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Biodiversity and Phytosociological Analysis of Plants around the Municipal Drains in Jaunpur

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***Abstract*—**The habitat where the present study has been carried out is productive in relation to nutrient quality and they may perform several useful functions, but are also threatened for their existence. Hence, the proposed work, will add much new information about biodiversity of macrophytes in drains and their embankment. All the species were identified with their different stages of growth which encountered on the three selected sites (I, II and III). The number of species occurring at each site is grouped seasonally, i.e. summer, rainy and winter season and the species were further recorded for the study of phytosociology. Phytosociological characters such as frequency, density and abundance were influenced by the climatic, anthropogenic and biotic stresses prevailing at the three study sites. All the species present at the study sites have shown maximum values of frequency, density and abundance in rainy season in comparison to that of summer and winter seasons.

***Keywords*—**Abundance, Biodiversity, Density, Frequency, Macrophytes, Phytosociology.

I. Introduction

THE term biodiversity – the short form of biological diversity, was coined by Walter G. Rosen in 1985, however the origin of concept go for back in time [1]. We know that ecosystems are undergoing change due to pollution, invasive species, overexploitation by humans, and climate change. Most people are beginning to recognize that diversity at all levels - gene pool, species and biotic community is important and needs to be conserved [2]. The community is an assemblage of species population that occurs together in the same place at the same time. European Ecologists developed systems of description and classification and this aspect of ecology is known as phytosociology. A mixture of species which live in a habitat and are held together by common ecological tolerances, form a community. All these species are not equally important but there are only a few overtopping species which by their bulk and growth modify the habitat and control the growth of other species of the community as these species are called dominants [3]. The study of plant community structure is called plant sociology or phytosociology. “Phytosociology” the study of aspects of communal relations of plant was coined by Paczoski and this study is important for understanding the functioning of community. The study of plant community implies knowledge of structure and composition of the component species. Stone and Frayer (1935) estimated the combined influence of plant height, basal area, density and number of species on ‘complexity index’ in the evaluation of vegetation physiognomy [4]. The vegetation complex fluctuates from season to season and year to year. The fluctuation suggests a response by each species population to incoming heat, moisture and light as modified by the vegetation itself [5-6].

Much work has been done on pollution parameters and biodiversity of rivers, lakes, ponds and their marginal wetlands [7-11]. But so far the evolution of biodiversity and phytosociology of macrophytes of drains and their embankment have been ignored by the ecologists, though it is significant. Therefore, the present investigation forms a basis giving complete information in relation to the composition, structure, species diversity, growth forms, development and other characteristics of plant community.

Organization of the present paper is as follows. In Section II, the phytosociological analysis of vegetation around the embankments of municipal drains in Jaunpur district of Uttar Pradesh, India has been performed using standard methodologies. Results have been presented in Section III along with a brief discussion of the results.

II. Phytosociological Analysis

The embankment area of the municipal sewage represents a very distinct type of habitat on which different kinds of plant communities can be identified. In view of the above, three different sites, i.e., Site-I (near Rauza Ghat), Site-II (near Sipah overbridge) and Site-III (near Suraj Ghat) were selected in Jaunpur municipal area on the basis of pollution load and human population residing near the sites. Each site was demarcated for one hectare area, half hectare on both the sides of the municipal drains. Phenology was recorded at bimonthly intervals from March 2009 to Feb. 2010 by visiting the study sites (I, II and III) at periodic intervals. The phenology of the constituent species encountered at the study sites were marked by using different notations for different phenological stages of the life-cycle. During the life cycle of a plant, the occurrence of important events can be understood with the help of ‘phenological observations’. The observations related to the phenology of individual species at the three sites (I, II and III) has been given in Table 1.

