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Research Article

VEGETATION ECOLOGY OF WETLANDS OF CENTRAL INDIA WITH REFERENCE TO EMERGENT PLANT COMMUNITIES

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ABSTRACT
Emergent plant communities of Central India were studied in three different seasons. Six wetland sites were selected and sampled using stratified random design method by placing 1mx1m quadrat in three seasons in 2010-2011. Total 49 emergent plant species were recorded with dominant plant species as *Typha angustifolia*, *Scirpus litoralis, Cyperus alopecuroides, Eleocharis sps., Polygonum glabrum and Bothriochloa pertusa.* Maximum diversity was recorded for Sagar Lake Temple Site (SLTS) (H'=1.42) which is least disturbed site, while minimum diversity was recorded for Bebas River (BR) Site (H'=0.31) which is highly disturbed site by human interference. Distribution pattern was found contagious for all the species except *Alternanthera pungens*.

Keywords: *Contagious, Cover, Density, Ecotones, Frequency, Herbarium, Importance Value Index, Lakes, Quadrats*

INTRODUCTION
Wetlands are transitional zones in between terrestrial and aquatic ecosystems and have been termed as ecotones (Roy and Behera, 2003). Their values are increasingly receiving due attention as they contribute to a healthy environment in many ways (Prasad *et al.*, 2002). These wetlands provide a number of ecological services including ground water recharge, flood control, breeding sites for a number of animals, detoxifying the water etc.

They are gradually disappearing and shrinking in volume due to agricultural occupation, weed infestation, pollution, construction activities etc. This loss will lead to degradation of water quality and loss of plant and animal wealth resulting in loss of biodiversity.

The state of Madhya Pradesh situated in Central India, is not very rich in wetlands and has fewer wetlands in comparison to some other states of the country. Total wetland area estimated for this state is 818166 ha, which is 2.5 per cent of the total geographic area of the state (NWIA, 2011). Madhya Pradesh does not have many large sized wetlands, instead it has a large number of small wetlands (44952) having area< 2.25 ha. Some of these wetlands lie in Sagar, Madhya Pradesh, India.

Emergent plants make an important part of wetland ecosystem. They are the most productive plant communities (Wetzel, 2001) and have been termed as 'nutrient pump' (Odum, 1971).

As degradation of wetlands start from margin i.e. littoral zone which is usually dominated by emergent plants therefore they experience the deteriorating effects very early than submerged, free floating and fix floating plants.

There is lack of separate and intensive study of emergent flora of these wetlands, although in other parts of the country a few studies has been carried out on riverine vegetation (eg. Pradhan *et al.*, 2005). Therefore, this work has been carried out to identify different emergent plant communities and to study their diversity which would be helpful for biodiversity conservation and wetland management practices.

Study Area
This study was conducted in Sagar, Madhya Pradesh, India, situated a few kilometers in the North of Tropic of Cancer between 23˚10′N – 24˚ 27′ latitudes and 78˚ 04′ E – 79˚ 21′ E longitudes on an average altitude of ca 517 m above msl.

The area is by and large cropped by the Deccan trap lava flows whereas at places Vindhyan sand stone also crops out. The climate of the region is monsoonic type distributed into three distinguished seasons viz. summer, rainy and winter with average annual rainfall as 1234.8 mm. Six wetland sites with different geomorphology and water sources were selected for the present study after an intensive survey.

MATERIALS AND METHODS

Sampling Method

Sampling was carried out in three seasons viz. summer (5-15 June 2010), winter (5-15 December 2010) and late winter (5-15 March 2011) using stratified random design method (Singh *et al.*, 2006) taking 1 m x 1 m size of quadrats.

Minimum number of quadrats was determined after Mueller – Dombois and Ellenberg (1974) which varied for site to site from 10-20. Frequency, Density and their corresponding relative values were determined after Curtis and McIntosh (1950) while percent cover was determined using Daubenmire cover scale (Daubenmire, 1959, 1968) (Table 2).

