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Study Of Soil And Vegetation Characteristics In The Lower Gangetic Plains Of West Bengal

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ABSTRACT

The Lower Gangetic Plains particularly from Dakhineshwar to Uluberia, West Bengal was investigated for the taxonomic and ecological analyses of its naturalized vegetation. The physicochemical studies of soil were also performed from this site. It was observed mangrove plants prevailed at zones where higher percentage of silt was present, while inland plants were grown where percentage of sand and clay were higher. A total of 95 plant species were recorded and their phytoclimatic study was done and the result revealed that percentage of phanerophytes was maximum among others. From phytosociological study it was observed that mangrove associates such as *Cryptocoryne ciliata* and *Oryza coarctata* showed highest IVI values, on the other hand *Cynodon dactylon* was dominated at non-mangrove site. The present analyses indicated existence of two distinct plant communities in the site with more or less stable vegetation pattern.

Keywords: Lower Gangetic Plain, vegetation, diversity, community

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INTRODUCTION

Though India has a wide range of vegetation comprising of tropical rain forest, tropical deciduous forest, thorny forest, montane vegetation and mangrove forest, the Gangetic Plains in India form an important biogeographic zone in terms of vegetation characterized by fine alluvium and clay rich swamps, fertile soil and high water retention capacity. Around 400 species of angiosperms and 90-120 species of aquatic plants have been recorded from this biogeographic zone [1].

The Indo-Gangetic Plain is a 255 million hectare (630 million acre) fertile plain encompassing most of northern and eastern India, the eastern parts of Pakistan, and virtually all of Bangladesh. It is further classified into three parts: Upper, Middle and Lower Gangetic Plains. The Lower Gangetic Plains situated to the southeast of the Middle Gangetic Plains, is the delta region resulting from the confluence of the rivers Ganga and Brahmaputra, before they meet the Bay of Bengal. This region is rich in biodiversity particularly in the aquatic biodiversity and mangroves found in the swampy forests of the Sundarbans, and is declared a World Heritage Site by UNESCO. The Lower Gangetic Plain is one of the most important agricultural ecoregions in the world [2]. Despite its ecological importance, limited taxonomic and ecological studies [3; 4; 5; 6] have been undertaken in this area.

Considering the critical functions of vegetation it is highly important to gather a better understanding about its various characteristics and patterns that is crucial for biodiversity and conservation management by providing habitats for wildlife and contributing to the ecologically sustainable management of natural resources. In view of this, the present study focused on the assessment of soil and vegetation characteristics of the lower Gangetic Plains of West Bengal.

MATERIALS AND METHODS

Study site

For the present study, we selected the Lower Gangetic region covering the areas between Dakhineswar and Uluberia in Kolkata and Howrah districts respectively of West Bengal, India (N22˚39′20.48″, E 088˚20′59.48″ to N22˚33′59.9″, E 088˚14′51.5″). The study site is 3 m above the sea level, the topography of which is alluvial and varies from sand in the river beds to sticky clay in the interior along the silted up streams and mud in the swamps. Clay and deep loamy soil prevail in the north and lighter loams in the south, where the deposits are more recent. Tidal bore consists of the head-wave of the advancing tide, hemmed in where the estuary narrows suddenly into the river, and often exceeds 7 feet (2.1 m) in height. The difference from the lowest point of low-water in the dry season to the highest point of high-water in the rains is reported to be 20 feet 10 inches (6.35 m). The greatest mean rise of tide, about 16 feet (4.9 m), takes place in March, April or May - with a declining range during the rainy season to a mean of 10 feet (3.0 m), and a minimum during freshets of 3 feet 6 inches (1.07 mm). The climate is tropical monsoonal with very high summer having an average temperature of 35°C and a cold winter often experiencing temperature as low as 16°C. The average rainfall amounts to 325.4 mm/year.

