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PLANT COMMUNITY COMPOSITION IN RELATION TO SOIL PHYSICO-CHEMICAL PROPERTIES OF THE RATARGUL SWAMP FOREST, BANGLADESH

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Abstract

Vegetation composition in relation to soil physical and chemical properties of the Ratargul Swamp Forest was examined in the present study. Vegetation data were collected from 10 different sites by placing quadrats (10 m × 10 m) randomly at a distance of 500 m from each other in the forest area. Soil samples were collected from the centre of the quadrat. Plant species richness and the Shannon Diversity Index (*H'*) ranged from 3 to 7 and from 0.150 to 1.184 respectively, per quadrat. Among the tree species, *Pongamia pinnata* (L.) Merr. showed the highest important value index (IVI) value (15.62) indicating the dominance of the species in the forest. Among the shrubs, *Schumannianthus dichotomus* (Roxb.) Gagnep. showed the highest IVI value (36.25) and *Phyllanthus disticha* showed the lowest (2.2). Of the herbs, *Diplazium esculentum* (Retz.) Sw. showed the highest (92.44) and *Asparagus racemosus* L. showed the lowest (2.2) IVI values. Diameter at breast height (DBH) of *P. pinnata* (L.) Merr. varied largely from 29.26 to 169.77 cm indicating its growth variability from site to site in the forest. Soil pH, electric conductivity, organic carbon, total nitrogen and total phosphorus also showed a large range of variation in the study area. Redundancy Discriminant Analysis showed that soil moisture, conductivity, organic carbon and total nitrogen were significantly correlated with plant species data. *Crataeva nurvala* Buch.-Ham and *Mucuna zygantea* DC. correlated with soil organic carbon and moisture content. On the other hand, *S. dichotomus* (Roxb.) Gagnep. showed significant correlation with soil conductivity. Results, thus, indicate that vegetation composition is related with soil properties in the Ratargul Swamp Forest.

Introduction

Forest is one of the most diverse ecosystems with complex interactions among flora, fauna, microbiota and the structurally diverse habitats on earth(1). Swamp forests are more complex than the other forest types because of the nature of the aquatic vegetation with tolerance to periodic inundation and occurrence on the banks of rivers or lakes(2).

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It has characteristic hydromorphic soil that is saturated or inundated by the water table[3]. The fresh water swamps are associated with abundant and often unique plant growth dominated by trees and high shrubs in the tropics[4]. Although vegetation structure influences productivity and function of the forests[5] until recently relatively less attention has been paid on vegetation composition of swamp forest ecosystems due to their limited and sporadic distribution worldwide.

Ratargul Swamp Forest, situated in the north-western part of Sylhet, is the only fresh water forest in Bangladesh. This forest is a tropical wetland ecosystem having high potentials of biodiversity values and other intangibles[6]. Wetland forests play critical role in storing water and maintaining ground water level[7]. However, in spite of its socio-economic and ecological significance there has been limited information on the vegetation structure of the Ratargul forest. Nevertheless, such information is relevant for the management and conservation of this typical forest ecosystem. Therefore, the main objective of the present study was to study the phyto-sociological association in relation to the soil physico-chemical properties of the Ratargul Swamp Forest.

Materials and Methods

As shown in Fig. 1, Ratargul Swamp Forest is situated in the broad zone of Surma-Kushiyara flood plain in the southern side of the river Goyain under the district of Sylhet[6]. With an area of about 204.569 ha, it is the only swamp forest located in Bangladesh and one of the few freshwater swamp forests in the world. The forest is flooded with water coming from upper stream of the river Goyain during May to

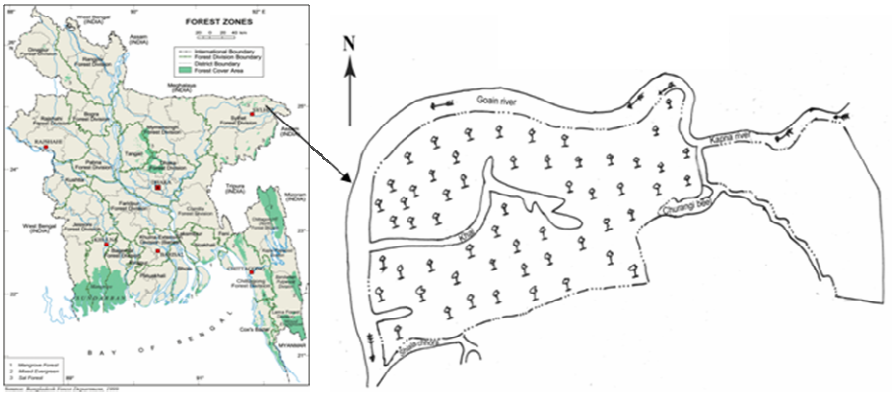

Fig. 1. Map of Ratargul Swamp Forest under the Sylhet Forest Division.

