Wetland Flora of Gorewada International Biopark, Nagpur, India

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Abstract Gorewada reservoir and adjacent area (1885 Ha) now converted into International Biopark abodes a variety of plant community to its credit. A study has been carried out to elucidate the aquatic flora with diverse plant wealth, indicator plants and their ecological status in wetlands of Gorewada catchment area. 114 plants species with 33 families have been identified from the Gorewada wet land area. 67 species belong to dicotyledons and 47 are monocotyledons.

Keywords Gorewada International Biopark, Nagpur, Wetland Flora, Indicator Categories

1. Introduction

Biodiversity accomplishes all vital requirements of organisms to complete their life cycle and amongst humans indirectly or directly dependent on both terrestrial as well as aquatic biodiversity, as both biodiversities provides natural resources in all ways to humans like cultural, economic, aesthetic, educational and scientific etc. Biodiversity covers all organisms like microorganism, plants and animals along with its all diverse genetic variations in species, varieties and populations in different habitats, ecosystems and in their natural areas, and its groups increases richness in natural environment [1].

Wetlands are vital parts of the hydrological cycle, highly productive, support exceptionally large biological diversity and provide a wide range of ecosystem services, such as food and fibre; waste assimilation; water purification; flood mitigation; erosion control; groundwater recharge; microclimate regulation; enhance aesthetics of the landscape; support many significant recreational, social and cultural activities, besides being a part of our cultural heritage [2].

The composition of a plant community is determined by a complex interaction of several biotic as well as abiotic factors including climate, soil type, position in the landscape and competition between plant species. Amongst which wetlands are the very important aquatic ecosystem, which maintains the balance in environment. Wetlands have seasonal variation in its floristic composition. Consequently, botanical explorations of wetland plants are necessary to gain more knowledge on species richness as well as their geographical distribution. Works on floristic studies of documentation of diversity of aquatic plants and wetlands flora in various water reservoirs and wetland areas of different states of India were carried out by many workers [3,4,5,6,7,8,9,10]. Besides these there are several researchers from Maharashtra state and its various districts and regions, explored the aquatic and wet lands plants diversity [11,12,13,14,15,16,17,18,19,20,21, 22].

Figure 1. Map of Gorewada International Biopark

Nagpur is one of the greenest cities of India with 18 per cent of its area under forests and plantations, 17 per cent under cultivation and 2 per cent under water bodies [23]. To maintain ecological equilibrium, there is a need of documentation of floristic composition of wetlands, which plays a crucial role as pollution indicator. From this the assessment of conservation of threatened taxa which are associated with wetland habitats also carried out. In view of this fact, the present study is meant to prepare the documentation of the phytodiversity of wetland of Gorewada International Biopark (Proposed), Nagpur, the first exploration of the kind in this area.

2. Material and Methods

2.1. Study Area

Proposed Gorewada International Biopark lies between latitudes $20^{\circ} 35'$ and $21^{\circ} 44'$ North and longitudes $78^{\circ} 15'$ and $79^{\circ} 40'$ East. It extends over to 1885 ha of reserved forests, in outskirts of Nagpur city. All area is divided into 7 beats (Compartments) viz. 790, 791, 792, 793, 794, 795, 796 and one water catchment area. Land is well drained and form catchment area of Gorewada Lake, known for its scenic beauty. Gorewada water reservoir, an area of around 57.93 sq. Hectare is situated on the eastern side of the proposed zoo and bio-park. Northern bank of the lake is made by beat number 796 and western side by beat number 795. Almost all compartments have well drainage system in the form of ponds and streams towards the water reservoir. The annual average rainfall of the area is 900 mm and the annual mean temperature varies from 10° C minimum to 45° C maximum [24].

2.2. Methods

For the study of wetland flora, the survey in and around ponds, lakes, streams with extensive field visits have been done in various time of the year to cover all the wetlands of the area in different seasons during 2008 to 2013. The different wetland of each 7 compartments along with water reservoir often visited are shown in map. The methodology adopted for the data on taxa distribution within the forest range were collected particularly with the help of two sources- field observations and identification with pertinent literatures [25,26,27]. Besides that the information on habit, habitat and flowering was carried out in the both dry and wet seasons. The identification of

Figure 2. Compartments wise Map showing wetlands

specimens was carried out by consulting relevant literature and regional floras [28,29,30,31] and morpho-ecological classification viz. I) Submerged anchored, II) Free Floating, III) Floating leaved anchored, IV) Floating shoot anchored, V) Emergent anchored and VI) Helophytes [32].