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TABLE I PHENOLOGY OF CONSTITUENT SPECIES OF THE STUDY SITES (I, II & III)

S. No	Plant Species	Family	Months						Luxuriant Flowering and/or Fruiting
			March (09)	May	July	Sept.	Nov.	Jan. (10)	
1.	*Acacia Senegal* Willd.	Mimosaceae	BCD	CDE	FAB	AB	B	BC	Almost throughout the year
2.	*Achyranthes aspera* Linn.	Amaranthaceae	DE	EF	AB	BC	CD	CDE	Oct. to Feb.
3.	*Alternanthera paronychioides* St. Hill.	Amaranthaceae	BC	CDE	EF	AB	ABC	BCD	Almost throughout the year
4.	*Alternanthera sessilis* (Linn.) Dc.	Amaranthaceae	EF	A	AB	BC	BCD	CDE	Almost throughout the year
5.	*Amaranthus Spinosus* Linn.	Amaranthaceae	CDE	DEF	AB	ABC	ABC	BCD	Almost throughout the year
6.	*Amiscophacelus axillaris* (L.) Rolla Rao	Commelinaceae	DE	DEF	AB	ABC	BCD	CDE	July to Jan.
7.	*Anchusa tenella* Hornem.	Boraginaceae	BCD	CDE	F	-	-	AB	March to June
8.	*Anisomeles indica* (L.) Kuntze	Lamiaceae	EF	-	AB	BC	BCD	CD	Sept. to Jan.
9.	*Arundo donax* Linn.	Poaceae	-	-	AB	BCD	BCD	BCDE	Sept. to Jan.
10.	*Bacopa monnieri* (L.)Panell	Scrophulariaceae	EF	AB	BCD	CD	CD	DE	July to Dec.
11.	*Bambusa arundinacea* (Retz.) Willd.	Poaceae	-	A	AB	-	-	-	No flowering and fruiting
12.	*Bothriospermum tenellem* (Hornem.)Fisch.	Boraginaceae	BCD	CD	CDE	-	-	AB	March to June
13.	*Caesulia axillaris* Roxb.	Asteraceae	-	-	AB	ABC	BCD	CD	Sept. to Feb.
14.	*Calotropis procera* (Ait.) R. Br.	Asclepiadaceae	BCD	CD	CD	CDE	CDEF	AB	March to July
15.	*Capparis trifoliata* Roxb.	Capparidaceae	AB	BCD	CD	CDE	DE	-	April to July
16.	*Cleome viscose* Linn.	Capparidaceae	-	AB	BCD	CD	DE	-	July to Sept.
17.	*Croton bonplandianum* Baill.	Euphorbiaceae	BCD	CDE	BCD	BCD	CDE	CDE	Major part of the year
18.	*Cynodon dactylon* (L.) Pers.	Poaceae	BCD	DE	AB	BC	CDE	CDE	Major part of the year
19.	*Cyperus difformis* Linn.	Cyperaceae	-	-	AB	BCD	BCD	CDE	Aug. to Jan.
20.	*Dentella repens* (L.) Forst.	Rubiaceae	A	AB	AB	BCD	CD	CDE	Almost throughout the year

TABLE II CHANGES IN FREQUENCY (%) OF PLANT SPECIES AT SITES I, II AND III
(BASED ON 50 QUADRAT SAMPLING)

S. No.	Plant Species	SUMMER			RAINY			WINTER		
		I	II	III	I	II	III	I	II	III
1.	*Achyranthes aspera*	10	8	4	24	22	20	28	24	18
2.	*Alternanthera paronychioides*	8	-	6	18	12	16	-	4	8
3.	*Alternanthera sessilis*	6	8	-	22	30	18	20	24	16
4.	*Amaranthus Spinosus*	18	12	6	26	20	22	16	18	14
5.	*Amiscophacelus axillaris*	-	4	6	16	20	14	10	12	14
6.	*Anchusa tenella*	4	-	4	8	10	-	-	12	8
7.	*Anisomeles indica*	-	-	-	20	12	16	22	16	12
8.	*Arundo donax*	-	4	-	14	18	12	8	10	6
9.	*Bacopa monnieri*	4	-	-	10	8	6	4	6	4
10.	*Bothriospermum tenellum*	6	-	4	12	14	8	6	8	10
11.	*Caesulia axillaris*	-	-	-	4	6	-	12	14	-
12.	*Calotropis procera*	-	4	4	8	10	6	6	4	-
13.	*Cleome viscose*	-	-	-	6	4	6	4	-	-
14.	*Croton bonplandianum*	8	12	-	16	18	14	20	16	-
15.	*Cynodon dactylon*	50	48	34	80	92	88	100	96	98
16.	*Cyperus difformis*	-	-	-	20	16	8	-	10	6
17.	*Dentella repens*	-	4	6	6	8	-	8	4	6
18.	*Desmostachya bipinnata*	12	10	14	20	24	18	16	-	10
19.	*Eclipta prostrate*	10	8	10	16	10	20	4	8	6
20.	*Euphorbia thymifolia*	12	14	16	20	12	18	8	10	12