September and rest of the year water remains only in the narrow river basin and channels. The area has irregular relief with 3 - 6 m local difference in elevation[6]. There are three channels locally known as *Chengir Khal*, *Kaier Khal* and *Shiali Chhora* of the forest area.

Vegetation analysis and soil sampling were done in December, 2014. To collect vegetation data, 10 m × 10 m size quadrats were used. A total of 10 quadrats were applied randomly in the forest area at 500 m distance from each other. Then, number of plant species and number of individuals of the respective species were recorded in each quadrat. Diameter at breast height (DBH) of the tree species was recorded. Soil samples were collected at 0 - 10 cm depth from the centre of each of the quadrat. Collected soil samples were kept in plastic bags. Immediately after collection, soil samples were brought to the Ecology and Environment Laboratory, Department of Botany, University of Dhaka.

The collected soil was sieved through a 2-mm-mesh screen to remove plant roots, rocks, and macrofauna. After sieving, soil samples were analyzed for physico-chemical properties. Soil pH, conductivity and moisture content were determined in the laboratory within 24 hours after collection. Soil pH was recorded in suspension made with distilled water (2 : 1, v : w) using a pH meter (Hanna pH meter, pHeP). Soil conductivity was measured using a conductivity meter. Soil moisture content was determined using 10 g fresh soil at 80°C for 24 hours. Total nitrogen (N) was analyzed by Kjeldahl method following extraction from 2.0 g soil with conc. H_2SO_4[8]. For the determination of soil phosphorus (P), 5.0 g finely powdered soil was taken in a beaker and digested with concentrated nitric acid. Color development was done with ammonium molybdate reagent and absorption was measured using a spectrophotometer at the wavelength of 440 nm. Soil organic C was determined by Walkley and Black method using 1 g soil[8].

The relative value of density, frequency, dominance and Importance Value Index (IVI) for each species was calculated[9]. The Shannon Diversity Index (*H'*) was determined by following the method described elsewhere[10]. For the analyses of vegetation structure, ordination analysis was done using soil properties as environmental variables. Of the two main ordination techniques of Redundancy Discriminant Analysis (RDA) and Canonical Correspondence Analysis (CCA)[11], RDA explained more interspecific variation in soil properties data than the CCA in the present study. Therefore, RDA was used for ordination analysis using log-transformed abundance data of each species. The analyses were done using the software CANOCO ver. 4.5[12].

Results and Discussion

Physico-chemical properties of the soil of Ratargul Swamp Forest are shown in Table 1. Soil pH ranged from 4.6 to 5.5 indicating that the soil of the forest was acidic in nature. Values of soil conductivity ranged largely between the lowest of 23.8 and the highest of 71.8 μS/cm. A perennial anaerobic condition in the swamp may be responsible for low pH and electric conductivity[4]. Soil moisture content varied from 18.7 to 37.1% which might be related with the respective land-cover and elevation. Soil organic C (%) varied from 0.51 to 0.94% among the study sites. Range of total N and total P were 0.11 - 0.31%

and 0.064 - 0.091%, respectively. Waterlogging condition in swamp results in high leaching losses of nitrogen[4]. It was also reported that N and P contents of the swamp soils were lower than other forest ecosystem[13].

Table 1. Physico-chemical properties of the soil of Ratargul Swamp Forest, Bangladesh.