We visited the site between the months of February and March which showed transition between winter and summer seasons. The inland plants were recorded from both banks of the river Ganges and qualitative vegetation analyses were performed in order to understand the present status of vegetation of the study site. The study site was further divided into four different sub-zones for soil and quantitative vegetation analyses as follows:

Sub-zone I: Podra ghat (N22°33′40.5″, E 088°16′01.1″, elevation-3 m)
Sub-zone II: Water tank More (N22°34′00.1″, E088°14′51.4″, elevation-3 m)
Sub-zone III: Badamtala-Chunapatti (N22°33′46.8″, E088°15′40.9″ to N22°33′44.1″, E088°15′43.4″, elevation-3 m)
Sub-zone IV: Near Shibpur burning ghat (N22°33′39.7″, E088°19′35.1″ to N22°33′41.2″, E088°19′35.5″, elevation-3 m)

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Sampling

Field work was performed during February-March of 2016 in the study site. For soil analyses, 30g of soil samples were collected in tarson capped containers. From sub-zones I and II, soil samples were taken 8 times randomly from different parts and analysed, and final average data of all the 8 samples were estimated. From sub-zones III and IV, similar soil analyses were executed but soil samples were collected specifically from the area where the mangrove plant *Sonneratia caseolaris* was present. In case of vegetation analyses, plant species were recorded from both the sides of river Ganges for phytoclimate study. However, 8 quadrats of 5x5 square feet were laid randomly in each of the four sub-zones (I-IV) for determining IVI and other ecological indices.

Data analyses

Soil parameters such as sand, silt and clay percentage [7], soil pH [8] and salinity (by refractometer following standard protocols) were determined. For vegetation analyses, phytoclimate study was carried out [9] and biological spectrum was determined [10]. IVI and ecological indices such as Shannon-Weiner index and Sorensen index [11] were also obtained.

RESULTS

Physico-chemical properties of soil

The physical and chemical properties of soil were determined in the selected four sub-zones of the study site (Table 1) of which sub-zones I and II comprised of mangrove associates and sub-zones III and IV had inland riverine vegetation. The textural analysis showed that percentage of silt was highest in sub-zones I and II (83.1-84.33%) and lowest (69.6-78.93%) in sub-zones III and IV. The percentage of clay was more or less similar (10.2-12.8%) in all zones. Consequently, the percentage of sand was highest in sub-zones III and IV (8.74-20.2) and lowest in sub-zones I and II (4.07-4.1). The soil ph and water salinity were found to be in the range of 7.6-8.01 and 1.06-1.5 respectively and were more or less similar in all cases.

Table 1: Properties of the soil samples in the sub-zones of the study site

STUDY SITE	% OF SILT	% OF CLAY	% OF SAND	SOIL Ph	WATER SALINITY	SOIL SALINITY
Sub-zone I	83.1	12.8	4.1	7.9	1.5	0.36
Sub-zone II	84.33	11.6	4.07	8.01	1.06	0.8
Sub-zone III	78.93	12.33	8.74	7.6	1.5	1.36
Sub-zone IV	69.6	10.2	20.2	7.9	1.1	0.75
Sub-zone I: Podra ghat; Sub-zone II: Water tank More; Sub-zone III: Badamtala-Chunapatti; Sub-zone IV: Near Shibpur Burning Ghat						

Phytoclimate Study

In this study, the life-forms of 95 species were determined according to Raunkiaer (1934), to obtain the Biological Spectrum (Table 2). The biological spectrum data on comparison with the normal spectrum as given by Raunkiaer (Table 3) revealed greater abundance of phanerophyte over chaemaephyte and cryptophyte, hemicryptophyte and therophyte are present in general, thus, indicating more or less stable vegetative condition.

