

FLORISTIC DIVERSITY IN THE WETLANDS OF SOUTH EAST RAJASTHAN : A STUDY OF ABHERA POND AND ITS NEIGHBOURHOOD

N. K. SHARMA and SURBHI SHARMA

P.G. Department of Botany, Govt. College, Kota-324001, India.

Wetlands are transitional zones which occupy intermediate position between the dry land and open water." Therefore wetland ecosystems are dominated by the influence of water and encompass diverse and heterogenous habitat. Considering these interesting habitats, the ecological survey of Abhera pond near Kota south east Rajasthan was undertaken. The studies revealed that alongwith wetland plants, some truly aquatic species and some terrestrial plants were found in Abhera pond and in its neighbourhood. Hence 170 species of vascular plants distributed in 147 genera and 63 families were recorded from the area. In addition to this seasonal patterns in the physiognomy phenology and distribution of plants were also obvious as a result of phytosociological studies done in all the seasons (In the year 2002-03) Seasonal behaviour of wetland species leading to the amphibiousness has also been emphasized.

Keywords : Ephemerals; Habitat; IVI; Wetlands.

Introduction

Wetlands have earned a global importance particularly since 1971 when the first international convention on wetlands was held at Ramsar Iraq. According to the proposals approved by the Ramsar Convention "wetlands are defined as transitional zones that occupy intermediate position between the dry land and open water." Therefore wetlands are characteristically transitory between aquatic and terrestrial ecosystem. These are water saturated, natural or man made lands of Earth, having water-logged or water saturated, natural or man made lands of Earth having water-logged conditions seasonally or permanently and are the most productive life support system of Earth¹. Hence wetlands can also be considered as ecotone between terrestrial and aquatic ecosystems².

The initial studies about wetland ecology in our country were carried out by Biswas and Calder³, and which were later on continued by several workers⁴⁻⁶. In Rajasthan studies regarding the aquatic and marshland flora were previously made by several workers⁷⁻¹² Sharma, Shringi and Tiagi¹³. However none of them have worked out the various aspects of floristic diversity and phytosociological aspects of Abhera pond and its neighbourhood. Therefore present investigations may be considered as initial efforts in this direction.

Study site - In the present investigation the floristic survey and phytosociological studies were carried out at Abhera pond and its neighbourhood. This is a perennial permanent

pond located near village Nanta, 7 kms. away from Kota city in south west direction (25° 45' - 25°50' N latitude and 77° 17'-77° 22' E longitude at 300 m above msl). The neighbourhood of the pond presents lush green site in the rainy season. The large Abhera pond is considered important for irrigation purpose as well as partially for fish breeding also by the Fisheries Development Department of Rajasthan. The pond has got an approximate area of 25 hectares, out of which nearly 15 hectares of the area is covered with water. It has got maximum depth of 13 feet only now-a-days because of its continuous silting in rainy season and negligence in maintenance. Fluctuations in water level and year round anthropogenic influences constitute essential feature of this area. Temporal and spatial pattern of vegetation in this area and its neighbourhood were also taken into account during present course of studies.

Methodology - The large Abhera pond supports a rich variety of aquatic and marshland plants including typical wetland vegetation alongwith submerged and emergent free floating and amphibious plants. For the sake of convenience regarding the studies about the floristic diversity in the area aquatic as well as terrestrial vegetation of its neighbourhood both were considered simultaneously. For this purpose plant exploration trips at Abhera and its neighbourhood were organized in the form of monthly collection trips during July, 2002 to December, 2003. The plant specimens collected were duly identified with help

of floras of Shetty & Singh¹⁴ Duthie¹⁵ and Sharma¹⁶. Phytosociological studies of vegetation were carried out to analyze the distribution pattern and changes in the physiognomy of vascular plants in the surveyed area. For this purpose four stands were selected in the East, West, North and South directions of the pond, where 5(1x1 mt.) quadrats were laid randomly just near and slightly away from water body. These phytosociological studies were carried out in the winter, summer and rainy (in the month of September) seasons. For expression of the dominance and ecological success of these wetland species, IVI was calculated (Table 1) by taking Relative frequency (R.F.), Relative density (R.D.) and Relative dominance (R. Com.) into considerations, as suggested by Mishra¹⁷. In this manner a clear and complete picture of the floristic diversity of the area could be made available.

Results and Discussion

As a result of periodic and extensive plant explorations made by the authors in the years 2002 and 2003, 170 species belonging to 147 genera and 63 families were reported from the area under study (Table 2). Out of these 2 plant species viz. *Marsilea minuta* and *Azolla pinnata* were belonging to the 2 genera and 2 families of Pteridophyta. Hence Angiosperms are represented by 168 species belonging to 145 genera and 61 families. Here monocotyledons are represented by 30 species, belonging to 28 genera and 10 families, while Dicotyledons are having 138 species belonging to 117 genera and 51 families. The ratio of Monocots to Dicots is approximately 1 : 5.66 of families, 1 : 4.33 of genera and 1 : 4.88 of species. The ratio of total number of genera to species is approximately 1 : 1.2. This may be attributed to the presence of diversified habitats in the area under study i.e. Aquatic habitat, marshes, wet soils, dried water bodies and gravelly and rocky habitats, which flourish the appearance of more and more plant varieties.

