphorus (μgg^{-1})	Available Sulphur (μgg^{-1})	Available Potassium (μgg^{-1})	Calcium content (Cmol kg^{-1} soil)	CEC (Cmol kg^{-1} soil)
JU	35.97	6.82	1.32	2.29	22.01	3.14	20.0	75.0	100	0.82	3.35
NM	40.17	7.02	0.47	0.81	31.44	14.10	17.5	47.5	90	0.32	1.70
PA	88.40	7.18	1.36	2.34	15.72	56.59	50.0	150.0	101	0.63	1.00
DH	39.96	6.84	0.39	0.67	62.88	28.29	65.0	105.0	155	0.32	3.70

The values of available calcium of soils varied from 0.82 Cmol kg^{-1} soil to 0.32 Cmol kg^{-1} soil with changes of wetlands. The highest amount of calcium was found in JU and the lowest value was found in NM.

The maximum value of cation exchange capacity of soil was found in DH (3.70 Cmol kg^{-1} soil) and the minimum value was found in PA (1.0 Cmol kg^{-1} soil). Generally, optimum availability of nutrient in soils is occurred in pH between 6 to 7 (Miah *et al.*, 2005). The pH of sediment varied from 6.82 to 7.18 which indicate that the soils were about neutral in pH (Miah *et al.*, 2005).

Organic carbon and organic matter contents varied from 0.39% to 1.36% and 0.67% to 2.29%, respectively in various wetland soils investigated. Organic carbon content was very lower in soils of NM and DH but moderate in JU and PA wetland soils. Organic matter content was very low in DH (0.67%) and NM (0.81%) wetland soils and medium in soil of JU wetland (2.34%) and PA (2.29%). Alam *et al.* (2003) reported that total organic matter content of the soils varied from 0.98% to 4.59% in some fresh water wetland soils of Bangladesh. So, the present findings agree with Alam *et al.* (2003).

Nitrogen is one of the most important elements in aquatic ecosystem and together with phosphorus it is the most production stimulating nutrient and acts as a catalyst for the decomposition of organic material in sediment (Jansson *et al.*, 1994). Available soil nitrogen (NH_4^+ and NO_3^-) is an important chemical parameter of wetland soil because it maintains the growth of hydrophytes in wetland soil. The concentration of available nitrogen in NH_4^+ form in wetland soils was high in DH (62.88%) and low in PA (15.72%). Soil NO_3^- was high in PA (56.59%) and low in JU (3.14%).

Available soil phosphorus contents of four fresh water wetlands varied remarkably. It ranged from 17.5µg/g to 65µg/g. Alam *et al.* (2003) reported that soil available phosphorus in greater Dhaka district was varied from 0.45µg/g to 19.675µg/g but the present findings of soil available phosphorus in DH (65µg/g) and PA (50µg/g) wetlands were different from Alam *et al.* (2003).

Available sulphur contents of soil varied from 47.5µg/g to 155µg/g. Alam *et al.* (2003) reported that soil available sulphur in greater Dhaka district was varied from 0.14µg/g to 113.75µg/g. During the study, soil available sulphur in wetland PA was very high. Cation (K^+,

Ca^{2+}) in wetlands soils were varied from one to other wetlands. According to *Alam et al.* (2003) in greater Dhaka district K^+ and Ca^{2+} contents of wetland soil varied from 39.5µg/g to 68.75µg/g and 38.75µg/g to 175µg/g, respectively.

Cation exchange capacity (CEC) of wetland soil varied in different wetlands. The CEC was very low in NM (1.7Cmol kg^{-1} soil) and PA (1.0 Cmol kg^{-1} soil) and moderate in JU (3.35 Cmol kg^{-1} soil) and DH (3.7 Cmol kg^{-1} soil) comparing with Miah *et al.* (2005).

The occurrence of hydrophytes was found to fluctuate along with different fresh water wetlands. It was revealed from the present investigation that all the recorded plant species do not grow in all habitats. Total 20 hydrophytic species were recorded during present investigation. Among them dominant species of JU, NM, PA and DH wetlands were *Alternanthera paronychiodies, Nymphaea rubra, Paspalidium punctatum* and *Ludwigia hysophifolia,* respectively.

A total of 73 hydrophytic species belonging to five life form categories (free floating, suspended, anchored, rooted footing and emergent amphibious) were identified in fresh water wetland in greater Dhaka district (Alam *et al.*, 2003). Sixteen hydrophytic species occurred in wetland of JU. Most of them were rooted attached and the dominant species was *Alternanthera paronychiodies.* Soil pH (6.82) was nearly neutral of the wetlands. Available soil nutrient concentrations of JU wetland for hydrophytes was lower than remaining three wetlands. Only the amount of CEC and Ca^{2+} were higher than that of other study sites.

In NM, 8 species of hydrophytes were found. *Schoenoplectus juncodies* was rooted attached hydrophyte and the most abundant species. Soil textural class of NM was sandy loam and pH was near neutral. Most of the plant available nutrients were lower in NM wetland than that of other wetland and it is an undisturbed wetland.

