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Inventory of Plant Species, Phytosociology and Species Diversity of Gunjan Ecological Park Pit Lake, West Bengal, India

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ABSTRACT

The present study is conducted to produce an account of the inventory of plant species, phytosociological characteristics and determination of species diversity of vegetation of Gunjan Ecological Park pit lake, West Bengal, India. Pit lakes are large water body and are generated from abandoned open mines. These pit lakes are not only large water reservoirs but also have rich floral biodiversity which could play a great role in socio-economic aspect. The vegetation of these pit lakes are also important for rehabilitation. Our principle objective of this paper is to inventory of the embankment and aquatic vegetation and determine the phytosociology and phytoclimate of the study area. Five different sites were randomly taken in various directions of the study area. A total of 50 quadrats were laid down in various directions of the study area to quantify vegetation. During our investigation, we found hundred different embankment tree species representing 41 families and 14 aquatic species of 13 families in the study site. The growth patterns, life form, life span, phytosociology and phytoclimate analysis of plant communities of the study area could reflects the ecological restoration of this region.

KEY WORDS: Pit lake, Phytoclimate, Phytosociology, Restoration

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INTRODUCTION

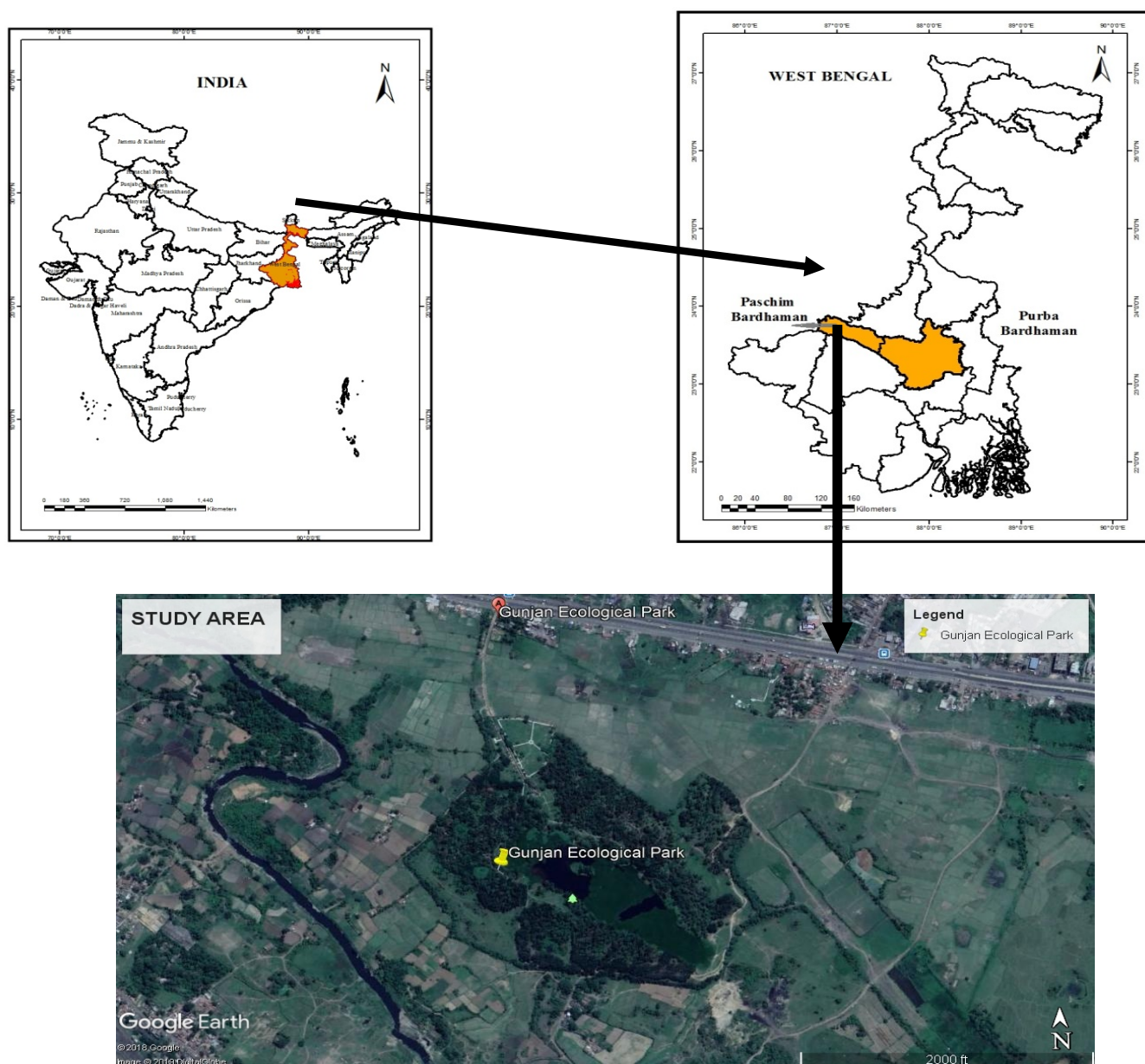
Open cast mining operation disrupts landscape pattern, disrupts indigenous flora and soil microbes. Pit lakes are generated after closing of surface mining operations and dewatering process ceases. These pits are flooded with water mainly by ground water recharge and also by side drainage. Pit lakes provide a huge source of water and have values as resources for multifarious purposes such as water supply, recreation, wildlife habitat, fisheries etc. depending on their characteristics and topography. In the context of land use and climate change, it is very useful to study the function of species richness in proper functioning of ecosystem^{1, 2}. Species richness is dependent on different types of biotic and abiotic factors^{3, 4}. The plant diversity is influenced mainly by species distribution and abundance at any site. The study has been conducted for detailed inventory and phytosociological analysis of different embankment plant species of the study area. This paper also highlights about the different available hydrophytes in the study area. The present study also deals with the determination of biological spectrum of floral assemblage of the embankment flora. The term biological spectrum was introduced to evaluate the distribution of different life forms and their respective phytoclimatic condition. A normal spectrum was made to compare the spectrum of different life forms. The obtain differences between the normal spectrum and a biological spectrum would indicate which life-form characterizes the phytoclimate of the vegetation under study. The percentage distribution of different life-forms was calculated to prepare biological spectrum of the study area and the obtain values were used to compare with the values thus determined, were compared with the Raunkiaer's normal spectrum⁵. Jacard's Generic Coefficient⁶ which gives an indication of trend of the microclimatic status of a floristic organization was determined by the following formula: Generic Coefficient = No. of genera/No. of species x 100.