A careful analysis of the floristic data reveals that 48 species of vascular plants were observed in almost all the directions in Abhera and its environs. However 59 plant species were found only in one of the four directions, this may be attributed to their distribution pattern, degree of ecological amplitude and capability of their propagule dispersal and ecesis.

Phenological studies about the vegetation of the area under study reveal that out of the 16 species of angiosperms 22 species flowering almost through out the year, while most of the species exhibit flowering only in monsoon and post monsoon period. This may be attributed to the ephemeral nature of most of the plants as well as availability of suitable conditions for flowering and

agencies for the pollination. However, flowering in 22 species eg. *Coldenia procumbens*, *Gnaphalium indicum*, *Polygonum plebium*, *Potentilla supina* and *Ranunculus sceleratus*, takes place in winter or late winter or in spring season. This may be attributed the appearance of wet soils or dried pockets in or near the water bodies after receding the water level due to evaporation or due to use of water for canal irrigation. The plants make late appearance in these conditions and then flower afterwards.

Thorough analysis about the various plants habitats of Abhera pond and its neighbourhood reveal that out of the 170 species, more than 100 species belong to aquatic and marshland flora alongwith some specific plant species found in dried soils of water bodies or slightly away from the wet soil beds of Abhera pond. Out of these species, five are that of submerged hydrophytes viz. *Ceratophyllum demersum*, *Hydrilla verticellata*, *Vallisneria spiralis*, *Potamogeton crispus* and *Potamogeton perfoliatus*, five hydrophytic species are of rooted plants with floating leaves viz. *Nelumbo nucifera*, *Nymphaea nauchali*, *Impomoea aquatica*, *Nymphoides hydrophylla* and *Nymphoides indica*, while two species *Lemna perpusilla* and *Azolla pinnata* are of free floating vascular plants. However some species eg. *Marsilea minuta*, *Hygrophila auriculata* and *Polygonum glabrum* etc. are found in amphibious conditions, while others eg. *Exacum pedunculatum*, *Hoppea dichotoma* and *Crotalaria hirsuta* are found in wet soils or near the banks of water bodies. On the other hand some species viz. *Glinus lotoides*, *Coldenia procumbens* and *Heliotropium supinum* are found some far away in dried soils or in the dried beds of water bodies. Dominance of wet land species or aquatic and marshland flora of the area may be attributed to the vicinity of large Abhera tank and other minor water bodies eg. ditches, puddles and nals in the area under study.

The phytosociological data collected during the study period (Table-1) reveal that *Cynodon dactylon*, *Marsilea minuta* and *Scirpus articulatus* are those species which depict highest mean IVI in almost all the directions. Other noteworthy dominant plant species are, *Chloris virgata*, *Indigofera cordifolia*, *Polygonum plebium*, *Bacopa monnieri*, *Hoppea dichotoma*, *Potentilla supina* and *Rotala indica*. However presence of first two species alongwith *Hoppea dichotoma* in rainy season only may be attributed to their ephemeral nature, while absence of *Marsilea minuta* in rainy season and early winters from the Quadrats may be attributed to the increased water level in pond and other water bodies which inhibit the appearance of this species in the increased depths. In post monsoon season or in winters when water level recedes,

Table 1. Mean IVI of Abhera wetlands in different in different directions during 2002-03