Table 2: List of plants recorded from both sides of river Ganga especially from Dakhineshwar to Uluberia and their respective lifeforms

NAME OF THE PLANT	COMMON NAME	ORDER	FAMILY	TYPE	LIFE FORM
Acalypha indica L.	Muktajhuri	Malphigiales	Euphorbiaceae	Undershru	Therophyte

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				b	
Acanthus ilicifolius L.	Harkochkanta	Scrophulariales	Acanthaceae	Shrub	Chamaephyte
Acorus calamus L.	Sweet sedge	Arocales	Acoraceae	Herb	Therophyte
Ageratum conyzoides L.	Oochunti	Asterales	Asteraceae	Shrub	Therophyte
Albizia lebbeck (L.)Benth.	Siris	Fabales	Fabaceae	Tree	Phanerophyte
Alstonia scholaris L.R.Br	Chhayim	Gentianales	Apocynaceae	Tree	Phanerophyte
Alternanthera nodiflora R Br	Joyweeds	Caryophyllales	Amaranthaceae	Shrub	Therophyte
Amaranthus viridis L.	Chaulai	Caryophyllales	Amaranthaceae	Tree	Phanerophyte
Anthocephalus cadamba (Roxb.)Miq.	Kadam	Rubiales	Rubiaceae	Tree	Phanerophyte
Antigonon lectopus Hook & Arn	Mexican creeper	Polygonales	Polygonaceae	Climber	Phanerophyte
Argyreia nervosa (Burm.f)Bojer	Guguli	Convolvulales	Convolvulaceae	Climber	Phanerophyte
Arundo donax L.	Gaba Nal	Cyperales	Poaceae	Herb	Chamaephyte
Barringtonia acutangula (L.) Gaertn	Hijal	Ericales	Lecythidaceae	Tree	Phanerophyte
Brachiaria mutica (Forssk) Stapf	Nardul	Poales	Poaceae	Herb	Chamaephyte
Brassica nigra L.	Sarisha	Capparales	Brassicaceae	Shrub	Therophyte
Caesalpinia bonducella (L.) Fleming	Nata karanja	Caesalpiniales	Caesalpiniaceae	Tree	Phanerophyte
Calotropis gigantea (L.) Draynd	Akanda	Gentianales	Asclepiadaceae	Tree	Phanerophyte
Calotropis procera (Aiton) Draynd	Akanda	Gentianales	Asclepiadaceae	Shrub	Therophyte
Canna indica L.	Sarbajaya	Cannales	Cannaceae	Herb	Therophyte
Cardiospermum helicacabum L.	Balloon plant	Sapindales	Sapindaceae	Climber	Phanerophyte
Chenopodium album L.	Bethura sak	Caryophyllales	Amaranthaceae	Herb	Therophyte
Chrozophora rottleri (Geis)Klotzsch ex Juss	Khudiokra	Malphigiales	Euphorbiaceae	Undershrub	Therophyte
Clerodendrum infortunatum L.	Ghetu	Lamiales	Lamiaceae	Shrub or small tree	Therophyte
Coccinia grandis (L.)Voigt	Kunduru	Cucurbitales	Cucurbitaceae	Shrub	Phanerophyte
Cocos nucifera L.	Narikel	Arecales	Arecaceae	Tree	Phanerophyte
Colocasia esculenta (L.)Schott	Kochu	Arecales	Araceae	Herb	Hemicryptophyte
Commelina benghalensis L.	Kanchira	Commelinales	Commelinaceae	Herb	Hemicryptophyte
Commelina diffusa Burm.f	Climbing day flower	Commelinales	Commelinaceae	Herb	Hemicryptophyte
Crinum viviparum L.	River crinum lily	Asparagales	Amaryllidaceae	Herb	Therophyte
Croton bonplandianum Baill.	-	Euphorbiales	Euphorbiaceae	Tree	Therophyte
Cryptocoryne ciliata (Roxb.)Fisch. Ex Wydler	Kerali	Arecales	Araceae	Herb	Therophyte
Cyperus rotundus L.	Nutgrass	Cyperales	Cyperaceae	Climber	Cryptophyte
Datura fastuosa L.	Dhutura	Solanales	Solanaceae	Shrub	Therophyte