MATERIALS AND METHODS

Study area

Gunjan ecological park is located in between 23⁰39'54.5''N and 87⁰1'49.6''E at 94.5m elevation in Jamuria block under Asansol subdivision, West Bengal (figure 1). It is about 40 years old. Its mean depth is 70-80ft above.. Sripur is nearest village. Other village around this pitlake is Nigha. It is used for pisciculture, fishing activity; irrigation, livestock bathing, domestic purpose and fodder purpose. Conservation initiative was adopted by local Police department and they transformed this pit lake and its surroundings area into an ecological park.

Location map of the study area



Source: Google Earth

Figure 1: Location Map of the study Site

Inventory of plant species

An extensive survey of the selected study area was performed and the floral species were identified using standard literature^{7, 8}. Herbariums of different plant species were also prepared following standard literature⁹ at Dept. of Botany, Durgapur Govt. College, Durgapur, West Bengal.

Phytosociological studies

A total of 5 randomly selected sites have been taken for vegetation analysis. At each site 10 quadrats (1x1 m) were laid. Individuals of shrubs, herbs, climbers and tree seedlings were enumerated within each quadrat. The compositions of vegetation were analyzed in terms of density, relative density, frequency, relative frequency, abundance, relative abundance calculated following standard methods¹⁰. The sum basal area values were used to calculate importance value indexes (IVI) for the species were calculated using the sum of relative density, relative frequency and relative abundance. Jacard's Generic Coefficient⁶ which gives an indication of trend of the microclimatic status of a floristic organization was determined by the following formula: Generic Coefficient = No. of genera/No. of species x 100.

The distribution pattern of the species was studied following Whitford's index¹¹.

Whitford's index = Abundance (A)/ Frequency (F) if A/F ratio:< 0.025 :Regular distribution; 0.025 - 0.05 :Random distribution, > 0.05 :Contagious or clumped distribution Raunkiaer frequency class analysis was performed to examine the rarity or commonness of the tree species¹². In this classification, the percentage frequency of the species was classified as A, B, C, D, and E, where A represents rare (0–20%), B represents low frequency (20–40%), C represents intermediate frequency (40–60%), D represents moderately high frequency (60–80%), and E represents high frequency or common (80–100%) (See table 3).

Diversity indices analysis

The data generated were synthesized to represent the diversity of plant species. Diversity parameters were determined using the Shannon-Weaver information function¹³. Vegetations were also measured for species richness¹⁴ and evenness ($H/\ln S$), where H means Shannon's diversity index and S represents species richness (See table 4).

Phytoclimatic study

In this study, the life-forms of 100 species recorded from the study area was determined following the system of classification of Raunkiaer and the Biological Spectra obtained accordingly⁵ (Table 5).

Statistical analysis

Correlation analysis has been performed to study the inter-relationship between phytosociological attributes.

RESULTS AND DISCUSSION

The study site deserves special mention for its floristic composition. Since, the presence of all life forms of plants is one of the characteristic features of forest and may form the bulk of the forest flora and have immense functional values, the present work keeps confined into taxonomic account of them. A summary of phytosociological data of embankment flora is summarized in table 3. The community was composed of as many as 100 species of 90 genera from 41 families of which 16 species are trees, 58 are herbs, 11 are shrubs and 15 climber species were recorded (figure 2). The study also reflects about the aquatic flora, composed of 13 families, 13 genus and 14 species (table 2). Taxonomic survey of the embankment flora reflects the dominance of dicotyledonous plants, whereas aquatic flora shows equal proportion of monocotyledonous and dicotyledonous plants (table 1 & 2).

Table 1: Inventory of Plant Species of Gunjan Ecological Park Pit Lake.

Sl. No.	Plants	Family	Life form	Life span	Monocot /dicot	Habit
1	<i>Abrus precatorius</i>	Papilionaceae	Ph	Perennial	D	Climber
2	<i>Abutilon indicum</i>	Malvaceae	Ch	Perennial	D	Shrub
3	<i>Acacia auriculiformis</i>	Mimosaceae	Ph	Perennial	D	Tree
4	<i>Acacia nilotica</i>	Mimosaceae	Ph	Perennial	D	Tree
5	<i>Acalypha indica</i>	Euphorbiaceae	Th	Annual	D	Herb
6	<i>Achyranthus aspera</i>	Amaranthaceae	Th	Annual or perennial	D	Herb
7	<i>Acmella paniculata</i>	Asteraceae	Th	Annual	D	Herb
8	<i>Aegle marmelos</i>	Rutaceae	Ph	Perennial	D	Tree
9	<i>Aerva lanata</i>	Amaranthaceae	Th	Perennial	D	Herb
10	<i>Ageratum conyzoides</i>	Asteraceae	Th	Annual	D	Herb
11	<i>Ailanthus excelsa</i>	Simaroubaceae	Ph	Perennial	D	Tree
12	<i>Albizia lebbek</i>	Mimosaceae	Ph	Perennial	D	Tree
13	<i>Alstonia scholaris</i>		Ph	Perennial	D	Tree
14	<i>Alternanthera sessilis</i>	Amaranthaceae	Hc	Perennial	D	Herb
15	<i>Amaranthus spinosus</i>	Amaranthaceae	Th	Perennial	D	Herb
16	<i>Amaranthus sviridis</i>	Amaranthaceae	Th	Annual	D	Herb
17	<i>Ampelocissus latifolia</i>	Vitaceae	Ph	Annual	D	Climber
18	<i>Andrographis paniculata</i>	Acanthaceae	Th	Annual	D	Herb
19	<i>Anisomeles indica</i>	Lamiaceae	Th	Perennial	D	Herb
20	<i>Azadirachta indica</i>	Meliaceae	Ph	Perennial	D	Tree
21	<i>Argyreia nervosa</i>	Convolvulaceae	Ph	Perennial	D	Climber
22	<i>Bacopa monnieri</i>	Scrophulariaceae	Ch	Perennial	D	Herb
23	<i>Barleria cristata</i>	Acanthaceae	Th	Perennial	D	Shrub
24	<i>Barleria prionitis</i>	Acanthaceae	Th	Perennial	D	Shrub
25	<i>Blumea lacera</i>	Asteraceae	Th	Annual	D	Herb
26	<i>Boerhaavia repens</i>	Nyctaginaceae	Ch	Perennial	D	Herb