S.No.	Name of species	East	West	North	South	Remarks
1.	<i>Acalypha ciliata</i>	-	-	-	10/04	Present only in South
2.	<i>Aloe vera</i>	-	0.68	-	-	Present only in West
3.	<i>Alternanthera sessilis</i>	-	-	4.52	-	Present only in North
4.	<i>Alysicarpus monilefer</i>	-	10.04	-	3.97	Present only in West
5.	<i>Ammania baccifera</i>	2.53	9.16	30.80	6.80	Present in all direct
6.	<i>Bacopa monnieri</i>	6.60	3.50	29.90	11.02	Present in all direct
7.	<i>Bergia ammanioides</i>	8.21	7.14	-	10.71	Absent only in North
8.	<i>Cassia tora</i>	2.66	3.07	-	8.90	Absent only in North
9.	<i>Centraurium centaurioides</i>	-	2.50	5.13	-	Present in W. & N.
10.	<i>Chloris virgata</i>	12.56	20.98	5.80	-	Absent only in South
11.	<i>Convolvulus arvensis</i>	-	4.80	-	-	Present only in West
12.	<i>Cynodon dactylon</i>	53.01	29.80	21.30	36.25	Present in all direct
13.	<i>Dactylectenium aegypticum</i>	-	7.94	-	7.53	Present in W. & S.
14.	<i>Eclipta prostrata</i>	7.80	10.40	5.19	5.00	Present in all direct
15.	<i>Eragrostis tenella</i>	3.85	2.29	4.32	-	Present in E., W. & N.
16.	<i>Evolvulus alsinoides</i>	1.62	2.97	39.30	-	Present in E., W. & N.
17.	<i>Exacum pedunculatym</i>	-	5.94	8.09	2.30	Present in W., N. & S.
18.	<i>Glinus lotoides</i>	-	15.22	5.22	8.02	Present in W., N. & S.
19.	<i>Heliotropium supinum</i>	4.38	-	8.43	-	Present in E. & N.
20.	<i>Hoppea dichotoma</i>	9.53	10.80	12.31	23.55	Present in all direct
21.	<i>Indigofera cordifolia</i>	-	23.74	-	2.98	Present in W. & S.
22.	<i>Justicea heterocarpa</i>	7.91	2.32	-	-	Present in E. & S.
23.	<i>Launaea coromandelica</i>	2.87	-	-	-	Present only in East
24.	<i>Lindenbergia indica</i>	1.62	9.05	-	3.93	Present in E. W. & S.
25.	<i>Marsilea minuta</i>	51.15	24.80	8.86	34.70	Present in all direct.
26.	<i>Melilotus indica</i>	1.91	-	1.86	-	Present in E. & N.
27.	<i>Nymphoides indicum</i>	-	-	2.46	-	Present only in North
28.	<i>Oldenlandia umbellata</i>	2.32	2.16	7.06	1.59	Present in all direct.
29.	<i>Oxalis corniculata</i>	-	6.97	6.72	-	Present in W. & N.
30.	<i>Phyla nodiflora</i>	2.00	-	1.87	2.13	Present in E. N. & S.
31.	<i>Polygonun plebium</i>	3.71	3.30	8.16	36.50	Present in all direct
32.	<i>Potentilla supina</i>	-	2.57	28.81	9.56	Present in W. N. & S.
33.	<i>Rotala indica</i>	9.62	-	10.93	16.40	Present in E. N. & S.
34.	<i>Rumex dentatus</i>	3.95	9.63	1.62	-	Present in E. W. & N.
35.	<i>Rungia elagans</i>	1.76	6.32	5.37	3.00	Present in all direct.
36.	<i>Scirpus articulatus</i>	37.01	30.60	3.26	8.70	Present in all direct
37.	<i>Cyperus difformis</i>	18.32	15.15	15.91	-	Present in E. W. & N.
38.	<i>Sesbania bispinosa</i>	3.15	-	-	-	Present in only East
39.	<i>Sida rhombifolia</i>	3.07	-	-	8.80	Present in E. & S.
40.	<i>Tridax procumbens</i>	-	-	1.78	12.02	Present in N. & S.
41.	<i>Verbascum chinense</i>	-	-	-	3.16	Prsent only in South
42.	<i>Varnonia cinerea</i>	-	-	3.18	-	Present in North

Table 2. Check list of Plants of Abhera and its neighbourhood

S.No.	Name of species	Family	Phenology	Presence			
				E	W	N	S
(A)	<i>Dicotyledons</i>						
1.	<i>Acacia catechu</i> Wild	Mimosaceae	Sept.-Dec.	-	-	+	-
2.	<i>Acacia leucophloeta</i> (Roxb) Wild	Mimosaceae	Sept.-Dec.	-	-	+	-
3.	<i>Acacia nilotica</i> (L) Wild	Mimosaceae	Sept.-Nov.	-	-	+	+
4.	<i>Acalypha ciliata</i> Forsk	Euphorbiaceae	July-Oct.	-	+	+	-
5.	<i>Ageratum conyzoides</i> (L)	Asteraceae	Throughout the yr.	+	+	+	+
6.	<i>Alternanthera sessilis</i> (L) R.B.	Amaranthaceae	Aug.-Nov.	+	+	+	+
7.	<i>Alysicarpus monilifer</i> (L) DC.	Fabaceae	July-Sept.	+	+	+	+
8.	<i>Amaranthus spinosus</i> L.	Amaranthaceae	July-Oct.	+	-	-	-
9.	<i>Amaranthus viridis</i> L.	Amaranthaceae	July-Oct.	+	-	-	-
10.	<i>Ammannia baccifera</i> L.	Lythraceae	Aug.-Feb.	+	+	+	+
11.	<i>Anisomeles indica</i> (L) O. Ktz.	Lamiaceae	Aug. - Dec.	-	+	-	-
12.	<i>Anogeissus pendula</i> Ed.	Combretaceae	Oct. - Jan.	-	+	-	-
13.	<i>Argemone mexicana</i> L.	Papaveraceae	Dec. - Jun.	-	-	+	-
14.	<i>Bacopa monnieri</i> (L) Wet.	Scophulariaceae	Aug. - Nov.	+	+	+	+
15.	<i>Balanites aegyptiaca</i> (L) Del.	Balanitaceae	Apr. - Sept.	+	-	-	-
16.	<i>Barlaeria prionitis</i> L.	Acanthaceae	Sept. - Feb.	-	+	-	-
17.	<i>Bauhinia racemosa</i> Lam.	Caesalpinaceae	May - Nov.	-	-	+	-
18.	<i>Bergia ammannioides</i> Roth.	Elatinaceae	Aug. - Nov.	+	+	-	+
19.	<i>Blumea lacera</i> D.C.	Asteraceae	Feb. - June	+	+	+	-
20.	<i>Boerhaavia diffusa</i> L.	Nyctiginaceae	Throughout the yr.	-	+	-	+
21.	<i>Borreria articularis</i> (LF) Mill	Rubiaceae	July - Nov.	-	+	-	+
22.	<i>Butea monosperma</i> (L) Taub	Fabaceae	Mar. - June	-	+	+	+
23.	<i>Caesulia axillaris</i> Roxb	Asteroceae	Aug. - Nov.	-	-	+	-
24.	<i>Calotropis procera</i> Ait	Asclapiadaceae	Throughout the yr.	-	-	+	-
25.	<i>Cassia auriculata</i> L.	Caesalpinaceae	Aug. - Nov.	-	+	+	-
26.	<i>Cassia occidentalis</i> L.	Caesalpinaceae	Aug. - Nov.	+	+	+	+
27.	<i>Cassia tora</i> L.	Caesalpinaceae	Aug. - Nov.				
28.	<i>Catharantus pusillus</i> (Murr.) G. Don	Apocynaceae	July - Sept.	+	-	-	-
29.	<i>Centaurim centaurioides</i> (Roxb.) Rao & Ramadri	Gentianoceae	Dec. - March	+	+	+	+
30.	<i>Chenopodium murale</i> L.	Chenopodiaceae	Nov. - Apr.	+	-	-	-
31.	<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	Sept. - Mar.	+	+	-	+
32.	<i>Cissampelos pariera</i> L.	Menispermaceae	July - Dec.	-	+	-	-
33.	<i>Cleome viscosa</i> L.	Cleomaceae	July - Dec.	-	+	-	-
34.	<i>Cocculus hirsutus</i> (L) Diet.	Menispermaceae	Nov. - April	-	-	-	+
35.	<i>Cohlearia cochlearioides</i> (Roth.) Sant & Mahesh	Brassicaceae	Dec. - April	+	-	-	-
36.	<i>Coldenia procumbens</i> L.	Boraginaceae	Dec. - Mar.	-	-	+	-
37.	<i>Convolvulus microphyllous</i> L.	Convolvulaceae	May - Dec.	+	+	+	+
38.	<i>Corchorus capsularis</i> L.	Boraginaceae	Dec. - Oct.	+	-	-	+