Wetlands near Pakija dyeing industry is a polluted site, where water was polluted by different sources such as industrial waste water, automobile workshop waste and household waste. The soil pH level of the site was much higher than other sites and most of the plant nutrients were higher than that of other study sites. Only four rooted attached hydrophytic species were found here in which most abundant species was *Paspalidium punctatum.*

Only two species of hydrophytes occurred in wetland of DH. *Ludwigia hysophifolia* was the most abundant species. Available nitrogen (62.88µg/g), phosphorus (65.0µg/g), potassium (155.00µg/g) and CEC (3.70 Cmol kg^{-1} soil) was higher in DH than that of other wetlands. Organic carbon and organic matter was very low in DH than JU, NM and PA. The growth and abundance of hydrophytes are largely dependent on the physiochemical parameters of soils. Correlations between physicochemical parameters of soils of studied wetlands are described in Table 3.

The physico-chemical characteristics of wetland soils affect the growth and development of hydrophytes. The rooted attached hydrophyte *Paspalidium punctatum* (abundance = 425.0) was recorded from wetland adjacent to Pakija dyeing industry, Savar (PA) where the average pH and the content of organic carbon, organic matter, available nitrogen in ammonium form, available nitrogen in nitrate form, available phosphorus, potassium and calcium were 7.18, 1.36%, 2.34%, 15.72µg/g, 56.59µg/g, 50.0µg/g, 101.0µg/g and 0.63 Cmol kg^{-1} soil, respectively. *Alternanthera paronychiodies* (abundance = 93.3) was the most abundant species of wetland of Jahangirnagar University (JU) where the average pH and the contents of organic carbon, organic matter, available nitrogen in ammonium form, available nitrogen in nitrate form, available phosphorus, potassium and calcium were 6.82, 1.32%, 2.29%, 22.01µg/g, 3.14µg/g, 20.0µg/g, 100.0µg/g and 0.82 Cmol kg^{-1} soil, respectively. A significant strong negative correlation ($r = -0.973^*$, at 0.05 level of significance) was found between pH and cation exchange capacity (CEC) of soils of wetlands of Savar and Dhanmondi Thana (Table 3).

Table 3. Pearson Correlation matrix of soil physicochemical parameters of four wetlands

	Moisture content	pH	Organic carbon	Organic matter	Available						CEC
					NH_4^+	NO_3^-	P	S	K^+	Ca^{2+}	
Moisture content	1	.870	.538	.531	-.507	.920	.370	.842	-.212	.216	-.758
		.130	.462	.469	.493	.080	.630	.158	.788	.784	.242
	4	4	4	4	4	4	4	4	4	4	4
pH	.870	1	.292	.285	-.559	.762	.058	.488	-.483	-.047	-.973(*)
	.130		.708	.715	.441	.238	.942	.512	.517	.953	.027
	4	4	4	4	4	4	4	4	4	4	4
Organic carbon	.538	.292	1	1.000(**)	-.820	.230	-.190	.464	-.486	.937	-.295
	.462	.708		.000	.180	.770	.810	.536	.514	.063	.705
	4	4	4	4	4	4	4	4	4	4	4
Organic matter	.531	.285	1.000(**)	1	-.820	.221	-.196	.458	-.487	.940	-.290
	.469	.715	.000		.180	.779	.804	.542	.513	.060	.710
	4	4	4	4	4	4	4	4	4	4	4
Available NH_4^+	-.507	-.559	-.820	-.820	1	-.131	.569	-.130	.888	-.702	.660
	.493	.441	.180	.180		.869	.431	.870	.112	.298	.340
	4	4	4	4	4	4	4	4	4	4	4
Available NO_3^-	.920	.762	.230	.221	-.131	1	.673	.895	.146	-.092	-.591
	.080	.238	.770	.779	.869		.327	.105	.854	.908	.409
	4	4	4	4	4	4	4	4	4	4	4
Available P	.370	.058	-.190	-.196	.569	.673	1	.741	.828	-.314	.172
	.630	.942	.810	.804	.431	.327		.259	.172	.686	.828
	4	4	4	4	4	4	4	4	4	4	4
Available S	.842	.488	.464	.458	-.130	.895	.741	1	.286	.233	-.291
	.158	.512	.536	.542	.870	.105	.259		.714	.767	.709
	4	4	4	4	4	4	4	4	4	4	4
Available K^+	-.212	-.483	-.486	-.487	.888	.146	.828	.286	1	-.414	.659
	.788	.517	.514	.513	.112	.854	.172	.714		.586	.341
	4	4	4	4	4	4	4	4	4	4	4
Available Ca^{2+}	.216	-.047	.937	.940	-.702	-.092	-.314	.233	-.414	1	.011
	.784	.953	.063	.060	.298	.908	.686	.767	.586		.989
	4	4	4	4	4	4	4	4	4	4	4
CEC	-.758	-.973(*)	-.295	-.290	.660	-.591	.172	-.291	.659	.011	1
	.242	.027	.705	.710	.340	.409	.828	.709	.341	.989	
	4	4	4	4	4	4	4	4	4	4	4

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)
No of samples = 4

Dhanmondi Lake was totally devoid of rooted attached hydrophytic species.

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