3. Results and Discussion

Exhaustive field visits to the all wetland areas in 7 compartments and area adjoining the water reservoir carried out in all seasons of the year and documented all floral components. The statistical analysis of the floristic components also carried out. A total of 114 species from 33 families were identified from the Gorewada wet land area. 67 species belong to dicot and 47 are monocots

(Table No.2). Some of the major dominant wetland phyto-diversity are *Hydrilla*, *Utricularia*, *Vallisneria*, *Ceratophyllum*, *Azolla*, *Eichhornia*, *Ipomea*, *Lemna*, *Trapa*, *Nymphoides indica*, *Spigelia anthelmia* L. [33] etc. According to ecological classification, majority of the taxa belong to category V, i.e. muddy elements. Category I, submerged species are represented by *Vallisneria*, *Nechandra*, *Naias*, *Ceratophyllum* and *Hydrilla*, While *Ottelia*, *Aponogeton* and *Limnophyllum* forms the floating leaves category, II. *Typha* and *Ipomea fistulosa* are the most frequent taxa of category IV. (Table. No.1& Figure. 3). besides these, algae, aquatic fungi, bryophytes and pteridophytes are also major parts of the wetland ecosystem. The detailed list of floral components according to its habits and ecological class occurred in Gorewada International Biopark given below. (Table No. 1).

Table 1. Floristic diversity of wetland belonging to different morpho-ecological classes and plant indicators from the study area are given as below

Sr. No	Botanical Name	Family	Habit	Ecological class
1.	<i>Justicia diffusa</i> Willd.	Acanthaceae	Wet Patches	VI
2.	<i>Justicia simplex</i> D.Don.	Acanthaceae	Wet Patches	VI
3.	<i>Rungia pectinata</i> (L.) Nees.	Acanthaceae	Moist Places	VI
4.	<i>Hygrophila auriculata</i> (K. Schum.) Heine	Acanthaceae	Wet Patches	VI
5.	<i>Justicia procumbens</i> L.	Acanthaceae	Margin of lake	VI
6.	<i>Justicia quinqueangularis</i> Koen.	Acanthaceae	Margin of lake	VI
7.	<i>Alternanthera sessilis</i> (L.) R.Br.	Amaranthaceae	Wet mud	VI
8.	<i>Celosia argentea</i> L.	Amaranthaceae	Moist Region	VI
9.	<i>Amaranthus viridis</i> L.	Amaranthaceae	Moist Places	VI
10.	<i>Aponogeton natans</i> (L.) Engl. & Krause	Aponogetonaceae	Submerged	VI
11.	<i>Gnaphalium polycaulon</i> Pers.	Asteraceae	Moist Places	VI
12.	<i>Blumea lacera</i> (Burm.f.) DC.	Asteraceae	Margin of Lake	VI
13.	<i>Caesulia axillaris</i> Roxb.	Asteraceae	Margin of Lake	VI
14.	<i>Cyathocline purpurea</i> (D.Don.) O.Ktze.	Asteraceae	Dry Mud Patches	VI
15.	<i>Glossocardia bosvallea</i> (L.f.) DC.	Asteraceae	Sandy / Moist	VI
16.	<i>Sonchus brachyotus</i> DC.	Asteraceae	Moist Region	VI
17.	<i>Vernonia cinerea</i> (L.) Less	Asteraceae	Moist Region	VI
18.	<i>Trichodesma sedgwickianum</i> Banerjee	Boraginaceae	Margin of Lake	VI
19.	<i>Heliotropium supinum</i> L.	Boraginaceae	Margin of Lake	VI
20.	<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	Submerged	I
21.	<i>Cleome chelidonii</i> L.f.	Cleomaceae	Wet Patches	VI
22.	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn.	Combretaceae	Margin of Lake	VI
23.	<i>Commelina benghalensis</i> L.	Commelinaceae	Wet mud patches	VI
24.	<i>Cyanotis axillaris</i> (L.) D.Don ex Sweet	Commelinaceae	Wet mud patches	VI
25.	<i>Merremia emarginata</i> (Burm.f.) Hall.f.	Convolvulaceae	Moist Region	VI
26.	<i>Evolvulus alsinoides</i> (L.) L.	Convolvulaceae	Wet Patches	VI
27.	<i>Ipomoea fistulosa</i> Mart. ex Choisy	Convolvulaceae	Wet mud patches	III
28.	<i>Eleocharis atropurpurea</i> (Retz.) K.B. Presl.	Cyperaceae	Wet Patches	VI
29.	<i>Cyperus iria</i> L.	Cyperaceae	Wet Patches	VI
30.	<i>Cyperus corymbosus</i> Rottb.	Cyperaceae	Wet Patches	VI