Table 2. Contd.

S.No	Name of species	Family	Phenology	Presence			
				E	W	N	S
39.	<i>Corchorus tridens</i> L.	Tiliaceae	Aug. - dec.	-	+	-	-
40.	<i>Corchorus trilocularis</i> L.	Tiliaceae	July - Nov.	-	+	-	-
41.	<i>Cordia dichotoma</i> Forst. F.	Ehretiaceae	Feb. - Jun.	+	-	-	-
42.	<i>Coronopus didymus</i> (L) Sm.	Brassicaceae	Jan. - Apri.	-	-	-	+
43.	<i>Crotalaria orixensis hirsuta</i>	Fabaceae	Aug. - Oct.	-	-	+	-
44.	<i>Datura metel</i> L.	Solanaceae	Most pt. of the yr.	-	-	+	-
45.	<i>Desmodium gangeticum</i> (L) DC.	Fabaceae	Aug. - Nov.	-	+	-	-
46.	<i>Desmodium triflorum</i> DC.	Fabaceae	Sept. - Nov.	+	+	-	+
47.	<i>Dichrostachys cinerea</i> (L) Wight	Mimosaceae	Aug. - Oct.	+	-	+	-
48.	<i>Digera muricata</i> (L) Mart	Amaranthaceae	Aug. - Nov.	-	+	-	-
49.	<i>Dipteracantus prostratus</i> (Poir) Nees.	Acanthaceae	July - Nov.	-	+	-	-
50.	<i>Eclipta prostrata</i> L.	Asteraceae	Throughout the yr.	+	+	+	+
51.	<i>Elytraria acaulis</i> (L) Linda	Acanthaceae	Aug. - Oct.	+	+	+	+
52.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Throughout the yr.	+	+	+	+
53.	<i>Euphorbia parviflora</i> L.	Euphorbiaceae	Aug. - Oct.	+	+	+	+
54.	<i>Evolvulus alsinoides</i> L.	Convolvulaceae	July - Dec.	+	+	+	+
55.	<i>Exacum pedunculatum</i> L.	Gentianaceae	Sept. - Feb.	+	+	+	+
56.	<i>Glinus lotoides</i> L.	Molluginaceae	Aug. - Mar.	+	+	+	+
57.	<i>Glossocardia bosvallea</i> (L.F.) DC	Asteraceae	Aug. - Oct.	+	+	-	-
58.	<i>Gnaphalium indicum</i> L.	Asteraceae	Jan. - Apri.	-	+	-	-
59.	<i>Gnaphalium pulvinatum</i> Del.	Asteraceae	Jan. - Apr.	-	+	-	-
60.	<i>Grangea maderaspatana</i> (L) Poir	Asteraceae	Most of the year	-	+	-	-
61.	<i>Grewia subinaequalis</i> DC	Tiliaceae	Mar. - June	+	-	-	-
62.	<i>Heliotropium marifolium</i> Retz.	Boraginaceae	Sept. - Mar.	-	-	-	+
63.	<i>Heliotropium supinum</i> L.	Boraginaceae	Sept. - Mar.	+	+	+	+
64.	<i>Holoptelea integrifolia</i> (Roxb.) Planch	Ulmaceae	March - Ja.	+	+	+	+
65.	<i>Hoppea dichotoma</i> Heyre	Gentianaceae	Oct. - Mar.	+	+	+	+
66.	<i>Hygrophila auriculato</i> Heine	Acanthaceae	Oct. - Apr.	-	-	+	-
67.	<i>Ichnocarpus frutescens</i> (L) RBr.	Apocynaceae	Dec. - Apr.	+	+	+	+
68.	<i>Indigofera cordifolia</i> Heyne ex. Roth	Fabaceae	July - Dec.	+	-	+	-
69.	<i>Indigofera linifolia</i> wild	Fabaceae	July - Dec.	+	-	+	-
70.	<i>Ipomoea aquatica</i> Forsk.	Convolvulaceae	Most part of the yr	-	+	-	-
71.	<i>Ipomoea carnea</i> jacqu.	Convolvulaceae	Most part of the yr	+	+	-	+
72.	<i>Justicia heterocarpa</i> T. Anders	Acanthaceae	Aut. - Nov.	+	+	-	-
73.	<i>Kickxia ramosissima</i> (Will) Janchan	Scrophulariaceae	Throughout the yr.	+	+	+	+
74.	<i>Lannea coromendalica</i> (Houtt.) Merril	Anacardiaceae	Feb. - June	+	+	+	+
75.	<i>Lantana camara</i> L.	Verbenaceae	Throughout the yr.	-	-	+	-
76.	<i>Lepidagathis hamiltoniana</i> Wall	Acanthaceae	Nov. - March	-	-	-	+
77.	<i>Leucas cephalotes</i> spreng.	Lamiaceae	Sept. - Dec.	-	-	-	+
78.	<i>Leucas aspera</i> (Willd) Link	Lamiaceae	Throughout the yr.	-	-	-	+