TABLE III CHANGES IN DENSITY (M^{-2}) OF PLANT SPECIES AT SITES I, II AND III
(BASED ON 50 QUADRAT SAMPLING)

S. No.	Plant Species	SUMMER			RAINY			WINTER		
		I	II	III	I	II	III	I	II	III
1.	*Achyranthes aspera*	0.48	0.22	0.18	5.76	2.86	1.66	1.18	1.14	0.64
2.	*Alternanthera paronychioides*	0.20	-	0.24	2.34	0.66	0.70	-	0.18	0.28
3.	*Alternanthera sessilis*	0.24	0.26	-	2.14	1.72	0.84	1.04	0.80	0.54
4.	*Amaranthus Spinosus*	0.50	0.28	0.26	2.30	2.66	1.98	0.88	0.56	0.68
5.	*Amiscophacelus axillaris*	-	0.10	0.10	3.04	2.08	1.02	0.52	0.34	0.30
6.	*Anchusa tenella*	0.14	-	0.14	0.36	0.38	-	-	0.32	0.18
7.	*Anisomeles indica*	-	-	-	1.40	0.62	0.76	0.96	0.50	0.56
8.	*Arundo donax*	-	0.10	-	0.32	1.72	0.60	0.30	0.22	0.10
9.	*Bacopa monnieri*	0.14	-	-	0.28	0.52	0.42	0.08	0.24	0.18
10.	*Bothriospermum tenellum*	0.22	-	0.06	0.64	0.46	0.58	0.34	0.36	0.38
11.	*Caesulia axillaris*	-	-	-	0.22	0.38	-	0.56	0.64	-
12.	*Calotropis procera*	-	0.10	0.12	0.22	0.26	0.30	0.26	0.12	-
13.	*Cleome viscosa*	-	-	-	0.26	0.12	0.80	0.10	-	-
14.	*Croton bonplandianum*	0.18	0.26	-	0.78	0.74	0.38	0.94	0.64	-
15.	*Cynodon dactylon*	24.90	31.5	36.52	89.60	124.2	86.36	91.04	71.04	98.50
16.	*Cyperus difformis*	-	-	-	1.96	0.62	0.52	-	0.44	0.26
17.	*Dentella repens*	-	0.06	0.16	0.28	0.34	-	0.22	0.18	0.20
18.	*Desmostachya bipinnata*	0.36	0.32	0.42	1.26	1.06	0.94	0.66	-	0.46
19.	*Eclipta prostrate*	0.34	0.18	0.30	0.76	0.44	0.96	0.08	0.38	0.16
20.	*Euphorbia thymifolia*	0.44	0.54	0.48	1.76	0.86	1.46	0.34	0.42	0.36
Total		28.140	33.920	38.980	115.68	142.70	100.28	99.500	78.520	103.78

TABLE IV CHANGES IN ABUNDANCE (M^{-2}) OF PLANT SPECIES AT SITES I, II AND III (BASED ON 50 QUADRAT SAMPLING)