Importance Value Index (IVI) of each species was determined following formula IVI=RF+ RD +RC, where RF= Relative Frequency, RD= Relative Density and RC= Relative Cover (Curtis and Mclntosh, 1951 and Misra, 1968). Species having maximum IVI was considered as dominant and the species following maximum IVI was considered as Co- dominant species and the community was named after these two species. Distribution pattern was determined for each species in each season using A/F ratio, where A= Abundance and F= Frequency (Whitford, 1949). On the basis of A/F ratio, distribution of a species was assessed as regular (< 0.025), random (.025-.05) or contagious (>0.05). Diversity parameters determined were:

1. *Shannon Wiener Index of Diversity*, $\overline{H}$, (Shannon & Weaver, 1949) –

$$\overline{\mathrm{H}} = -\sum_{i=1}^{ns} \left(\mathrm{ni}/\mathrm{N}\right) \ln \left(\frac{\mathrm{ni}}{\mathrm{N}}\right)$$

(where $\overline{H}$ = Shannon Weiner Index of Diversity, S = total number of species in the sample, ni = importance value of a species (here density, N = Total importance value of all species)

2. *Concentration of Dominance(*c) or Shimpson Index (Shimpson, 1949) :

$$c = \sum_{i=1}^{S} \left(\frac{ni}{N}\right)^2$$

(cd = Concentration of Dominance, ni = Importance value of i^{th} species, N = Total importance value of all species in a community.

3. *Pielou's Index for Evenness* J' (Pielou, 1995)

$\overline{H}$ as : $J' = \frac{\overline{H}}{\ln S}$ (where, J' = Pielou's index of evenness, $\overline{H}$ = Shannon – Weiner Index of Diversity, S = Total number of species.

4. *Beta Diversity* (β Diversity): β Diversity was calculated by the formula as given by Whittaker (1965), β Diversity = $\frac{Sc}{\overline{S}}$ (where, Sc = Total number of species occurring in a set of samples counting each species only one whether or not it occurs more than once, $\overline{S}$ = Average number of species per individual sample.

To assess similarity among different sites quantitatively modified Sorenson's index of similarity was used (Motyka *et al.*, 1950), $IS_{MO} = \frac{2M_W}{\mathrm{MA} + \mathrm{MB}} \times 100$ (where, IS_{MO}= Index of Similarity, Motyka, M_W =The sum of the smaller quantitative values (Density) of the species common to two communities (sites) and not the sum of both values, MA = Sum of the quantitative values of all species in one of the two sites, MB = Sum of the quantitative values of all species in the other site).

All the plant species occurring were uprooted, collected and brought to the laboratory for identification and herbarium preparation. Plant species were identified using Flora of Madhya Pradesh (Shukla *et al.*, 1992), Flora of Hassan District (Saldhana and Nicolson, 1978) and Flora of British India (Hooker, 1872-1897). Herbarium is submitted in the Botany Dept. of Dr. H. S. Gour University, Sagar (M.P.), India.

RESULTS AND DISCUSION

Emergent Plant Communities

Seasonal changes in IVI and A/F ratio of emergent plant species of different sites are presented in Table 3. In all 49 emergent plant species were observed excluding common species. 24 plant species were recorded from the Rajghat Dam Bridge Site (RDBS) with different seasons dominated by different types of plant communities.

Summer 2010 had *Typha angustifolia – Fimbristylis dipsacea* community while winter 2010 and late winter 2011 had *Typha angustifolia - Cyperus pangorei* community. Maximum IVI for dominant species *T. angustifolia* was recorded in winter, while minimum in summer and is consistently increasing (Table 3). RDDS had 6 species characterized by *Scirpus litoralis- T. angustifolia* community with IVI 157.52 and 100.45 respectively.