27	<i>Borassus flabellifer</i>	Arecaceae	Ph	Perennial	M	Tree
28	<i>Brassica nigra</i>	Brassicaceae	Th	Annual	D	Herb
29	<i>Caesalpinia pulcharima</i>	Caesalpiaceae	Ph	Perennial	D	Tree
30	<i>Calotropis gigantea</i>	Asclepiadaceae	Ch	Perennial	D	Shrub
31	<i>Calotropis procera</i>	Asclepiadaceae	Ch	Perennial	D	Shrub
32	<i>Cassia sophora</i>	Caesalpiaceae	Ch	Perennial	D	Shrub
33	<i>Cardamine hirsute</i>	Brassicaceae	Hc	Annual	D	Herb
34	<i>Cardiospermum halicacabum</i>	Sapindaceae	Ph	Annual	D	Climber
35	<i>Cassia fistula</i>	Caesalpiaceae	Ph	Perennial	D	Tree
36	<i>Cassia tora</i>	Caesalpiaceae	Th	Annual	D	Herb
37	<i>Cayratia trifolia</i>	Vitaceae	Ph	Perennial	D	Climber
38	<i>Celosia argentea</i>	Amaranthaceae	Th	Annual	D	Herb
39	<i>Centella asiatica</i>	Apiaceae	Hc	Perennial	D	Herb
40	<i>Chenopodium album</i>	Amaranthaceae	Th	Annual	D	Herb
41	<i>Cheilocostus speciosus</i>	Costaceae	Th	Perennial	M	Herb
42	<i>Chlorophytum comosum</i>	Asparagaceae	Th	Perennial	M	Herb
43	<i>Cissampelos pareira</i>	Menispermaceae	Ph	Perennial	D	Climber
44	<i>Cissus rotundifolia</i>	Vitaceae	Ph	Perennial	D	Climber
45	<i>Cleome ruidosperma</i>	Cleomaceae	Th	Annual	D	Herb
46	<i>Cleome viscosa</i>	Cleomaceae	Th	Annual	D	Herb
47	<i>Clerodendrum infortunatum</i>	Lamiaceae	Ch	Perennial	D	Shrub
48	<i>Cocculus hirsutus</i>	Menispermaceae	Ph	Perennial	D	Climber
49	<i>Colocasia esculenta</i>	Araceae	Th	Perennial	M	Herb
50	<i>Commelina benghalensis</i>	Commelinaceae	Th	Annual	M	Herb
51	<i>Crotalaria juncea</i>	Papilionaceae	Th	Annual	D	Herb
52	<i>Coldenia procumbens</i>	Boraginaceae	Hc	Annual	D	Herb
53	<i>Croton bonplandianus</i>	Euphorbiaceae	Th	Perennial	D	Herb
54	<i>Cuscuta reflexa</i>	Convolvulaceae	Ph	Perennial	D	Climber
55	<i>Cyanotis axillaris</i>	Commelinaceae	Th	Perennial	M	Herb
56	<i>Cyanotis tuberosa</i>	Commelinaceae	Th	Perennial	M	Herb
57	<i>Cyperus rotundus</i>	Cyperaceae	Cry	Perennial	M	Herb
58	<i>Cyperus cyperoides</i>	Cyperaceae	Cry	Perennial	M	Herb
59	<i>Dactyloctenium aegyptium</i>	Poaceae	Th	Annual	M	Herb
60	<i>Dalbergia sissoo</i>	Papilionaceae	Ph	Perennial	D	Tree
61	<i>Datura stramonium</i>	Solanaceae	Ch	Perennial	D	Shrub
62	<i>Desmodium gangeticum</i>	Papilionaceae	Hc	Perennial	D	Herb
63	<i>Desmodium triflorum</i>	Papilionaceae	Hc	Perennial	D	Herb
64	<i>Dicliptera paniculata</i>	Acanthaceae	Th	Perennial	D	Herb
65	<i>Digitaria ciliaris</i>	Poaceae	Th	Annual	M	Herb
66	<i>Dioscorea alata</i>	Dioscoreaceae	Ph	Perennial	D	Climber
67	<i>Duranta repens</i>	Verbenaceae	Ch	Perennial	D	Shrub
68	<i>Eclipta alba</i>	Asteraceae	Th	Annual	D	Herb

69	<i>Elephantopus scaber</i>	Asteraceae	Th	Perennial	D	Herb
70	<i>Eupatorium odoratum</i>	Asteraceae	Ch	Perennial	D	Herb
71	<i>Evolvulus nummularis</i>	Convolvulaceae	Hc	Perennial	D	Herb
72	<i>Frimbristylis tomentosa</i>	Cyperaceae	Th	Perennial	M	Herb
73	<i>Gamochaeta coarctata</i>	Asteraceae	Th	Annual	D	Herb
74	<i>Gomphrena serrata</i>	Amaranthaceae	Th	Perennial	D	Herb
75	<i>Hemigraphis hirta</i>	Acanthaceae	Hc	Perennial	D	Herb
76	<i>Heliotropium indicum</i>		Ph	Perennial	D	Tree
77	<i>Hyptiss uaveolens</i>	Lamiaceae	Th	Annual	D	Herb
78	<i>Ipomoea obscura</i>	Convolvulaceae	Ph	Perennial	D	Climber
79	<i>Justicia adhatoda</i>	Acanthaceae	Ch	Perennial	D	Shrub
80	<i>Kyllinga brevifolia</i>	Cyperaceae	Th	Annual	M	Herb
81	<i>Luffa aegyptiaca</i>	Cucurbitaceae	Ph	Perennial	D	Climber
82	<i>Mazus pumilus</i>	Mazaceae	Th	Annual	D	Herb
83	<i>Melia azedarach</i>	Meliaceae	Ph	Perennial	D	Tree
84	<i>Oplismenus compositus</i>	Poaceae	Th	Annual or Perennial	M	Herb
85	<i>Oxalis corniculata</i>	Oxalidaceae	Hc	Annual or Perennial	D	Herb
86	<i>Paederia foetida</i>	Rubiaceae	Ph	Perennial	D	Climber
87	<i>Pongamia pinnata</i>	Papilionaceae	Ph	Perennial	D	Tree
88	<i>Ricinus communis</i>	Euphorbiaceae	Ch	Perennial	D	Shrub
89	<i>Ruellia tuberosa</i>	Acanthaceae	Th	Perennial	D	Herb
90	<i>Rungia pectinata</i>	Acanthaceae	Th	Annual or short lived perennial	D	Herb
91	<i>Scoparia dulcis</i>	Plantaginaceae	Th	Annual or perennial	D	Herb
92	<i>Senna siamea</i>	Caesalpinaceae	Ph	Perennial	D	Tree
93	<i>Sida cordata</i>		Th	Perennial	D	Herb
94	<i>Solanum sisymbriifolium</i>	Solanaceae	Th	Annual	D	Herb
95	<i>Synedrella nodiflora</i>	Asteraceae	Th	Annual	D	Herb
96	<i>Tinospora cordifolia</i>	Menispermaceae	Ph	Annual	D	Climber
97	<i>Trichosanthes cucumerina</i>	Cucurbitaceae	Ph	Annual	D	Climber
98	<i>Tridax procumbens</i>	Asteraceae	Th	Perennial	D	Herb
99	<i>Triumfetta rhomboidea</i>	Tiliaceae	Th	Annual	D	Herb
100	<i>Ziziphus jujuba</i>	Rhamnaceae	Ph	Perennial	D	Tree