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Derris scandens (Aubl.)Pittier	Noalata	Fabales	Fabaceae	Shrub	Phanerophyte
Eclipta alba L.	Kesut	Asterales	Asteraceae	Shrub	Therophyte
Eichornia crassipes Solms	Kachuripana	Commelinales	Pontederiaceae	herb	Hemicryptophyte
Eupatorium odoratum L.	Snakeroot	Asterales	Asteraceae	Shrub	Chamaephyte
Ficus benghalensis L.	Bat	Urticales	Moraceae	Tree	Phanerophyte
*Ficus cunia buch.*Ham. Ex Roxb.	-	Rosales	Moraceae	Tree	Phanerophyte
Ficus hispida L.f.	Dumur	Rosales	Moraceae	Tree	Phanerophyte
Ficus religiosa L.	Aswatha	Rosales	Moraceae	Tree	Phanerophyte
Heliotropium indicum L.	Hatisura	Lamiales	Boraginaceae	Herb	Therophyte
Imperata cylindrica (L.) Beauv	Ulu	Cyperales	Poaceae	Herb	Cryptophyte
Ipomoea fistulosa Mart. Ex Choisy	Bush morning glory	Convolvulales	Convolvulaceae	Herb	Chamaephyte
Justicia adhatoda L.	Vashak	Scrophulariales	Acanthaceae	Shrub	Chamaephyte
Justicia simplex D. Don		Scrophulariales	Acanthaceae	Shrub	Chamaephyte
Lantana camara L.	Manindrakanta	Lamiales	Verbenaceae	Shrub	Chamaephyte
Lannea coromandelica Roxb.	Jiyal	Anacardiales	Anacardiaceae	Tree	Phanerophyte
Leonurus sibiricus L.	Rakhtadrone	Lamiales	Lamiaceae	Shrub	Chaemaephyte
Lippia geminata Kunth	Vutvairab	Lamiales	Verbenaceae	Shrub	Phanerophyte
Malachra capitata (L.) L	Ban bhindi	Malvales	Malvaceae	Shrub	Chamaephyte
Mallotus philippensis (Lam.)Mull.Arg.	Tunj	Malpighiales	Euphorbiaceae	Tree	Phanerophyte
Merremia tuberosa (L.)Rendle	-	Convolvulales	Convolvulaceae	Herb	Therophyte
Mikania scandens (L.)Willd.	Latapata	Asterales	Asteraceae	Climber	Phanerophyte
Mimosa pudica L.	Lajjaboti	Fabales	Fabaceae	Tree	Phanerophyte
Mimosa rubicaulis Lam	Shaih kanta	Fabales	Fabaceae	Tree	Phanerophyte
Mucuna pruriens (L.) DC	Valvet bean	Fabales	Fabaceae	Climbing shrub	Chamaephyte
Nicotiana plumbaginifolia Willd	Tex mex tobacco	Solanales	Solanaceae	Undershrub	Phanerophyte
Oryza coarctata Roxb.	Wild rice	Poales	Poaceae	Herb	Therophyte
Pandanus foetidus Roxb.	Keya	Pandanales	Pandanaceae	Tree	Phanerophyte
Parthenium hysterophorus L.	-	Solanales	Solanaceae	Undershrub	Chamaephyte
Passiflora suberosa L.	Jhumkolata	Violales	Pasifloraceae	Herb	Phanerophytes
Physalis minima L.	Pygmy ground cherry	Solanales	Solanaceae	Shrub	Chamaephyte
Phyla nodiflora Cham	Bhui okra	Lamiales	Verbenaceae	Herb	Therophyte
Polygonum hydropiper L.	Pakurmul	Polygonales	Polygonaceae	Herb	Therophyte