Quadrat	pH	Moisture (%)	Conductivity (μS/cm)	Organic carbon (%)	Total nitrogen (%)	Total phosphorus (%)
1	4.9	18.7	34.5	0.59	0.13	0.091
2	5.0	27.2	36.0	0.81	0.16	0.091
3	4.6	32.9	52.3	0.94	0.23	0.083
4	5.5	37.1	26.9	0.70	0.11	0.091
5	4.7	22.8	71.8	0.73	0.27	0.064
6	5.3	24.6	32.0	0.51	0.31	0.075
7	5.2	25.3	27.1	0.69	0.16	0.083
8	4.8	24.5	23.8	0.75	0.17	0.091
9	5.0	28.6	56.2	0.76	0.26	0.088
10	5.0	27.7	34.3	0.70	0.20	0.095

Phyto-sociological association among the plant species is shown in Table 2. A total of 16 plant species were recorded in the study area. All 16 plant species were under 16 families indicating a high biological diversity at family level taxa. Among the species observed, 7 were trees, 4 were shrubs and the rest were of herbs in habit. Among the tree species *P. pinnata* (L.) Merr. showed the highest IVI value (15.62) followed by *Crataeva nurvala* Buch.-Ham. (8.6), *Barringtonia acutangula* (L.) Gaertn. (6.71), *Sygygium fruticosum* (Roxb.) DC. (6.11), *Lagerstroemia speciosa* L. (4.53), *Trewia polycarpa* Benth. (4.53) and *Streblus asper* Lour. (4.15). These data indicated that *P. pinnata* (L.) Merr. was the dominating tree species over the other in the forest. Among the shrubs, *Schumannianthus dichotomus* (Roxb.) Gagnep. showed the highest IVI value (36.25) followed by *Calamus viminalis* Willd. (26.25%), *Pothos scandens* L. (5.29) and *Phyllanthus disticha* (2.2). Among the herb species, *Diplazium esculentum* (Retz.) Sw. showed the highest IVI value (92.44) followed by *Mikania cordata* (Burm. f.) Rob. (51.32), *Dopartium junceum* Ham. (28.5), *Mucuna zygantea* DC. (4.99) and *Asparagus racemosus* L. (2.2) indicating that *D. esculentum* (Retz.) Sw. was the common and *A. racemosus* L. was the rare species in the Ratarugul Swamp Forest. Although IVI value was high for *D. junceum* Ham., relative frequency was high for *C. viminalis* Willd. (16.98%) indicating the frequent occurrence of the later one.

Table 2. Phyto-sociological association among the plant species found in the Ratargul Swamp Forest, Bangladesh.

Sl.	Scientific name	Local name	Family	RD	RF	RA	IVI
	Tree						
1	*Pongamia pinnata* (L.) Merr.	Koroch	Apocynaceae	1.63	13.21	0.78	15.62
2	*Crataeva nurvala* Buch.-Ham.	Borun	Capparaceae	0.57	7.55	0.48	8.60
3	*Barringtonia acutangula* (L.) Gaertn.	Hijol	Lecythidaceae	0.49	5.66	0.56	6.71
4	*Syzygium fruticosum* (Roxb.) DC.	Tit jam	Myrtaceae	0.21	5.66	0.24	6.11
5	*Lagerstroemia speciosa* L.	Jarul	Lythraceae	0.28	3.77	0.48	4.53
6	*Trewia polycarpa* Benth.	Pitali	Euphorbiaceae	0.28	3.77	0.48	4.53
7	*Streblus asper* Lour.	Shaorah	Moraceae	0.14	3.77	0.24	4.15
	Shrub						
8	*Schumannianthus dichotomus* (Roxb.) Gagnep.	Sitalpati	Marantaceae	14.9	15.09	6.26	36.25
9	*Calamus viminalis* Willd.	Bet	Arecaceae	6.96	16.98	2.59	26.25
10	*Pothos scandens* L.	Hatilata	Araceae	0.57	3.77	0.95	5.29
11	*Phyllanthus disticha*	Chitki	Phyllanthaceae	0.07	1.89	0.24	2.20
	Herb						
12	*Diplazium esculentum* (Retz.) Sw.	Dheki shak	Athyriaceae	46.13	7.55	38.76	92.44
13	*Mikania cordata* (Burm. f.) Rob.	Assamlata	Asteraceae	17.74	3.77	29.81	51.32
14	*Dopatrium junceum* Ham.	Binsowan	Scrophulariaceae	9.23	3.77	15.50	28.50
15	*Mucuna zygantea* DC.	Alkushi	Fabaceae	0.71	1.89	2.39	4.99
16	*Asparagus racemosus* L.	Satamuli	Liliaceae	0.07	1.89	0.24	2.20

RD = Relative density, RF = Relative frequency, RA = Relative abundance and IVI = Importance value index.