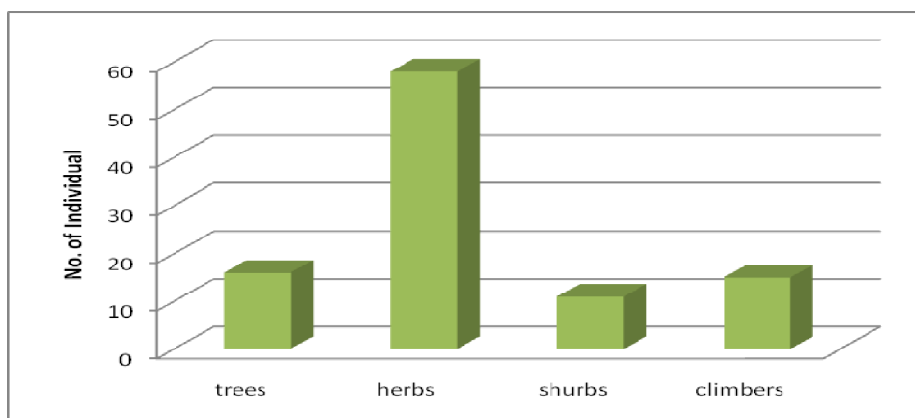


Figure 2: General Synoptic Account of Embankment Flora of Gunjan Ecological Park Pit Lake, West Bengal, India

Table 2: General Synoptic Account of Aquatic Flora of Gunjan Ecological Park Pit Lake, West Bengal, India

Sl. No.	Plants	Family	Life form	Life span	Monocot /dicot	Habit
1	<i>Aponogeton crispus</i>	<i>Aponogetonaceae</i>	Cry	Perennial	M	Herb
2	<i>Eichhornia crassipes</i>	<i>Pontederiaceae</i>	Cry	Perennial	D	Herb
3	<i>Typha angustifolia</i>	<i>Typhaceae</i>	Cry	Perennial	M	Herb
4	<i>Vallisneria spiralis</i>	<i>Hydrocharitaceae</i>	Cry	Annual or perennial,	M	Herb
5	<i>Spirodela polyrrhiza</i>	<i>Araceae</i>	Cry	Annual or perennial	M	Herb
6	<i>Portulaca pilosa</i>	<i>Portulacaceae</i>	Hc	Perennial	D	Herb
7	<i>Portulaca oleracea</i>	<i>Portulacaceae</i>	Hc	Annual	D	Herb
8	<i>Potamogeton crispus</i>	<i>Potamogetonaceae</i>	Cry	Perennial	M	Herb
9	<i>Lemna minor</i>	<i>Lemnaceae</i>	Cry	Perennial	M	Herb
10	<i>Ludwigia perennis</i>	<i>Onagraceae</i>	Th	Annual	D	Herb
11	<i>Rumex dentatus</i>	<i>Polygonaceae</i>	Hc	Annual or biennial	D	Herb
12	<i>Ipomoea aquatica</i>	<i>Convolvulaceae</i>	Cry	Perennial	D	Climber
13	<i>Hydrilla verticillata</i>	<i>Hydrocharitaceae</i>	Hc	Perennial	M	Herb
14	<i>Enydra fluctuans</i>	<i>Asteraceae</i>	Hc	Perennial	D	Herb

Cry: Cryptophytes, Hc: Haemicryptophytes, Th: Helophytes, Ph: Phenerophytes, Che: Chamaephyte, M: Monocot, D: Dicot. Phytosociology of vegetation community is a good indicator of ecological condition of land ecosystem. Alteration in the abiotic factors may lead to changes in the community structure in a short span of time¹⁵. Present study reflected mean density is highest in trees whereas shrubs species shows lowest value. The dominance was different for tree, shrub and herb and climbers component of the study area. In terms of importance value *Senna siamea* (IVI: 41.91) was the dominant tree species whereas *Borassus flabellifer* (IVI: 6.14) was the least dominant tree species. Among herbaceous species *Alternanthera sessilis* (IVI: 12.32) was the dominant species. In the shrub layer *Barleria prionitis* (53.54) and among the climber species, *Dioscorea alata* (IVI: 44.9) was the dominant species (table. 3).

Plant communities show three types of spatial distribution: clumped, random and regular. To understand the pattern of aggregation and dispersion of species, it is very important to know the habitat and resource utilization of the species. The distribution patterns of the species are influenced by the different physico-chemical parameters of water and soil^{16, 17, 18}. Majority of species of the study site showed random as well as clumped distribution pattern in the study sites.