Twelve species were recorded from Sagar Lake Temple Site (SLTS). It is dominated by different emergent plant communities in different seasons with *Cyperus alopecuroides- Scirpus maritimus* in summer 2010, *C. alopecuroides – Hygrophila auriculata* in winter 2010 and *C. alopecuroides- T. angustifolia* in late Winter 2011. Thus, dominant species is same while co-dominant changes from season to season. This approves the temporal and spatial changes taking place in the site. Maximum IVI for the dominant species was recorded in summer season (113.05).

Six species were recorded in the summer 2010 from Sagar Lake (SL) site characterized by *Eleocharis sps.- Alternanthera paronichoides* community. In winter 2010-11 lake was cleaned up by Municipal Corporation of emergent vegetation for *Trapa* and *Nelumbo* culture. Therefore, further sampling could not be done.

Bebas River (BR) site had 6 species dominated by *Polygonum glabrum- Cyperus pangorei* community with maximum IVI recorded in summer for dominant species and winter for co-dominant species. Ajagara Nala (AN) site had 14 species dominated by *Bothriochloa pertusa- Capillipedium huegelii* community.

Maximum IVI for dominant species was observed in summer while for co-dominant in winter. Dominant species differs for each and every wetland site of present study.

Distribution Pattern

A/F ratio indicates contagious distribution (A/F >0.05) of all the species except for *Alternanthera pungens* (A/F<0.05, in late winter, RDBS) showing regular distribution (Table 3). Emergent plants grow in clumps making their distribution regular while *A. pungens* is an upland species not growing in clumps.

Diversity Parameters

Maximum diversity was recorded for SLTS (H=1.45±0.45, d=0.29±0.14) followed by RDBS (H= 1.42± 0.10, d=0.35±0.25), with maximum diversity for SLTS in late winter (1.66) and for RDBS in summer (1.45), while other sites are species poor (Table 4). Conversely c was recorded minimum for SLTS followed by RDBS.

Evenness and Species heterogeneity was also recorded maximum for SLTS (J=0.68±0.12, Species heterogeneity=1.88±0.29). RDBS is the least disturbed site as it is far away from human settlements and has moisture throughout the year due to water coming from Municipal Corporation's Water Filtration Assembly allowing growth of many plant species. Likewise SLTS is moderately disturbed site having a fencing that protects the plant species. This site forms the buffer zone of Sagar Lake. Therefore, moisture content remains even in the summer allowing growth of emergent plant species making the site species rich.

Other sites are species poor with minimum diversity recorded for BR site (H=0.46±0.59, d=0.19±0.04) because it is highly disturbed site by anthropogenic activities as bathing, washing, encroachment of

littoral zone for agricultural activities etc. affecting the growth of emergent vegetation. So, BR site had maximum value of c.
SL site is also species poor although it contains water throughout the year. It is highly disturbed site due to a number of anthropogenic activities as *Trapa* culture, fishing, Lotus culture, pollution, concretization of littoral zone etc. These activities alter the geological and physico-chemical properties of littoral zone which prohibit establishment of emergent flora.
AN site receives water from a seasonal river that flows only in monsoon (June to September) becomes species rich in winter and late winter but dry conditions of summer allow growth of a few species (3) only reducing the average diversity of the site to 0.9 ±0.31. This site harbors a number of riparian plant species in winter and late winter.
β Div. was recorded maximum for RDBS (5.35±1.95) followed by SLTS(4.80±2.34) showing spatial heterogeneity of the site. Albeit, the site's geomorphology is quite uneven with some rocky portion and some ditches.