Number of plant species per quadrat ranged from 3 to 7 as shown in Table 3. Shannon Diversity Index (*H'*) varied about eight times between the lowest (0.150) and the highest (1.184) values indicating large variability in plant diversity among sampling sites. Diameter at breast height (DBH) of the commonly found tree species *P. pinnata* (L.) Merr. was found to vary from 29.26 to 169.77 cm indicating a large range of variation in the growth of this species in the forest.

Table 3. Plant species richness, Shannon Diversity Index (*H'*) and diameter at breast height (DBH) of *Pongamia pinnata* (L.) Merr. in Ratargul Swamp Forest.

Quadrat	Species richness	*H'*	DBH of *P. pinnata*
1	4	0.742	1.73
2	3	0.150	5.57
3	6	0.997	1.90
4	7	1.184	-
5	9	1.063	1.00
6	7	1.013	-
7	5	0.668	0.96
8	5	0.806	-
9	3	0.699	2.22
10	4	0.560	1.19

- = Indicates not observed.

Biplot scores of the plant species derived from RDA analysis where soil properties were used as environmental variables are shown in Fig. 2. The first and the second axes explained 59.8 and 80.6%, respectively of the cumulative variation on the correlations between species and environmental data. Total canonical Eigen value was 0.807 and the corresponding axes were constrained by the environmental variables. RDA analysis showed that soil moisture, conductivity and organic C were significantly correlated with species data. *C. nurvala* Buch.-Ham. and *M. zygantea* DC. correlated with soil organic C and moisture content. *S. dichotomus* showed significant correlation with soil electric conductivity. Results thus indicated that vegetation composition is related with soil properties in the Ratargul Swamp Forest. The variability in soil physical and chemical properties from site to site indicates the habitat heterogeneity in the Ratargul Swamp Forest. Therefore, distribution of *C. nurvala* Buch.-Ham., *M. zygantea* DC. and *S. dichotomus* (Roxb.) Gagnep. was found to vary with soil organic carbon, moisture and conductivity. Data obtained, thus, suggest that soil is the important factor in determining the species pattern and distribution in the forest.

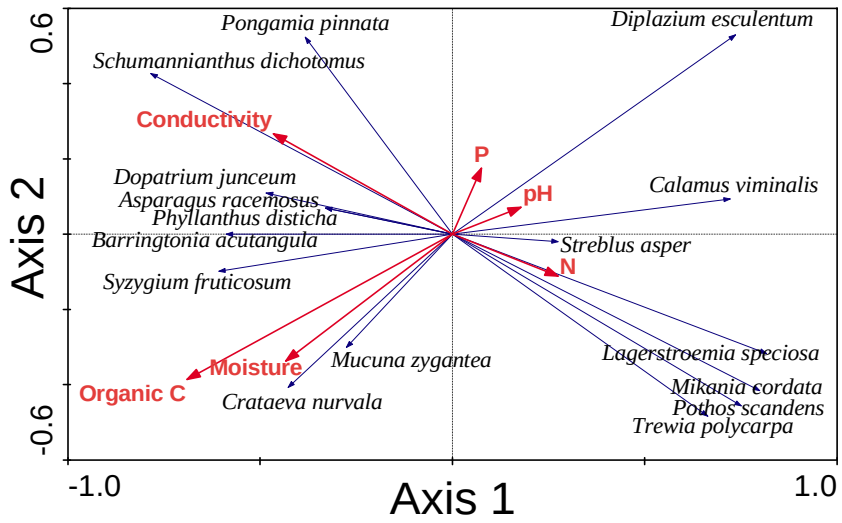

Fig. 2. Biplot scores of the plant species derived from the RDA using species abundance data and soil properties of the Ratargul Swamp Forest.

Range of variation in soil physico-chemical properties as well as plant community composition from site to site of the forest indicates the diversity potentials of the forest for micro and macro fauna including wildlife. The diversity in plant species and habitats are vital for regulating the complex functional dynamics of the forest that occur among producer, consumer and decomposer communities[14]. Freshwater wetland forests are classic and globally rare. Therefore, appropriate measures should be taken for the conservation of the Ratargul Swamp Forest.

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