Table 3: Phytosociological Attributes of Different Species of Gunjan Ecological Park Pit Lake, West Bengal, India

Sl. no	Plant name	D	RD	A	RA	F	FC	RF	IVI	A/F
TREES										
1	<i>Acacia auriculiformis</i>	0.18	1.41	4.50	12.44	4	A	0.60	14.45	1.125
2	<i>Acacia nilotica</i>	0.44	3.44	2.20	6.08	20	A	3.02	12.55	0.110
3	<i>Aegle marmelos</i>	0.70	5.48	2.06	5.69	34	B	5.14	16.31	0.061
4	<i>Ailanthus excelsa</i>	0.70	5.48	1.17	3.23	60	C	9.06	17.77	0.019
5	<i>Albizia lebbek</i>	0.80	6.26	2.22	6.14	36	B	5.44	17.84	0.062
6	<i>Alstonia scholaris</i>	0.60	4.69	1.20	3.32	50	C	7.55	15.57	0.024
7	<i>Azadirachta indica</i>	1.30	10.17	2.10	5.80	62	D	9.37	25.33	0.034
8	<i>Borassus flabellifer</i>	0.04	0.31	2.00	5.53	2	A	0.30	6.14	1.000
9	<i>Caesalpinia pulcharima</i>	0.36	2.82	1.20	3.32	30	B	4.53	10.67	0.040
10	<i>Cassia fistula</i>	0.92	7.20	2.00	5.53	46	C	6.95	19.68	0.043
11	<i>Dalbergia sissoo</i>	1.10	8.61	1.22	3.38	90	E	13.60	25.58	0.014
12	<i>Heliotropium indicum</i>	0.78	6.10	2.44	6.74	32	B	4.83	17.68	0.076
13	<i>Melia azedarach</i>	0.82	6.42	1.28	3.54	64	D	9.67	19.63	0.020
14	<i>Pongamia pinnata</i>	1.06	8.29	4.42	12.21	24	B	3.63	24.13	0.184
15	<i>Senna siamea</i>	2.56	20.03	2.67	7.37	96	E	14.50	41.91	0.028
16	<i>Ziziphus jujuba</i>	0.42	3.29	3.50	9.67	12	A	1.81	14.78	0.292
HERBS										
Sl. no	Plant name	D	RD	A	RA	F	FC	RF	IVI	A/F
1	<i>Acalypha indica</i>	0.60	1.33	3.75	2.36	16	A	0.79	4.48	0.234
2	<i>Achyranthus aspera</i>	1.80	3.98	2.65	1.67	68	D	3.37	9.02	0.039
3	<i>Acmella paniculata</i>	0.90	1.99	2.14	1.35	42	C	2.08	5.42	0.051
4	<i>Aerva lanata</i>	1.88	4.15	3.03	1.91	62	D	3.08	9.14	0.049
5	<i>Ageratum conyzoides</i>	1.36	3.00	4.53	2.86	30	B	1.49	7.35	0.151
6	<i>Alternanthera sessilis</i>	2.68	5.92	2.91	1.84	92	E	4.56	12.32	0.032
7	<i>Amaranthus spinosus</i>	0.34	0.75	1.42	0.89	24	B	1.19	2.83	0.059
8	<i>Amaranthus sviridis</i>	0.86	1.90	4.78	3.01	18	A	0.89	5.81	0.265
9	<i>Andrographis paniculata</i>	0.64	1.41	2.13	1.35	30	B	1.49	4.25	0.071
10	<i>Anisomeles indica</i>	0.34	0.75	1.21	0.77	28	B	1.39	2.91	0.043
11	<i>Bacopa monnieri</i>	0.48	1.06	6.00	3.78	8	A	0.40	5.24	0.750
12	<i>Blumea lacera</i>	0.90	1.99	1.15	0.73	78	D	3.87	6.59	0.015
13	<i>Boerhaavia repens</i>	0.98	2.17	7.00	4.41	14	A	0.69	7.27	0.500
14	<i>Brassica nigra</i>	0.10	0.22	2.50	1.58	4	A	0.20	2.00	0.625
15	<i>Cardamine hirsute</i>	0.42	0.93	3.50	2.21	12	A	0.60	3.73	0.292
16	<i>Cassia tora</i>	0.92	2.03	1.92	1.21	48	C	2.38	5.62	0.040
17	<i>Celosia argentea</i>	0.12	0.27	3.00	1.89	4	A	0.20	2.36	0.750
18	<i>Centella asiatica</i>	0.20	0.44	3.33	2.10	6	A	0.30	2.84	0.556

19	<i>Chenopodium album</i>	0.18	0.40	4.50	2.84	4	A	0.20	3.43	1.125
20	<i>Cheilocostus speciosus</i>	0.10	0.22	2.50	1.58	4	A	0.20	2.00	0.625
21	<i>Chlorophytum comosum</i>	0.10	0.22	1.67	1.05	6	A	0.30	1.57	0.278
22	<i>Cleome ruidosperma</i>	0.18	0.40	1.50	0.95	12	A	0.60	1.94	0.125
23	<i>Cleome viscosa</i>	0.92	2.03	1.92	1.21	48	C	2.38	5.62	0.040
24	<i>Colocasia esculenta</i>	0.28	0.62	4.67	2.94	6	A	0.30	3.86	0.778
25	<i>Commelina benghalensis</i>	0.30	0.66	3.00	1.89	10	A	0.50	3.05	0.300
26	<i>Crotalaria juncea</i>	0.26	0.57	1.86	1.17	14	A	0.69	2.44	0.133
27	<i>Coldenia procumbens</i>	0.06	0.13	1.50	0.95	4	A	0.20	1.28	0.375
28	<i>Croton bonplandianus</i>	0.82	1.81	1.78	1.12	46	C	2.28	5.22	0.039
29	<i>Cyanotis axillaris</i>	0.90	1.99	3.00	1.89	30	B	1.49	5.37	0.100
30	<i>Cyanotis tuberosa</i>	0.46	1.02	3.29	2.07	14	A	0.69	3.78	0.235
31	<i>Cyperus rotundus</i>	0.22	0.49	2.20	1.39	10	A	0.50	2.37	0.220
32	<i>Cyperus cyperoides</i>	0.12	0.27	3.00	1.89	4	A	0.20	2.36	0.750
33	<i>Dactyloctenium aegyptium</i>	1.04	2.30	1.33	0.84	78	D	3.87	7.01	0.017
34	<i>Desmodium gangeticum</i>	0.62	1.37	1.82	1.15	34	B	1.69	4.21	0.054
35	<i>Desmodium triflorum</i>	0.98	2.17	1.44	0.91	68	D	3.37	6.45	0.021
36	<i>Dicliptera paniculata</i>	0.50	1.10	3.57	2.25	14	A	0.69	4.05	0.255
37	<i>Digitaria ciliaris</i>	0.86	1.90	1.95	1.23	44	C	2.18	5.32	0.044
38	<i>Eclipta alba</i>	0.16	0.35	2.67	1.68	6	A	0.30	2.33	0.444
39	<i>Elephantopus scaber</i>	0.76	1.68	5.43	3.42	14	A	0.69	5.80	0.388
40	<i>Eupatorium odoratum</i>	1.52	3.36	1.69	1.06	90	E	4.46	8.89	0.019
41	<i>Evolvulus nummularis</i>	1.56	3.45	1.70	1.07	92	E	4.56	9.08	0.018
42	<i>Frimbristylis tomentosa</i>	0.18	0.40	4.50	2.84	4	A	0.20	3.43	1.125
43	<i>Gamochaeta coarctata</i>	1.54	3.40	1.64	1.03	94	E	4.66	9.10	0.017
44	<i>Gomphrena serrata</i>	0.58	1.28	3.22	2.03	18	A	0.89	4.21	0.179
45	<i>Hemigraphis hirta</i>	0.22	0.49	3.67	2.31	6	A	0.30	3.10	0.611
46	<i>Hyptiss uaveolens</i>	1.34	2.96	1.56	0.98	86	E	4.27	8.21	0.018
47	<i>Kyllinga brevifolia</i>	1.90	4.20	2.44	1.54	78	D	3.87	9.60	0.031
48	<i>Mazus pumilus</i>	1.28	2.83	1.88	1.19	68	D	3.37	7.39	0.028
49	<i>Oplismenus compositus</i>	2.48	5.48	2.58	1.63	96	E	4.76	11.87	0.027
50	<i>Oxalis corniculata</i>	1.82	4.02	2.33	1.47	78	D	3.87	9.36	0.030
51	<i>Ruellia tuberosa</i>	0.60	1.33	2.73	1.72	22	B	1.09	4.14	0.124
52	<i>Rungia pectinata</i>	0.38	0.84	2.11	1.33	18	A	0.89	3.06	0.117
53	<i>Scoparia dulcis</i>	0.18	0.40	1.80	1.14	10	A	0.50	2.03	0.180
54	<i>Sida cordata</i>	0.30	0.66	3.75	2.36	8	A	0.40	3.42	0.469
55	<i>Solanum sisymbriifolium</i>	0.14	0.31	2.33	1.47	6	A	0.30	2.08	0.389
56	<i>Synedrella nodiflora</i>	0.12	0.27	3.00	1.89	4	A	0.20	2.36	0.750
57	<i>Tridax procumbens</i>	1.76	3.89	1.96	1.23	90	E	4.46	9.59	0.022