Table 1: Seasonal Changes in A/F and IVI of Emergent Plant Species of Different Sites (Sum-Summer, Win-Winter)

Name of the Species	A/F Ratio			IVI		
	Sum 2010	Win 2010-11	Late Win 2012	Sum 2010	Win 2010-11	Late win 2012
Rajghat Dam Bridge Site (RDBS)						
Typha angustifolia L.	0.44	0.89	0.38	96.11	129.39	129.82
Fimbristylis dipsacea (Rottb.) Cl.	0.67	-	-	78.69	-	-
Cyperus pangorei Rottb.	8.55	1.71	17.10	57.42	60.52	78.17
Cyperus pumilus L.	1.04	2.84	4.40	22.77	56.80	4.58
Cyperus cyperoides (L.) Kuntze	0.18	0.27	-	14.53	11.68	-
Cyperus difformis L.	0.18	-	-	5.68	-	-
Fimbristylis podocarpa Nees.	0.60	-	3.40	5.48	-	3.93
Phyla nodiflora (L.) Greene	0.25	-	-	3.77	-	-
Cyperus laevigatus L.	1.20	-	3.00	3.23	-	3.69
Ipomoea carnea jacq. (I. fistulosa Mart ex Choisy)	0.20	-	0.80	2.97	-	2.34
Polygonum glabrum Willd.	0.40	0.10	-	2.05	3.96	-
Eclipta alba (L.) Hassk.	0.40	0.40	-	1.86	4.24	-
Eragrostis sps.	0.20	1.05	-	1.81	4.85	-
Parthenium hysterophorus L.	0.20	-	-	1.81	-	-
Blumea sps.	0.20	-	0.60	1.81	-	2.24
Alternanthera pungens Humb.	-	0.35	0.01	-	9.26	26.37
Ludwigia prostrata Roxb.	-	0.22	-	-	6.48	-
Cyathocline purpurea (Don) Kuntze	-	0.55	0.40	-	4.42	4.82
Ageratum conyzoides L.	-	0.45	-	-	4.29	-
Glinus lotoides L.	-	0.25	0.06	-	4.10	12.41
Alternanthera sessili s (L.) R. Br.	-	-	-	-	-	
*Scirpus maritimus*L.	-	-	0.18	-	-	6.46

Contd….

Table 2: Continued.

Name of the Species	A/F Ratio			IVI		
	Sum. 2010	**Win. 2010-11**	**Late win. 2012**	**Sum. 2010**	**Win. 2010-11**	**Late win. 2012**
Lindernia antipoda (L.) Alston	-	-	0.14	-	14.13	-
Polypogon monspeliensis (L.) Desf.	-	-	0.31	-	-	11.04
Rajghat Dam Down Stream Site (RDDS)						
Scirpus litoralis Schrad.	4.43	7.04	71.85	96.34	157.52	148.41
Typha angustifolia L.	0.37	0.65	8.49	77.75	98.61	100.45
Polygonum barbatum L.	0.79	2.36	7.82	68.51	21.35	17.70
Cyperus pangorei Rottb.	10.0	8.80	11.84	52.81	22.25	24.74
Alternanthera paronychioides St. Hil.	0.80	-	-	4.58	-	
Rumex dentatus L. Subsp. Klotzschianus (Meisn.) Rebb. f.	-	-	-	-	-	8.71
Sagar Lake Temple Site (SLTS)						
Cyperus alopecuroides Rottb.	0.45	2.23	2.01	113.05	95.40	98.83
Scirpus maritimus L.	0.93	1.93	0.78	90.88	22.10	32.05
Hygrophila auriculata (Sdchumach) Heine	0.34	1.13	0.60	40.96	93.75	12.89
Typha angustifolia L.	0.54	0.84	0.88	34.65	54.57	65.59
Glinus lotoides L.	0.07	0.60	0.20	9.64	6.54	3.07
Ipomoea aquatica Forsk.	0.10	0.07	0.07	7.58	8.60	9.18
Phyla nodiflora (L.) greene	0.20	-	-	3.26	-	-
Caesulia axillaris Roxb.	-	0.20	0.20	-	12.43	3.07