Polygonum plebeium R. Brown	Chekuni sak	Polygonales	Polygonaceae	Herb	Therophyte
Pongamia pinnata (L.)Merr.	Karanja	Fabales	Fabaceae	Tree	Phanerophyte
Psidium guajava L.	Piyara	Myrtales	Myrtaceae	Tree	Phanerophyte
Pterospermum acerifolium (L.) Willd.	Muskunda	Malvales	Malvaceae	Tree	Phanerophyte
Quisqualis indica L.	Rangoonkebel	Myrtales	Combretaceae	Climber	Phanerophyte
Ricinus communis L.	Rerri	Malpighiales	Euphorbiaceae	Tree	Phanerophyte
Rumex maritimus L.	Ban palang	Polygonales	Polygonaceae	Herb	Therophytes
Saccharum spontaneum L.	Kans grass	Poales	Poaceae	Herb	Chamaephyte
Sagittaria montevidensis Cham. & Schltdl	-	Alismatales	Alismataceae	Herb	Hemicryptophyte
Sida alba L.	-	Malvales	Malvaceae	Herb	Chaemaephyte
Solanum melongena L.	Bon begun	Solanales	Solanaceae	Undershrub	Chamaephyte
Solanum nigrum L.	Gurki begun	Solanales	Solanaceae	Shrub	Therophyte
Solanum sisymbrifolium Lam.	Sticky night shade	Solanales	Solanaceae	Undershrub	Chamaephyte
Solanum xanthocarpum Schrard & Wendle	Kantakari	Solanales	Solanaceae	Shrub	Chamaephyte
Sonneratia caseolaris (L)Engl.	Chak-keora	Myrtales	Lythraceae	Tree	Phanerophyte
Spilanthes indica L.	Murmuria	Asterales	Asteraceae	Herb	Therophyte
Stephania hernandifolia Lour	Nimukha	Ranunculales	Menispermaceae	Climber	Phanerophyte
Sterculia foetida L.	Baxo badam	Malvales	Malvaceae	Tree	Phanerophyte
Streblus asper Lour	Sheora	Urticales	Moraceae	Tree	Phanerophyte
Syzygium jambolanum (Lam)DC	Jam	Myrtales	Myrtaceae	Tree	Phanerophyte
Terminalia alata B.Heyne ex Roth	Asan	Myrtales	Combretaceae	Tree	Phanerophyte
Terminalia catappa L.	Katbadam	Myrtales	Combretaceae	Tree	Phanerophyte
Thevetia peruviana (Pers)Schum	kolke	Gentianales	Apocynaceae	Tree	Phanerophyte
Tiliacora acuminata Miers	Bhaga lata	Ranunculales	Menispermaceae	Climbing shrub	Phanerophyte
Trema orientalis L	-	Urticales	Moraceae	Tree	Phanerophyte
Tridax procumbens L.	-	Asterales	Asteraceae	Herb	Therophyte
Turia acutangula (L.)M.Roem.	Bathsponge	Cucurbitales	Cucurbitaceae	Herb	Therophyte
Vernonia cinerea Less.	Kuksim	Asterales	Asteraceae	Shrub	Therophyte
Vitis trifolia L.	-	Vitales	Vitaceae	Shrub	Phanerophyte
Ziziphus jujuba Mill.	Kul	Rosales	Rhamnaceae	Tree	Phanerophyte

Table 3: Comparison of the Biological spectrum of the study site with Raunkiaer spectrum

Lifeform	No. of representative species	Raunkiaer spectrum (%)	Obtained biological spectrum (%)
P	44	46	45.36
Ch	18	9	18.5

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H	5	26	5.1
Cr	2	6	2.0
T	26	13	27.36

Phytosociological study

Four sub-zones (I–IV) were selected for the above study. Sub-zones I and II mainly comprised of the regions where plants were found to grow along with the mangrove *Sonneratia caseolaris* thereby, termed as mangrove associates while, sub-zones III and IV lacked any mangrove and comprised of only inland plants. At sub-zone I, *Cryptocoryne ciliata* showed highest IVI (31.27) and *Sagittaria montavidensis* showed lowest IVI value (4.25) (Table 4). At sub-zone II, *Oryza coractata* showed highest IVI (564.57) and *Acanthus ilicifolius* showed lowest IVI (3.08) (Table 5). At sub-zone III, the IVI was highest for *Cynodon dactylon* (45.45) and lowest in case of *Amaranthus viridis, Parthenium hysterophorus, Solanum melongena, Lantana camara* (1.75) (Table 6). At sub-zone IV, *Cynodon dactylon* again showed highest IVI (63.93) and *Vernonia cinerea, Sida alba* showed lowest IVI (2.59) respectively (Table 7).