58	<i>Triumfetta rhomboidea</i>	2.02	4.46	2.15	1.36	94	E	4.66	10.48	0.023
SHURB										
Sl. no	Plant name	D	RD	A	RA	F	FC	RF	IVI	A/F
1	<i>Abutilon indicum</i>	0.96	20.78	2.18	9.50	44	C	18.49	48.77	0.050
2	<i>Barleria cristata</i>	0.10	2.16	2.50	10.89	4	A	1.68	14.73	0.625
3	<i>Barleria prionitis</i>	1.02	22.08	1.82	7.93	56	C	23.53	53.54	0.033
4	<i>Calotropis gigantea</i>	0.10	2.16	2.50	10.89	4	A	1.68	14.73	0.625
5	<i>Calotropis procera</i>	0.18	3.90	1.80	7.84	10	A	4.20	15.94	0.180
6	<i>Cassia sophera</i>	0.92	19.91	1.92	8.35	48	C	20.17	48.43	0.040
7	<i>Clerodendrum infortunatum</i>	0.68	14.72	2.43	10.58	28	B	11.76	37.06	0.087
8	<i>Datura stramonium</i>	0.06	1.30	3.00	13.07	2	A	0.84	15.21	1.500
9	<i>Duranta repens</i>	0.04	0.87	2.00	8.71	2	A	0.84	10.42	1.000
10	<i>Justicia adhatoda</i>	0.30	6.49	1.36	5.94	22	B	9.24	21.68	0.062
11	<i>Ricinus communis</i>	0.26	5.63	1.44	6.29	18	A	7.56	19.48	0.080
CLIMBERS										
Sl. no	Plant name	D	RD	A	RA	F	FC	RF	IVI	A/F
1	<i>Abrus precatorius</i>	0.14	1.55	2.33	8.76	6	A	1.13	11.43	0.389
2	<i>Ampelocissus latifolia</i>	0.30	3.31	1.25	4.69	24	B	4.51	12.51	0.052
3	<i>Argyrea nervosa</i>	0.36	3.97	1.64	6.14	22	B	4.14	14.25	0.074
4	<i>Cardiospermum halicacabum</i>	0.34	3.75	1.13	4.25	30	B	5.64	13.65	0.038
5	<i>Cayratia trifolia</i>	0.50	5.52	1.25	4.69	40	B	7.52	17.73	0.031
6	<i>Cissampelos pareira</i>	0.22	2.43	1.57	5.90	14	A	2.63	10.96	0.112
7	<i>Cissus rotundifolia</i>	0.18	1.99	3.00	11.26	6	A	1.13	14.38	0.500
8	<i>Cocculus hirsutus</i>	0.06	0.66	1.50	5.63	4	A	0.75	7.04	0.375
9	<i>Cuscuta reflexa</i>	0.08	0.88	1.33	5.01	6	A	1.13	7.02	0.222
10	<i>Dioscorea alata</i>	1.84	20.31	2.04	7.67	90	E	16.92	44.90	0.023
11	<i>Ipomoea obscura</i>	1.36	15.01	1.70	6.38	80	D	15.04	36.43	0.021
12	<i>Luffa aegyptiaca</i>	1.24	13.69	2.38	8.95	52	C	9.77	32.41	0.046
13	<i>Paederia foetida</i>	0.90	9.93	1.18	4.45	76	D	14.29	28.66	0.016
14	<i>Tinospora cordifolia</i>	0.76	8.39	2.92	10.97	26	B	4.89	24.25	0.112
15	<i>Trichosanthes cucumerina</i>	0.78	8.61	1.39	5.23	56	C	10.53	24.36	0.025

D=Density, A=Abundance, F=Frequency, FC=Frequency Class, RF=Relative Frequency, RD=Relative Density, RA=Relative Abundance, IVI=Important Value Index

The diversity indices of different embankment plants species are listed in table 4. Shannon diversity index value of tree, herbs, shrubs and climbers species are 2.537, 3.724, 1.992 and 2.149 respectively. Mean species richness value of tree, herb, shrub and climbers are 3.364, 3.247, 2.513 and 2.977 respectively, whereas, the mean evenness index of tree, herb, shrub and climbers are 0.045, 0.018, 0.067 and 0.048 respectively. The Generic Coefficient, which serves as an index of

diversification, was found to be 90%. The biological spectrum data (Table 5 & Fig.3) highlight much lower abundance of cryptophytes and much higher abundance of therophytes.