Contd.…

Table 2: Continued

Name of the Plant Species	A/F Ratio			IVI		
	Sum. 2010	**Win. 2010-11**	**Late Win. 2012**	**Sum. 2010**	**Win. 2010-11**	**Late Win. 2012**
Cyperus cephalotus Vahl	-	0.65	-	-	6.62	-
Rumexdentatus L. subsp. Klotzschianus (Meisn.) Rcbb. f.	-	-	0.78	-	-	44.11
Ludwigia prostrata Roxb.	-	-	1.02	-	-	21.31
Eclipta prostrata (L.) L.	-	-	12.00	-	-	10.15
Sagar Lake Site						
Eleocharis sps.	13.17	-	-	164.03	-	-

Alternanthera paronychioides St. Hil.	2.60	-	-	51.08	-	-
Polygonum glabrum Willd.	0.37	-	-	38.40	-	-
Cyperus serotinus Rottb.	1.24	-	-	30.20	-	-
Ludwigia adscendens (L.) Hara	36.00	-	-	12.25	-	-
Ipomoea aquatica Forsk.	0.20	-	-	4.03	-	-
Bebas River Site (BR site)						
Polygonum glabrum Willd.	0.69	0.50	0.89	256.53	214.00	247.98
Cyperus pangorei Rottb.	0.88	1.12	0.42	24.64	52.76	34.16
Parthenium hysterophorus L.	0.60	-	-	9.93	-	-
Fimbristylis dipsacea (Rottb.) Cl.	0.10	-	0.10	8.90	-	8.93
Alternanthgera pungens Humb.	-	0.03	0.10	-	23.46	8.93
Xanthium strumarium L.	-	0.80	-	-	9.77	-
AN Site						
Bothriochloa pertusa (L.) A. Camus	2.58	2.88	2.40	204.02	153.64	176.28
Capillipedium huegelii (Hack.) Stapf	6.00	5.11	6.13	49.85	70.54	40.84
Cyperus pangorei Rottb.	0.74	2.50	0.63	46.13	7.12	13.88
Coix lacryma-jobi L.	-	0.36	-	-	21.85	-
Pseudosorghum fasciculare (Roxb.) A. Camus	-	1.50	-	-	10.19	-
Cyathocline purpurea (Don) Kuntze	-	1.10	0.04	-	10.67	18.15
Rotala rotundifolia (Roxb.) Koehne	-	3.00	10.00	-	7.42	-

Contd……,

Table 2: Continued

Name of the Plant Species	A/F Ratio			IVI		
	Sum. 2010	**Win. 2010-11**	**Late Win. 2012**	**Sum. 2010**	**Win. 2010-11**	**Late Win. 2012**
Coix lacryma-jobi L.	-	0.36	-	-	21.85	-
Pseudosorghum fasciculare (Roxb.) A. Camus	-	1.50	-	-	10.19	-
Cyathocline purpurea (Don) Kuntze	-	1.10	0.04	-	10.67	18.15
Rotala rotundifolia (Roxb.) Koehne	-	3.00	10.00	-	7.42	-
Ajagara Nala (AN) Site						
Dipteracanthus prostratus (Poir) Nees.	-	1.20	-	-	6.32	13.91
Canscora decurrens Dalzell	-	0.30	-	-	5.76	-
Canscora decussata Sch. And Sch.	-	0.30	-	-	5.76	-
Blumea sps.	-	-	0.25	-	-	12.68
Rumex dentatus L. subsp. *Klotzschianus* (Meisn.) Rcbb. f.	-	-	0.10	-	-	12.21
Polygonum plebeium R. Br.	-	-	0.10	-	-	6.02
Verbascum chinense L. Santapau	-	-	0.10	-	-	6.02

Table 3: Diversity Parameters and their F-Values (Significant Values with Asteriks)