Table 2. Contd.

S.No.	Name of species	Family	Phenology	Presence			
				E	W	N	S
79.	<i>Limnophila aquatica</i> (Roxb.) Alton	Scrophulariaceae	Aug. - Feb.	+	+	+	-
80.	<i>Lindenbergia indica</i> (L) Vatke	Scrophulariaceae	July - Apr.	+	+	+	+
81.	<i>Lindernia ciliata</i> Pennel	Scrophulariaceae	Aug. - Feb.	-	+	+	+
82.	<i>Ludwigia perennis</i> L.	Onagraceae	Aug. - Oct.	+	+	-	-
83.	<i>Martynia annua</i> L.	Martyniaceae	Aug. - Oct.	-	-	+	-
84.	<i>Medicago lupulina</i> L.	Fabaceae	Jan. - Mar.	-	-	-	+
85.	<i>Medicago Polymorpha</i> L.	Fabaceae	Dec. - March	-	-	+	-
86.	<i>Melilotus indica</i> (L) All.	Fabaceae	Jan. - Apr.	-	-	+	-
87.	<i>Mollugo pentaphylla</i> L.	Molluginaceae	Jul. - Oct.	-	-	-	+
88.	<i>Momordica balsamina</i> L.	Cucurbitaceae	July - Oct.	-	-	+	-
89.	<i>Mucuna prurita</i> Hook	Fabaceae	Aug. - April	-	-	+	-
90.	<i>Nelumbo nucifera</i> Gaeten	Nelumbonaceae	Aug. - Nov.	+	+	+	+
91.	<i>Neptunia triquetra</i> Benth	Mimosaceae	Apr. - Aug.	+	+	-	-
92.	<i>Nymphaea nauchali</i> Burm.f.	Nymphaeaceae	Aug. - Feb.	+	+	+	+
93.	<i>Nymphoides hydrophylla</i> (Lour) Ktze.	Menyanthaceae	Sept. - Mar.	+	+	+	+
94.	<i>Nymphoides indica</i> (Lour) O.Ktz.	Menyanthaceae	Most part of the yr.	+	+	+	+
95.	<i>Ocimum americanum</i> L.	Lamiaceae	Sept. - Dec.	-	+	+	-
96.	<i>Oldenlandia umbellata</i> L.	Oxilidaceae	Aug. - Oct..	+	+	+	+
97.	<i>Oxalis corniculata</i> L.	Oxilidaceae	Throughout the yr.	+	+	+	+
98.	<i>Oxystelma secamone</i> (L) K.Schum	Asclepiadaceae	Jul. - Feb.	+	-	-	-
99.	<i>Pedaliium murax</i> L.	Pedaliaceae	Aug. - Nov.	-	+	-	-
100.	<i>Phyla nodiflora</i> (L) E. Green	Verbenaceae	Throughout the yr.	+	+	+	+
101.	<i>Phyllanthus fraternus</i> webster	Euphorbiaceae	Aug. - Dec.	+	-	-	+
102.	<i>Physalis minima</i> L.	Solanaceae	July - Dec.	+	-	-	+
103.	<i>Plumbago zeylanica</i> L.	Plumbaginaceae	Most part of the yr.	-	+	-	-
104.	<i>Polycarpon prostratum</i> (Forsk.) Asch. & Schweinf	Caryophyllaceae	July - Oct.	+	-	-	-
105.	<i>Polygonum barbatum</i> L.	Polygonaceae	Sept. - Jan.	-	+	-	-
106.	<i>Polygonum glabrum</i> Willd.	Polygonaceae	Throughout the yr.	-	+	-	-
107.	<i>Polygonum plebium</i> R. Br.	Polygonaceae	Dec. - Apr.	+	+	+	+
108.	<i>Portulaca oleracea</i> L.	Portulacaceae	Aug. - Dec.	+	-	-	-
109.	<i>Potentilla suprina</i> L.	Rosaceae	Mar. - Jul.	+	+	+	+
110.	<i>Prosopis juliflora</i> (Swartz) DC.	Mimosaceae	Mar. - Jul.	+	+	+	+
111.	<i>Pupalia lappacea</i> (L) Juss.	Amaranthaceae	Almost throught yr	-	-	+	-
112.	<i>Ranunculus sceleratus</i> L.	Ranunculaceae	Dec. - March	-	+	+	-
113.	<i>Rhynchosia minima</i> (L) Dc.	Fabaceae	Aug. - Nov.	-	-	-	+
114.	<i>Rotala indica</i> (Willd)	Lythraceae	Sept. - Dec.	+	+	+	+
115.	<i>Rotala serpyllifolia</i> (Roth.) Bremek.	Lythraceae	Aug. - Dec.	+	-	-	-
116.	<i>Ruellia tuberosa</i> L.	Acanthaceae	Nov. - Mar.	-	-	+	-
117.	<i>Rumex dentatus</i> L.	Polygonaceae	Dec. - Feb.	+	+	+	+