Table 4: Diversity Indices of Different Embankment Flora of Gunjan Ecological Park Pit Lake, West Bengal, India

Sl. no	Name of the plant	Richness(S)	Shanon (H)	Evenness
TREE				
1	<i>Acacia auriculiformis</i>	2.197	0.061	0.028
2	<i>Acacia nilotica</i>	3.091	0.118	0.038
3	<i>Aegle marmelos</i>	3.555	0.161	0.045
4	<i>Ailanthus excelsa</i>	3.045	0.114	0.037
5	<i>Albizzia lebbek</i>	3.689	0.176	0.048
6	<i>Alstonia scholaris</i>	3.401	0.146	0.043
7	<i>Azadirachta indica</i>	4.174	0.235	0.056
8	<i>Borassus flabellifer</i>	0.693	0.018	0.027
9	<i>Caesalpinia pulcharima</i>	2.890	0.102	0.035
1	<i>Cassia fistula</i>	3.829	0.192	0.050
1	<i>Dalbergia sissoo</i>	4.007	0.214	0.053
1	<i>Heliotropium indicum</i>	3.664	0.173	0.047
1	<i>Melia azedarach</i>	3.714	0.179	0.048
1	<i>Pongamia pinnata</i>	3.970	0.209	0.053
1	<i>Senna siamea</i>	4.852	0.325	0.067
1	<i>Ziziphus jujuba</i>	3.045	0.114	0.037
		Mean= 3.364	H= 2.537	Mean= 0.045
HERB				
1	<i>Acalypha indica</i>	3.401	0.057	0.017
2	<i>Achyranthus aspera</i>	4.500	0.128	0.028
3	<i>Acmella paniculata</i>	3.807	0.078	0.020
4	<i>Aerva lanata</i>	4.543	0.132	0.029
5	<i>Ageratum conyzoides</i>	4.220	0.105	0.025
6	<i>Alternanthera sessilis</i>	4.898	0.167	0.034
7	<i>Amaranthus spinosus</i>	2.833	0.037	0.013
8	<i>Amaranthus sviridis</i>	3.761	0.075	0.020
9	<i>Andrographis paniculata</i>	3.466	0.060	0.017
10	<i>Anisomeles indica</i>	2.833	0.037	0.013
11	<i>Bacopa monnieri</i>	3.178	0.048	0.015
12	<i>Blumea lacera</i>	3.807	0.078	0.020
12	<i>Boerhaavia repens</i>	3.892	0.083	0.021

14	<i>Brassica nigra</i>	1.609	0.014	0.008
15	<i>Cardamine hirsute</i>	3.045	0.043	0.014
16	<i>Cassia tora</i>	3.829	0.079	0.021
17	<i>Celosia argentea</i>	1.792	0.016	0.009
18	<i>Centella asiatica</i>	2.303	0.024	0.010
19	<i>Chenopodium album</i>	2.197	0.022	0.010
20	<i>Cheilocostus speciosus</i>	1.609	0.014	0.008
21	<i>Chlorophytum comosum</i>	1.609	0.014	0.008
22	<i>Cleome rutidosperma</i>	2.197	0.022	0.010
23	<i>Cleome viscosa</i>	3.829	0.079	0.021
24	<i>Colocasia esculenta</i>	2.639	0.031	0.012
25	<i>Commelina benghalensis</i>	2.708	0.033	0.012
26	<i>Crotalaria juncea</i>	2.565	0.030	0.012
27	<i>Coldenia procumbens</i>	1.099	0.009	0.008
28	<i>Croton bonplandianus</i>	3.714	0.073	0.020
29	<i>Cyanotis axillaris</i>	3.807	0.078	0.020
30	<i>Cyanotis tuberosa</i>	3.135	0.047	0.015
31	<i>Cyperus rotundus</i>	2.398	0.026	0.011
32	<i>Cyperus cyperoides</i>	1.792	0.016	0.009
33	<i>Dactyloctenium aegyptium</i>	3.951	0.087	0.022
34	<i>Desmodium gangeticum</i>	3.434	0.059	0.017
35	<i>Desmodium triflorum</i>	3.892	0.083	0.021
36	<i>Dicliptera paniculata</i>	3.219	0.050	0.015
37	<i>Digitaria ciliaris</i>	3.761	0.075	0.020
38	<i>Eclipta alba</i>	2.079	0.020	0.010
39	<i>Elephantopus scaber</i>	3.638	0.069	0.019
40	<i>Eupatorium odoratum</i>	4.331	0.114	0.026
41	<i>Evolvulus nummularis</i>	4.357	0.116	0.027
42	<i>Frimbristylis tomentosa</i>	2.197	0.022	0.010
43	<i>Gamochoaeta coarctata</i>	4.344	0.115	0.026
44	<i>Gomphrena serrata</i>	3.367	0.056	0.017
45	<i>Hemigraphis hirta</i>	2.398	0.026	0.011
46	<i>Hyptiss uaveolens</i>	4.205	0.104	0.025
47	<i>Kyllinga brevifolia</i>	4.554	0.133	0.029
48	<i>Mazus pumilus</i>	4.159	0.101	0.024
49	<i>Oplismenus compositus</i>	4.820	0.159	0.033
50	<i>Oxalis corniculata</i>	4.511	0.129	0.029
51	<i>Ruellia tuberosa</i>	3.401	0.057	0.017
52	<i>Rungia pectinata</i>	2.944	0.040	0.014