Table 4: The Importance Value Index (IVI) of sub-zone I (Podra Ghat)

Plant Name	SU1	SU2	SU3	SU4	SU5	SU6	SU7	SU8	D	F	RD	RF	IVI
Crinum viviparum	37	0	0	0	0	0	0	0	0.18	12.5	9.73	2.94	12.67
Derris scandens	1	13	2	12	0	1	0	9	0.19	75	10	17.64	27.64
Polygonum glabrum	23	31	0	9	2	0	18	21	0.52	75	27.36	17.64	45
Acanthus ilicifolius	1	5	2	12	3	0	0	0	0.11	62.5	6.05	14.7	20.75
Cyperus rotundus	19	0	0	0	0	0	0	1	0.1	25	5.26	5.88	11.14
Oryza coarctata	0	37	32	2	0	0	0	0	0.35	37.5	18.68	8.82	12.77
Cryptocoryne ciliata	0	0	0	11	9	25	4	14	0.31	62.5	16.57	14.7	31.27
Mikania scandens	0	0	0	0	1	3	0	11	0.07	37.5	3.95	8.82	12.77
Caesalpinia bonducella	0	0	0	0	0	1	3	0	0.02	25	1.05	5.88	6.93
Sagittaria montevidensis	0	0	0	0	0	0	5	0	0.03	12.5	1.31	2.94	4.25
SU= Study Unit; D=Density; F=Frequency; RD=Relative Density; RF=Relative Frequency; IVI=Importance Value Index													

Table 5: The Importance Value Index (IVI) of sub-zone II (Water tank more)

Plant Name	SU1	SU2	SU3	SU4	SU5	SU6	SU7	SU8	D	F	RD	RF	IVI
Oryza coarctata	3	2	45	15	0	31	4	58	79	87.5	545.67	18.9	564.57
Sagittaria montevidensis	5	4	0	0	1	5	0	0	7.5	50	2.91	10.81	13.72
Colocasia esculenta	0	2	0	0	4	0	0	0	3	25	1.16	5.4	6.56
Derris scandens	1	0	3	1	0	0	5	2	4.5	62.5	1.74	13.51	15.25
Mikania scandens	0	0	0	0	4	0	3	1	4	37.5	1.55	8.1	9.65

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Polygonum glabrum	28	62	70	40	15	7	0	17	119.5	87.5	46.4	18.9	65.3
Cryptocoryne ciliata	1	7	5	0	10	22	14	0	29.5	745	11.45	16.21	27.66
Eichornia crassipes	0	0	0	8	11	0	0	0	9.5	25	3.68	5.4	9.08
Acanthus ilicifolius	0	0	0	0	0	0	2	0	1	12.5	6.38	2.7	3.08
SU= Study Unit; D=Density; F=Frequency; RD=Relative Density; RF=Relative Frequency; IVI=Importance Value Index													

Table 6: The Importance Value Index (IVI) of sub-zone III (Badamtala-Chunapatti)