S. No.	Plant Species	SUMMER			RAINY			WINTER		
		I	II	III	I	II	III	I	II	III
1.	*Achyranthes aspera*	4.80	2.75	4.50	24.00	13.00	8.30	4.21	4.75	3.56
2.	*Alternanthera paronychioides*	2.50	-	4.00	13.00	5.50	4.38	-	4.50	3.50
3.	*Alternanthera sessilis*	4.00	3.25	-	9.73	5.74	4.67	5.20	3.34	3.38
4.	*Amaranthus Spinosus*	2.78	4.67	4.34	8.85	13.30	4.45	5.50	4.67	4.86
5.	*Amiscophacelus axillaris*	-	2.50	1.67	19.00	10.40	7.29	5.20	2.83	2.14
6.	*Anchusa tenella*	3.50	-	3.50	4.50	3.80	-	-	2.67	2.25
7.	*Anisomeles indica*	-	-	-	7.00	5.17	4.75	4.36	3.13	4.67
8.	*Arundo donax*	-	2.50	-	2.29	9.56	3.34	3.75	2.20	1.67
9.	*Bacopa monnieri*	3.50	-	-	2.80	6.50	7.00	2.00	4.00	4.50
10.	*Bothriospermum tenellum*	3.67	-	1.50	5.34	3.29	7.25	5.66	4.50	3.80
11.	*Caesulia axillaris*	-	-	-	5.50	6.34	-	4.67	4.57	-
12.	*Calotropis procera*	-	2.50	3.00	2.75	2.60	1.67	4.34	3.00	-
13.	*Cleome viscose*	-	-	-	4.34	3.00	3.34	2.50	-	-
14.	*Croton bonplandianum*	2.25	2.17	-	4.88	4.12	2.71	4.70	4.00	-
15.	*Cynodon dactylon*	49.80	65.63	107.4	112.0	135.0	94.72	91.04	74.00	100.5
16.	*Cyperus difformis*	-	-	-	9.80	3.88	6.50	-	4.40	4.34
17.	*Dentella repens*	-	1.50	2.67	4.67	4.25	-	2.75	4.50	3.34
18.	*Desmostachya bipinnata*	3.00	3.20	3.00	6.30	4.42	5.23	4.13	-	4.60
19.	*Eclipta prostrate*	3.40	2.25	3.00	4.75	4.40	4.80	2.00	4.75	2.67
20.	*Euphorbia thymifolia*	3.66	3.86	3.00	8.80	7.17	8.12	4.25	4.20	3.00

TABLE V CHANGES IN BASAL COVER (CM^2M^{-2}) OF PLANT SPECIES AT SITES I, II AND III (BASED ON 50 QUADRAT SAMPLING)

S. No.	Plant Species	SUMMER			RAINY			WINTER		
		I	II	III	I	II	III	I	II	III
1.	*Achyranthes aspera*	0.05	0.02	0.02	0.62	0.31	0.18	0.13	0.12	0.07
2.	*Alternanthera paronychioides*	.0003	-	0.004	0.04	0.01	0.01	-	0.003	0.005
3.	*Alternanthera sessilis*	0.003	0.004	-	0.03	0.03	0.01	0.02	0.01	0.008
4.	*Amaranthus Spinosus*	0.04	0.02	0.02	0.16	0.19	0.07	0.06	0.04	0.05
5.	*Amiscophacelus axillaris*	-	0.003	0.003	0.20	0.07	0.03	0.02	0.01	0.009
6.	*Anchusa tenella*	0.008	-	0.008	0.02	0.02	-	-	0.02	0.01
7.	*Anisomeles indica*	-	-	-	0.01	0.005	0.006	0.008	0.004	0.004
8.	*Arundo donax*	-	0.10	-	0.32	1.74	0.40	0.30	0.22	0.10
9.	*Bacopa monnieri*	0.05	-	-	0.11	0.20	0.16	0.03	0.09	0.07
10.	*Bothriospermum tenellum*	0.16	-	0.04	0.47	0.34	0.42	0.25	0.26	0.28
11.	*Caesulia axillaris*	-	-	-	0.03	0.05	-	0.08	0.09	-
12.	*Calotropis procera*	-	0.02	0.02	0.04	0.04	0.02	0.04	0.02	-
13.	*Cleome viscosa*	-	-	-	0.02	0.009	0.02	0.008	-	-
14.	*Croton bonplandianum*	0.009	0.01	-	0.04	0.04	0.02	0.05	0.03	-
15.	*Cynodon dactylon*	1.94	2.46	2.85	6.99	9.69	6.90	7.10	5.54	7.68
16.	*Cyperus difformis*	-	-	-	0.26	0.08	0.07	-	0.06	0.03
17.	*Dentella repens*	-	0.009	0.03	0.04	0.05	-	0.03	0.03	0.03
18.	*Desmostachya bipinnata*	0.02	0.02	0.03	0.08	0.06	0.06	0.04	-	0.03
19.	*Eclipta prostrata*	0.04	0.02	0.04	0.20	0.06	0.12	0.01	0.05	0.02
20.	*Euphorbia thymifolia*	0.01	0.02	0.02	0.06	0.03	0.05	0.01	0.01	0.01
Total		2.33	2.70	3.08	9.74	13.02	8.44	8.18	6.60	8.40