53	<i>Scoparia dulcis</i>	2.197	0.022	0.010
54	<i>Sida cordata</i>	2.708	0.033	0.012
55	<i>Solanum sisymbriifolium</i>	1.946	0.018	0.009
56	<i>Synedrella nodiflora</i>	1.792	0.016	0.009
57	<i>Tridax procumbens</i>	4.477	0.126	0.028
58	<i>Triumfetta rhomboidea</i>	4.615	0.139	0.030
		Mean= 3.247	H= 3.724	Mean= 0.018
SHURBS				
1	<i>Abutilon indicum</i>	3.871	0.326	0.084
2	<i>Barleria cristata</i>	1.609	0.083	0.052
3	<i>Barleria prionitis</i>	3.932	0.334	0.085
4	<i>Calotropis gigantea</i>	1.609	0.083	0.052
5	<i>Calotropis procera</i>	2.197	0.126	0.058
6	<i>Cassia sophera</i>	3.829	0.321	0.084
7	<i>Clerodendrum infortunatum</i>	3.526	0.282	0.080
8	<i>Datura stramonium</i>	1.099	0.056	0.051
9	<i>Duranta repens</i>	0.693	0.041	0.059
10	<i>Justicia adhatoda</i>	2.708	0.178	0.066
11	<i>Ricinus communis</i>	2.565	0.162	0.063
		Mean= 2.513	H= 1.992	Mean= 0.067
CLIMBERS				
1	<i>Abrus precatorius</i>	1.946	0.064	0.033
2	<i>Ampelocissus latifolia</i>	2.708	0.113	0.042
3	<i>Argyreia nervosa</i>	2.890	0.128	0.044
4	<i>Cardiospermum halicacabum</i>	2.833	0.123	0.043
5	<i>Cayratia trifolia</i>	3.219	0.160	0.050
6	<i>Cissampelos pareira</i>	2.398	0.090	0.038
7	<i>Cissus rotundifolia</i>	2.197	0.078	0.035
8	<i>Cocculus hirsutus</i>	1.099	0.033	0.030
9	<i>Cuscuta reflexa</i>	1.386	0.042	0.030
10	<i>Dioscorea alata</i>	4.522	0.324	0.072
11	<i>Ipomoea obscura</i>	4.220	0.285	0.067
12	<i>Luffa aegyptiaca</i>	4.127	0.272	0.066
13	<i>Paederia foetida</i>	3.807	0.229	0.060
14	<i>Tinospora cordifolia</i>	3.638	0.208	0.057
15	<i>Trichosanthes cucumerina</i>	3.664	0.211	0.058
		Mean= 2.977	H= 2.149	Mean= 0.048

Table 5: Representation of Different Life-forms of Embankment Flora and Comparison of Obtained Biological Spectrum with Raunkiaer’s Standard Spectrum of Gunjan Ecological Park Pit Lake

Life-forms	No. of species	Raunkiaer's standard	Obtained biological spectrum
Phanerophyte	31	46	31
Therophyte	46	13	46
Hemicryptophyte	09	26	9
Chamaephyte	12	9	12
Cryptophyte	02	6	2

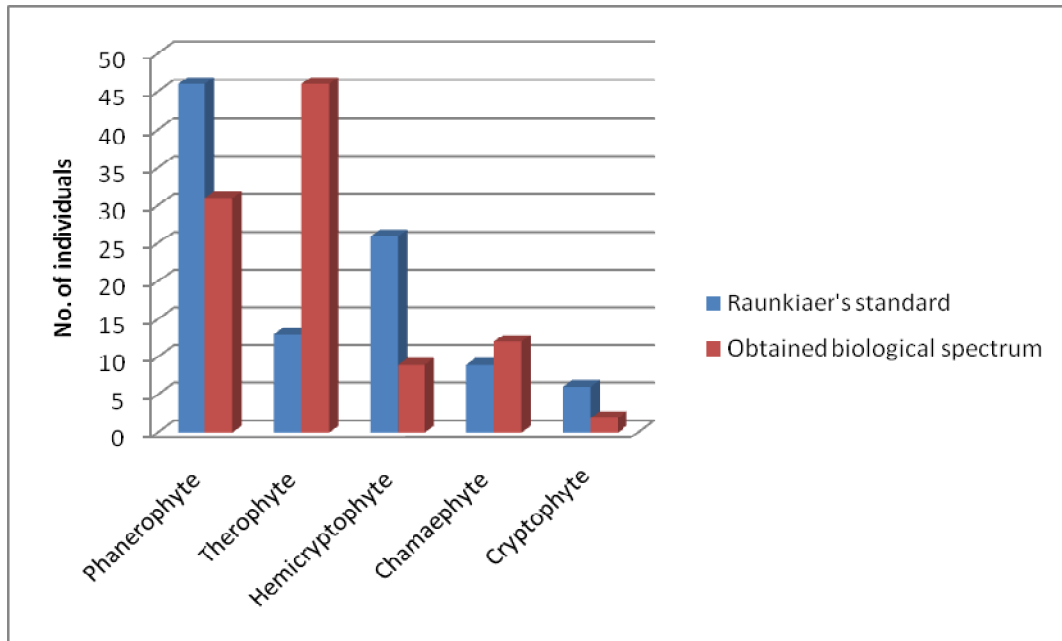


Figure 3: Graphical Representation of Different Life-forms of Embankment Flora of Gunjan Ecological Park Pit Lake

Correlation studies between different phytosociological parameters of tree species shows that density is positively correlated with frequency and IVI in case of tree, herbs, shrubs and climber species. The correlation between frequency and IVI also shows positive relation in tree, herb, shrub and climbers species (see table 6, 7, 8 & 9).

Table 6: Correlation Between Different Phytosociological Parameters of Tree Species in Gunjan Ecological Park Pit Lake

	<i>Density</i>	<i>Frequency</i>	<i>Abundance</i>	<i>IVI</i>	<i>A/F</i>
Density	1				
Frequency	0.795804	1			
Abundance	0.00037	-0.49033	1		
IVI	0.976478	0.788664	0.110756	1	
A/F	-0.503	-0.64554	0.518489	0.42922	1

Table 7 Correlation Between Different Phytosociological Parameters of Herb Species in Gunjan Ecological Park Pit Lake

	<i>Density</i>	<i>Frequency</i>	<i>Abundance</i>	<i>IVI</i>	<i>A/F</i>
Density	1				
Frequency	0.899679	1			
Abundance	-0.12062	-0.4358176	1		
IVI	0.98325	0.901710115	-0.03215614	1	
A/F	-0.597	-0.68609376	0.606784441	0.52405	1

Table 8: Correlation Between Different Phytosociological Parameters of Shrub Species in Gunjan Ecological Park Pit Lake

	<i>Density</i>	<i>Frequency</i>	<i>Abundance</i>	<i>IVI</i>	<i>A/F</i>
Density	1				
Frequency	0.9803152	1			
Abundance	-0.208462	-0.35301	1		
IVI	0.9966178	0.977448	0.15819051	1	
A/F	0.6691199	-0.71153	0.68848166	-0.6231	1

Table 9: Correlation Between Different Phytosociological Parameters of Climber Species in Gunjan Ecological Park Pit Lake

	<i>Density</i>	<i>Frequency</i>	<i>Abundance</i>	<i>IVI</i>	<i>A/F</i>
Density	1				
Frequency	0.9233225	1			
Abundance	0.1496045	0.15516932	1		
IVI	0.9913449	0.92611807	0.207382	1	
A/F	-0.590744	0.70414397	0.4850386	0.54458	1

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