Plant Name	SU1	SU2	SU3	SU4	SU5	SU6	su7	su8	D	F	RD	RF	IVI
Colacasia esculenta	2	21	4	0	0	0	0	0	0.135	37.5	2.62	5	7.62
Stephania hernandifolia	5	0	1	0	0	0	0	0	0.03	25	0.58	3.33	3.91
Ricinus communis	3	2	0	0	0	0	0	0	0.025	25	0.48	3.33	3.81
Rumex maritimus	2	0	0	0	0	0	0	0	0.01	12.5	0.19	1.66	1.85
Amaranthus viridis	1	0	0	0	0	0	0	0	0.005	12.5	0.09	1.66	1.75
Mikania scandens	6	2	3	0	0	0	0	0	0.055	37.5	1.07	5	7.07
Cynodon dactylon	72	0	0	75	0	74	82	79	1.91	62.5	37.15	8.3	45.45
Parthenium hysterophorus	1	0	0	0	0	0	0	0	0.005	12.5	0.09	1.66	1.75
Cyperus rotundus	6	0	0	0	0	0	0	0	0.03	12.5	0.58	1.66	1.75
Clerodendrum infortunatum	11	0	0	0	0	0	0	0	0.055	12.5	1.07	1.66	2.24
Phyla nodiflora	3	0	0	15	22	10	56	60	0.83	62.5	16.14	8.3	24.44
Commelina benghalensis	7	14	0	0	0	0	0	0	0.105	25	2.04	3.33	5.37
Nicotiana plumbaginifolia	1	0	0	28	30	16	14	0	0.445	62.5	8.65	8.3	16.95
Cardiospermum helicacabum	0	1	2	0	0	0	0	0	0.015	25	0.29	3.33	6.62
Solanum melongena	0	1	0	0	0	0	0	0	0.005	12.5	0.09	1.66	1.75
Chrozophora rottleri	0	0	4	0	0	0	0	0	0.02	12.5	0.38	1.66	2.04
Acalyphya indica	0	0	9	0	0	0	0	0	0.045	12.5	0.87	1.66	2.53
Lantana camara	0	0	1	0	0	0	0	0	0.05	12.5	0.09	1.66	1.75

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Coccinia grandis	0	0	2	0	0	0	0	0	0.01	12.5	0.19	1.66	1.85
Alternanthera sessiles	0	0	1	13	18	0	6	1	0.195	62.5	3.7	8.3	12
Croton bonplandianum	0	0	2	0	0	0	0	0	0.01	12.5	0.19	1.66	1.85
Trema orientalis	0	0	9	0	0	0	0	0	0.045	12.5	0.87	1.66	2.53
Solanum nigrum	0	0	1	0	0	0	0	0	0.005	12.5	0.09	1.66	1.76
Polygonum plebeium	0	0	0	8	5	14	30	0	0.285	50	5.54	6.66	12.2
Sphaeranthus indicus	0	0	0	40	44	22	40	45	0.775	62.5	15.07	8.3	23.37
Chenopodium album	0	0	0	3	2	0	3	0	0.04	37.5	0.77	5	3.77
Physalis minima	0	0	0	0	0	0	9	0	0.045	12.5	0.87	1.66	2.46
SU= Study Unit; D=Density; F=Frequency; RD=Relative Density; RF=Relative Frequency; IVI=Importance Value Index													

Table 7: The Importance Value Index (IVI) of sub-zone IV (Shivpur burning ghat)

Plant Name	SU1	SU2	SU3	SU4	SU5	SU6	SU7	SU8	D	F	RD	RF	IVI
Solanum nigrum	4	0	0	0	0	0	0	0	2	12.5	0.66	2.43	3.09
Phyla nodiflora	31	6	9	3	0	0	0	0	2.45	50	8.08	9.75	17.89
Heliotropium indicum	4	0	0	20	8	0	0	4	18	50	5.94	9.75	15.69
Polygonum glabrum	24	0	0	0	0	0	15	0	19.5	25	6.43	4.87	11.3
Eclipta alba	4	0	0	0	0	0	0	0	2	12.5	0.66	2.43	3.09
Cynodon dactylon	36	30	58	0	47	59	33	21	142	87.5	46.88	17.07	63.93
Sida alba	1	0	0	0	0	0	0	0	0.5	12.5	0.16	2.43	2.59
Polygonum plebeium	2	0	0	0	0	0	0	0	1	12.5	0.33	2.43	2.76
Sphaeranthus indicus	0	28	12	5	0	0	0	10	27.5	50	9.07	9.75	18.82
Rumex maritimus	0	11	6	12	1	0	0	1	15.5	62.5	5.11	12.19	17.3
Commelina diffusa	0	0	3	0	0	0	0	0	1.5	12.5	0.49	2.43	2.92
Vernonia cinerea	0	0	0	1	0	0	0	0	0.5	12.5	0.16	2.43	2.59
Alternanthera sessilis	0	0	0	0	12	6	0	1	9.5	37.5	3.13	7.31	10.44
Parthenium hysterophorus	0	0	0	0	20	38	15	0	36.5	37.5	12.04	7.31	19.35
Commelina benghalensis	0	0	0	0	0	1	2	0	1.5	25	0.49	4.87	5.36
Lippia	0	0	0	0	0	0	0	2	1	12.5	0.33	2.43	2.76