In phytosociological analysis each tiller has been considered as an individual plant and the plants which grow on the land in a creeping manner, each 5 cm portion of the plant having functional roots, is counted as an individual plant [12]. In the present investigation, the phytosociological study has been conducted seasonally, i.e., Summer, Rainy and Winter seasons. Structures of the selected sites were studied with the help of 50 x 50 cm quadrat which has been confirmed by following the species area curve method. Cottom and Curtis (1956) defined various parameters on the basis of which the present phytosociological investigation has been done [13]. These parameters are frequency, density, abundance and basal cover.

Different parameters for each species were calculated with the help of specific formulae listed below:

$$Frequency = \frac{No.\ of\ quadrats\ in\ which\ species\ occurred}{Total\ no.\ of\ quadrats\ sampled} \times 100 \quad (1)$$

$$Density = \frac{Total\ no.\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ no.\ of\ quadrats\ sampled} \quad (2)$$

$$Abundance = \frac{Total\ no.\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{Total\ no.\ of\ quadrats\ in\ which\ species\ occurred} \quad (3)$$

$$Basal\ Cover = Average\ basal\ area \times density \quad (4)$$

where,

$$\left[\begin{array}{l} Average\ basal\ area = \pi r^2\ (cm^2). \\ (where\ r\ is\ radius\ of\ stem\ at\ emerging\ point) \end{array}\right]$$

$$[Radius = Average\ diameter\ (cm)/2]$$

I. Results and Discussion

In Table 1, phenology of different species occurred at the three selected sites are shown at bimonthly intervals of the study period of March 2009 to Feb. 2010. It has practical uses in grassland and other ecosystems. There are various driving variables such as day length, soil water and soil temperature most closely associated with phenological development of plants around embankments of municipal drains [14]. The various phenological events of the plants describing the different stages of life span are represented by following symbols:

Phenological stage	Symbol
Germination	A
Vegetative	B
Flowering	C
Fruiting	D
Mature seeds	E
Death	F

During the months of Nov. to Jan. 2010 most of species are in the flowering and fruiting condition and some were also seen with mature seeds. The germination and vegetative stages of different plant species were seen mostly from the months May to September. From March to May few plants are found to attain the phenological stage of death. During this season some new plants appear and a few others survive in vegetative, flowering and fruiting stage inspite of scorching heat of summer. The soil along the sewage drains up to a limited region including the embankment area is moist almost throughout the year. Therefore, around the embankments of drains different plants can be seen in abundance almost in every season.

The frequency of different species on the three sites (I, II and III) are represented in Table 2. Frequency reveals the degree of dispersion of individual species in an area and is expressed in terms of percentage occurrence.

From the density values depicted in the Table 3, it is clear that total peak density values 115.68, 142.7 and 100.28 m^{-2} for all species were recorded during rainy season and their respective minimum density values were 28.14, 33.92 and 38.98 m^{-2}, recorded during summer season in the respective three sites I, II and III. On the perusal of Table 4, it is clear that abundance values of *Cynodon dactylon* were recorded maximum throughout the whole study period. During summer the values were 49.80, 65.63 and 107.41 m^{-2}, during rainy season the values were recorded 112.00, 135.00 and 94.72 m^{-2} and during the season of winter the abundance values of *C. daclyton* were recorded 91.04, 74.00 and 100.51 m^{-2} at the site I, II and III, respectively. The values of basal cover for all the plant species were maximum during rainy season, i.e., 9.74, 13.02 and 8.44 cm^2m^{-2} at sites I, II and III, respectively.

Phenological observations showed that climatic conditions play an important role in changing the phenology of individual species. A large number of plant species start their germination and growth during early winter season because of sufficient moisture in the soil and favourable condition of temperature for plant growth. Plant sociological characters such as frequency, density and abundance were exclusively influenced by the natural as well as biotic stresses prevailing at the present study sites. Maximum values of frequency and density were recorded in rainy season and minimum in summer season. Plants have shown comparatively higher frequency and density, consequently higher degree on dispersion and numerical strength of species in winter season on account of most sustainable climatic conditions. It seems, in such natural communities, that stability appears to depend on the balance between the stability and variability of the environment [15].

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