Diversity Parameter	**Name of the Site**	**Season**			**Average±Standard Error**
		Summer 2010	**Winter 2010-11**	**Spring 2011**	
	RDBS	1.45	1.37	1.43	1.42±0.10
	RDDS	0.76	0.72	1.02	0.83±0.40
H	SLTS	1.37	1.32	1.66	1.45±0.45
	BR	0.34	0.74	0.31	0.46±0.59
	AN	0.76	1	0.94	0.90±0.31
	RDBS	0.27	0.29	0.34	0.30±0.09
	RDDS	0.56	0.63	0.50	0.56±0.16
C	SLTS	0.29	0.32	0.25	0.29±0.09
	BR	0.84	0.55	0.84	0.74±0.41
	AN	0.56	0.49	0.52	0.52±0.09
	RDBS	0.33	0.26	0.46	0.35±0.25
	RDDS	0.09	0.07	0.11	0.09±0.05
D	SLTS	0.29	0.23	0.34	0.29±0.14
	BR	0.18	0.21	0.18	0.19±0.04
	AN	0.08	0.25	0.25	0.19±0.24
	RDBS	1.9	1.83	1.71	1.81±0.24
	RDDS	1.34	1.26	1.41	1.34±0.18
Sps. Het.	SLTS	1.86	1.77	2.00	1.88±0.29
	BR	1.09	1.35	1.09	1.18±0.37
	AN	1.34	1.43	1.39	1.39±0.11
	RDBS	0.54	0.55	0.56	0.55±0.02
	RDDS	0.79	0.52	0.63	0.65±0.33
J	SLTS	0.70	0.63	0.72	0.68±0.12
	BR	0.25	0.53	0.22	0.33±0.42
	AN	0.69	0.43	0.43	0.52±0.37
	RDBS	5.26	4.61	6.19	5.35±1.95
	RDDS	3.68	3.30	3.70	3.56±0.55
β Div.	SLTS	4.11	4.40	5.88	4.80±2.34
	BR	3.60	3.33	3.33	3.42±0.38
	AN	2.5	5.26	4	3.92±3.40

Table 4: Average Similarity in Percentage among Sites

Sites	**RDBS**	**RDDS**	**SLTS**	**BR**	**AN**
RDBS	-	28	10	9	5
RDDS	-	-	10	7	8
SLTS	-	-	--	0	0
BR	-	-		-	3
AN	-	-	-	-	-

Conclusion

These all wetlands lie in rural areas having their important role in rural lives through a number of ecological services. These wetlands have the potential to be used as recreation sites. They are also important for groudwater recharge, local flora and fauna. Aquatic and semiaquatic macrophytes play an important role in maintaining the riverine ecosystem (Pradhan *et al*., 2005). In recent times many species are gradually becoming rare in their earlier area of occurrence due to habitat modifications, overharvesting and invasion by exotic as well as aggressive weeds (Lacoul and Freedman, 2006). Therefore, aquatic plants are also directly threatened, sometimes even without coming to the knowledge of mankind (Cronk and Fennessy, 2001). There is not any effective management policy for the proper use of these wetlands and runoff from adjoining areas are adding sediments year by year. If used properly SLTS and SL sites can be used for waste water treatment of Sagar City. They can also be used for nutrient removal. According to Okurut *et al.,* (2001) the amount of nutrients removed through harvesting could remove substantial part of the inflow load in tropical and subtropical regions where harvest is possible several times during the year.

Wetlands have been considered effective buffers, retaining water and nutrients, improving water quality, and providing diverse and dynamic habitats for wildlife (Naiman *et al.,* 1994; Yin and Lan, 1995; Tabacchi *et al*., 1998 and Coveney *et al.*, 2002).

Therefore, remediation and restoration of lake shore wetlands is an essential component of lake restoration (Lu *et al.,* 2007). Restoration of SL and SLTS will improve quality of Sagar Lake and restoration of RDBS and RDDS will improve biodiversity at local level. RDBS and RDDS sites can also be used as recreation sites if developed properly. BR site has large littoral area having potential for emergent plant growth. This site is highly disturbed site and it must be protected from encroachment and should be developed as riparian wetland. Farmers and villagers should be made aware of importance of these ecosystems. Likewise AN site having a good amount of riparian flora must be protected and developed.

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