geminata													
SU= Study Unit; D=Density; F=Frequency; RD=Relative Density; RF=Relative Frequency; IVI=Importance Value Index													

Ecological studies

Alpha diversity (Table 8) by Shannon–Wiener index was estimated and it was observed that among mangrove associates, it was higher at sub-zone I (0.818) than II (0.571). On the other hand among inland plant associates, sub-zone IV (0.787) showed higher diversity than III (0.718). Out of the four sub-zones, sub-zone I comprised of maximum diversity as it was mainly covered by dense vegetation.

Table 8: Determination of Shannon–Wiener index at four sub-zones

Sub-zones of study site	Alpha diversity (H')
Sub-zone I	0.818
Sub-zone 2	0.571
Sub-zone 3	0.718
Sub-zone 4	0.787

Table 9: Comparison between mangrove and non-mangrove inland plant associates by Sorensen Index

Sub-zones	β-Diversity Index
I-II	0.736
III-IV	0.428
I-III	0.11
I-IV	0.07
II-III	0.11
II-IV	0.08
Sub-zone I: Podra ghat; Sub-zone II: Watertank More; Sub-zone III: Badamtala-Chunapatti; Sub-zone IV: Near Shibpur Burning Ghat	

Beta diversity analysis was also performed (Table 9) and it was observed that among mangrove associates the beta diversity was highest (0.736) and between non-mangrove inland plant associates the beta diversity was intermediate (0.428). Between mangrove and non-mangrove inland plant associates, the beta diversity is lowest (0.07- 0.11). This analysis between the different sub-zones revealed existence of two distinct plant communities.

DISCUSSION

This study highlights the vegetation composition and diversity in the Lower Gangetic Plains (LGP) of West Bengal. The LGP used to have dense forests which have largely been replaced with intensive agriculture. Vegetation composition in a geographical area depends on climatic, edaphic and biotic factors.

In view of this, several edaphic parameters were studied. Textural analysis revealed much higher proportion of silt particles than clay and sand in all the sub-zones which was expected as these sub-zones are situated near the river banks. pH of the soil was found to be basic in all the soil samples as these were rich in salts. This data was supported by measurement of water salinity in nearby areas.

Both taxonomic and ecological studies related to vegetation of the study site were performed. A total of 95 plant species could be identified from the study site. So far proportion of the different plant habits i.e. herbs, shrubs, climbers and trees in the study site is concerned, there was revelation of a trend of heterogeneity with preference extended to the tree habit. Moreover, phytoclimate of the site was found to be

phanerophytic upon comparison with the Raunkiaer's standard and indicated more or less stable vegetation pattern. The IVI values thus determined from the four sub-zones of the study site showed distinct vegetation composition between mangrove and non-mangrove inland plant associates. Furthermore, dominance of different plants was well depicted. However, importance of the members of monocots especially Poaceae was clearly observed in both the plant communities. IVI data correlated with beta diversity analysis between the different sub-zones also revealed existence of two distinct plant communities.

CONCLUSION

Two distinct plant communities i.e., mangrove associates and non-mangrove inland plant associates prevailed in the study site. Conspicuous proportion of the only mangrove *Sonneratia caseolaris* was found in the study site that might have been migrated from the nearby Sunderban region. The investigated area was under heavy biotic pressure due to deforestation and urbanization. Further study is required to quantify the data and suggest plans for the conservation of the area.

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