Table 2. Contd.

S.No.	Name of species	Family	Phenology	Presence			
				E	W	N	S
118.	<i>Rengia elagans</i> Dalz.	Acanthaceae	Aut. - Dec.	+	+	+	+
119.	<i>Securinega leucophyrus</i> (Wild) Muell. Arg.	Euphorbiaceae	Apr. - Nov.	-	-	-	+
120.	<i>Sesbania sesban</i> (L) Merrill	Fabaceae	Dec. - Mar.	-	+	-	+
121.	<i>Sesbania bispinosa</i> Wight	Fabaceae	Most of the yr.	+	-	-	-
123.	<i>Smithia conferta</i> Smith.	Fabaceae	Sept. - Jan.	+	-	-	-
124.	<i>Solanum nigrum</i> L.	Solanaceae	Aug. - Dec.	-	+	-	-
125.	<i>Solanum xanthocarpum</i> Schrad & Wendle.	Solanaceae	Most pt. of the yr.	-	+	-	-
126.	<i>Tamarix dioca</i> Roxb.	Tamaricaceae	Apr. - Aug.	-	-	-	+
127.	<i>Tephrosia hamiltonii</i> Drumm.	Fabaceae	July - Nov.	-	-	-	+
128.	<i>Trianthema portulacastrum</i> L.	Aizoaceae	July - Nov.	+	+	-	+
129.	<i>Trichodesma amplexicaule</i> Roth.	Boraginaceae	Aug. - Oct.	-	+	-	+
130.	<i>Tridax procumbens</i> L.	Asteraceae	Throughout the yr.	+	+	+	+
131.	<i>Trigonella occulta</i> Delile	Fabaceae	Dec. - Apr.	+	-	-	-
132.	<i>Triumfelta pentandra</i> A. Rich	Tiliaceae	July-Nov.	-	-	+	+
133.	<i>Verbascum chinense</i> (L) Sant.	Scrophulariaceae	Most pt. of the yr.	+	+	+	+
134.	<i>Vernonia cinerea</i> (L) Less	Asteraceae	Most pt. of the yr.	+	+	+	+
135.	<i>Veronica anagallis aquatica</i>	Scrophulariaceae	Oct. - May	-	+	+	-
136.	<i>Vicia sativa</i> L.	Fabaceae	Jan. - March	+	+	-	-
137.	<i>Xanthium strumarium</i> L.	Asteraceae	Oct. - May	-	-	-	+
138.	<i>Ziziphus nummularia</i> wt. & Arr.	Rhmnaceae	Sept. - Feb.	+	+	+	+
(B)	<i>Monocotyledens</i>						
139.	<i>Aloe vera</i> (L) Burm.	Liliaceae	Feb. - May	+	+	-	-
140.	<i>Asparagus racemossus</i> Willd	Liliaceae	Aug. - Mar.	-	-	-	+
141.	<i>Asphodelus tenuifolius</i> Cav.	Liliaceae	Dec. - Mar.	-	-	+	-
142.	<i>Brachiaria ramosa</i> (L) Stapf.	Poaceae	July - Oct.	-	-	+	-
143.	<i>Bulbostylis barbata</i> Clarke	Cyperaceae	Aug. - Nov.	-	-	+	-
144.	<i>Chloris virgata</i> Sw.	Poaceae	July - Nov.	+	+	+	+
145.	<i>Chrysopogon fulvus</i> (Spreng) Chiou.	Poaceae	Aug. - Nov.	+	+	-	-
146.	<i>Commelina benghalensis</i>	Commelinaceae	July - Oct.	+	+	-	+
147.	<i>Cyanotis axillaris</i> Heyne	Commelinaceae	Aug. - Dec.	-	+	+	-
148.	<i>Cynodon dactylon</i> (L) Pers.	Poaceae	July - Dec.	+	+	+	+
149.	<i>Cyperus differmis</i> L.	Cyperaceae	Aug. - Dec.	+	+	+	+
150.	<i>Dactyloctenium aegyptium</i> (L) Willd.	Poaceae	July - Nov.	+	+	+	+
151.	<i>Dichanthium cammplatatum</i> (Forsk) Stapf.	Poaceae	July - Nov.	+	+	+	+
152.	<i>Digitaria stricta</i> Roth.	Poaceae	July - Oct.	+	-	-	-
153.	<i>Echinochloa crus-galli</i> (L) P. Beauv.	Poaceae	Mar. - Aug.	-	+	-	-
154.	<i>Eragrostis pilosa</i> (L) P. Beauv.	Poaceae	Aug. - Feb.	+	+	-	-
155.	<i>Eragrostis tenella</i> (L) P. Beauv.	Poaceae	Aug. - Nov.	+	+	+	+

Table 2. Contd.

S.No.	Name of species	Family	Phenology	Presence			
				E	W	N	S
156.	<i>Hydrilla verticillata</i> (L.F.) Royle	Hydrocharitaceae	Oct. - Mar.	+	+	+	+
157.	<i>Hygroryza artistata</i> (Retz.) Ness.	Poaceae	Dec. - Mar.	+	+	+	-
158.	<i>Imperata cylindrica</i> (L) Raeuschel	Poaceae	May - Aug.	-	-	-	+
159.	<i>Juncus bufonius</i> L.	Juncaceae	Feb. - Apr.	-	+	+	+
160.	<i>Lemna perpusilla</i> Torrey	Lemnaceae	July - Sept.	+	-	+	+
161.	<i>Polypogon monosperensis</i> (L) Desf.	Poaceae	Mar. - Sept.	-	-	+	-
162.	<i>Phoenix sylvestris</i> (L) Roxb.	Arecaceae	Feb. - Apr.	-	+	+	+
163.	<i>Potamogeton crispus</i> L.	Potamogetonaceae	Nov. - June	+	+	-	-
164.	<i>Potamogeton perforliatus</i> L.	Potamogetonaceae	Jan. - May	+	-	-	-
165.	<i>Scirpus articulatus</i> L.	Cyperaceae	Sept. - Nov.	+	+	+	+
166.	<i>Sporobolus diander</i> (Retz.) P. Beauv.	Poaceae	Aug. - Oct.	-	-	-	+
167.	<i>Typha angusta</i> Bory	Typhaceae	Nov. - Feb.	-	-	+	-
168.	<i>Vallisneria spiralis</i> L.	Hydrochritaceae	Dec. - April	+	+	-	+
(C)	<i>Pteridophytes</i>						
169.	<i>Azalla pinnata</i>	Salviniaceae	Nov. - Dec.	-	+	+	-
170.	<i>Marsilea minuta</i>	Marsiliaceae	Apri. - June	+	+	+	+

the *Marsilea* begins to make its appearance on the scene.

Thorough screening of phytosociological data also reveal that ten species of wetland plants are recorded in the Quadrats at all the directions of the area. Note worthy of them are *Ammania baccifera*, *Bacopa monnieri*, *Marsilea minuta*, *Cynadon dactylon* and *Scirpus articulatus*. Wider range of their distribution may be attributed to their vegetative propogation through under ground stem modifications or their prostrate habit which provides a safeguard against grazing by bovine animals. However nine species were observed only in one direction or stand during quadrat studies. Striking examples are those of *Sesbania bispinosa*, *Verbascum chinese* and *Vernonia cinerea*. Limited occurrence of these species in the quadrats of one direction only may be attributed to certain biotic factors.

Vegetation composition in wetland habitats form a constantly changing pattern of the plant populations. These continuous changes depict the regeneration processes regulated by various plant communities mainly by speices type and death rate of preceding generations. Most of the metabolic activities of wetland plants are regulated through water absorption by the roots mostly concentrated in top soil layers. Due to higher rate of water absorption by the roots of these wetland plants, the rate of transpiration also remains high and this ultimately causes the conversion of marshy or muddy areas into soft and wet woil areas and finally of dry habitats.

During the course of present studis the wetland species were classified in to following categories based on the water structure in their specific habitats :

(A) *Semi-aquatic Plant Species (SAP)* : Those plants which are rooted in mud, in marshy habitats eg. *Marsilea minuta*, *Polygonum barbatum*, *Polygonum glabrum*, *Hygrophila*, *Limnophila* and *Ludwigia perennis* etc.

(B) *Super Saturated Soil Plants (SSSP)* : These plants are found just away from mud, in shallower marshes with slightly compact texture eg. *Bacopa monnieri*, *Phyla nodiflora*, *Marsilea minuta* and *Polycarpon prostratum* etc.

(C) *Saturated Soil Plants (SSP)* : These species are found in totally wet soils slightly away from marshy or muddy banks of the water bodies eg. *Hoppea dichotoma*, *Exacum pedunculatum*, *Potentilla supina*, *Eclipta prostrata*, *Gnaphalium indicum* and *Gnaphalium pulvinatum* etc. alongwith *Marsilea minuta*.

(D) *Dry Bed Plants (DBP)* : These species make their appearance after receding the water level in the soil cracks of water bodies or bit far away at dried water beds eg. *Polygonum plebium*, *Marsile minuta*, *Glinus lotoides*, *Coldenia procumbens* and *Heliotropium supinum* etc.

From the above mentioned categorization it is evident that *Marsilea minuta* appears to be the most ideal wetland species, showing its presence almost in all the zones of wetland habitats. It initiates its growth phase from shallower water level near the banks of water bodies.

reaches to muddy and marshy bottom and then culminating as plant of dry soil beds, via wet soil habitats. This process may be depicted as follows :

Shallower, peripheral water surface → Muddy and marshy places → wet soils → Dried water banks. However *Marsilea minuta* was abundant in the peripheral wetland zone of Abhera pond, but it was never recorded in the deep waters/central zone of the water bodies eg. pond/ditches/tank. Presence of *Marsilea minuta* in diversified wetland conditions as well as on dried water banks even in the months of summer seasons, may be attributed to the presence of higher proline contents in its plant body which enhances to presence of higher proline contents in its plant body which enhances the range of its ecological amplitude¹⁸. More over present observations are in conformity with Sanjay K. Vijay *et al.*¹⁹

The above categorization of wetland plants the presence of moisture pockets with green appearance is shown during the dry months of summer. This may be attributed to the prolific growth of some saturated soil plant species eg. *Gnaphalium pulvinatum*, *Polygonum monspeliensis*, *Potentilla supina* and *Marsilea minuta* etc. However mat forming prostrate plant species eg. *Cynodon doctylon* and *Potentilla supina* as well as many grasses escape grazing by being spread over to the surface of green belt and in some cases get appressed to the ground forming gregarious patches or rosettes. This phenomenon in their habit may be attributed to some genetic factors helping them to keep protected against intense sunlight to which these plants are exposed throughout the day time.

The amphibious and emergent plant species in the locality are designated as SAP (Semi Aquatic Plants), some note worthy examples of this category are *Hygrophila auriculata*, *Polygonum glabrum*, *Polygonum barbatum* and *Marsilea minuta*.

The category of super saturated soil plants (SSSP) includes the plants of shallow water marshes or muddy areas and form an ecotone between Semi-aquatic plants (SAP) and saturated soil plants (SSP). Here the plant composition changes in correspondence to water quantum to these ephemeral areas of the wetland habitats. In these places the prominent plant species are *Phyla nodiflora*, *Bergia ammaniodes* and *Bacopa monnieri*. Further away in the region of wet and soft soils some other plant species eg. *Ammania baccifera*, *Polycarpon prostratum* and *Gnaphalium indicum* make their appearance.

During summer season when water level recedes to its minimum we can observe the plant communities comprising of characteristic dry bed plants eg. *Glinus lotoides*, *Heliotropium supinum*, *Coldenia procumbens*

and *Polygonum plebium*. Appearance and predominance of these species in dry beds of water bodies may be attributed to their morphological and anatomical adaptations, as well as comparatively lower water requirements.

However presence of *Phoenix sylvestris* in the low lying habitats of the area under study once again proves its importance as Plant indicator of low lying areas.

In this manner analysis of plant taxa in relation to their environmental parameters of Abhera and its neighbourhood reveal unique floristic diversity and fluctuations in vegetation patterns starting from *Hydrilla* and *Ceratophyllum* (submerged aquatic) and terminates to *Acacia nilotica* (truly xerophytic) as shown in the following flow chart :

Hydrilla (submerged deep) → *Vallisneria* (submerged peripheral) → *Hygrophila* (Marshy and muddy habitats) → *Polycarpon* and *Bacopa* (SSSP) → *Polygonum monspeliensis* (wet soils) → *Coldenia procumbens* and *Polygonum plebium* (Dry bed plants) → *Cordia dichotoma* and *Cassia tora* (Mesophytes) → *Acacia nilotica* (truly xerophytic tree).

Presence of truly xerophytic species eg. *Acacia nilotica* some far away from Abhera pond may be attributed to the rocky and gravelly surface and poor water holding capacity of the soil surface. Therefore it is also evident from above flow chart that this transitional fluctuation in its vegetation patterns substantially correspond to climate and edaphic conditions and rainfall patterns. During summer season water levels of marsh wetlands deteriorate remarkably which causes exposure of the wetland plant species seeds to the extreme dryness. It is quite essential for breaking the seed dormancy. Besides this *Marsilea minuta* is the characteristic species to express the terrestrialization factor in unique manner by showing its presence in all zones of the wetland.

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