Table 1 Continued

31.	<i>Fuirena glomerata</i> Lamk.	Cyperaceae	Dry Mud patches	VI
32.	<i>Kyllinga brevifolia</i> Rottb.	Cyperaceae	Wet Patches	VI
33.	<i>Cyperus compressus</i> L.	Cyperaceae	Moist Region	VI
34.	<i>Cyperus niveus</i> Retz.	Cyperaceae	Moist Region	VI
35.	<i>Fimbristylis aphylla</i> Steud.	Cyperaceae	Moist Region	VI
36.	<i>Fimbristylis dichotoma</i> (L.) Vahl.	Cyperaceae	Moist Region	VI
37.	<i>Fimbristylis ferruginea</i> (L.) Vahl.	Cyperaceae	Margin of lake	VI
38.	<i>Fimbristylis spathacea</i> Roth.	Cyperaceae	Margin of lake	VI
39.	<i>Kyllinga nemoralis</i> (Forst.) Dandy	Cyperaceae	Moist Region	VI
40.	<i>Eriocaulon cinereum</i> R.Br.	Eriocauliaceae	Wetland	VI
41.	<i>Eriocaulon quinquangulare</i> L.	Eriocauliaceae	Wetland	VI
42.	<i>Eriocaulon luzulaefolium</i> Mast.	Eriocaulaceae	Wet Patches	VI
43.	<i>Phyllanthus amarus</i> Schum. & Thonn.	Euphorbiaceae	Dry Mud patches	VI
44.	<i>Euphorbia rosea</i> Retz.	Euphorbiaceae	Dry Mud patches	VI
45.	<i>Euphorbia hirta</i> L.	Euphorbiaceae	Margin of lake	VI
46.	<i>Chrozophora prostrata</i> Dalz.	Euphorbiaceae	Dry Mud patches	VI
47.	<i>Crotalaria albida</i> Heyne ex Roth	Fabaceae	Dry Mud patches	VI
48.	<i>Crotalaria sericea</i> Retz.	Fabaceae	Dry Mud patches	VI
49.	<i>Indigofera cordifolia</i> Heyne ex Roth	Fabaceae	Dry Mud patches	VI
50.	<i>Indigofera trifoliata</i> L.	Fabaceae	Dry Mud patches	VI
51.	<i>Smithia conferta</i> J.E. Sm.	Fabaceae	Dry Mud patches	VI
52.	<i>Aeschynomene indica</i> L.	Fabaceae	Wet Patches	VI
53.	<i>Zornia gibbosa</i> Spanoghe	Fabaceae	Dry Mud patches	VI
54.	<i>Zornia diphylla</i> (L.) Pers.	Fabaceae	Dry Mud patches	VI
55.	<i>Sesbania sesban</i> (L.) Merr.	Fabaceae	Wet patches	VI
56.	<i>Alysicarpus vaginalis</i> (L.) DC.	Fabaceae	Wetland	VI
57.	<i>Centaurium centaurioides</i> (Roxb.) Rao & Hemadri	Gentianaceae	Wetland	VI
58.	<i>Canscora decurrens</i> Dalz.	Gentianaceae	Margin of lake	VI
59.	<i>Exacum pedunculatum</i> L.	Gentianaceae	Margin Region	VI
60.	<i>Hoppea dichotoma</i> Willd.	Gentianaceae	Wetland	VI
61.	<i>Nymphoides cristata</i> (Roxb.) O. Ktze.	Gentianaceae	Surface of Lake	II
62.	<i>Hydrilla verticillata</i> (L.f.) Royle.	Hydrocharitaceae	Submerged	I
63.	<i>Otelia alismoides</i> (L.) Pers.	Hydrocharitaceae	Submerged	III
64.	<i>Vallisneria spiralis</i> L.	Hydrocharitaceae	Submerged	I
65.	<i>Nechamandra alternifolia</i> (Roxb.) Thw.	Hydrocharitaceae	Submerged	I
66.	<i>Leucas aspera</i> (Willd.) Spreng.	Lamiaceae	Moist Places	VI
67.	<i>Ocimum basilicum</i> L.	Lamiaceae	Margin of Lake	VI
68.	<i>Lemna paucicostata</i> Hagelm	Lemnaceae	Surface of Lake	II
69.	<i>Scilla hyacinthina</i> (Roth.) Macbr.	Liliaceae	Dry Mud patches	VI
70.	<i>Curculigo orchoides</i> Gaertn.	Liliaceae	Moist places	VI
71.	<i>Gloriosa superba</i> L.	Liliaceae	Moist places	VI
72.	<i>Mitreola petiolata</i> (J.F. Gmel.) Torr. & Gray.	Loganiaceae	Wet Patches	VI
73.	<i>Spigelia anthelmia</i> L.	Loganiaceae	Wet Patches	VI
74.	<i>Rumex dentatus</i> L.	Lythraceae	Margin of Lake	VI
75.	<i>Ammannia multiflora</i> Roxb.	Lythraceae	Dry Mud	VI

Table 1 Continued

76.	<i>Rotala indica</i> (Willd.) Koehne.	Lythraceae	Wet patches	VI
77.	<i>Woodfordia fruticosa</i> (L.) Kurz.	Lythraceae	Margin of Lake	VI
78.	<i>Najas minor</i> All.	Najadaceae	Submerged	IV
79.	<i>Ludwigia octovalvis</i> (Jacq.) Raven.	Onagraceae	Wet mud	VI
80.	<i>Biophytum sensitivum</i> (L.) DC.	Oxalidaceae	Wet Mud	VI
81.	<i>Aristida funiculata</i> Trin.	Poaceae	Dry Mud patches	VI
82.	<i>Chrysopogon fulvus</i> (Spreng.) Chiov.	Poaceae	Dry Mud patches	VI
83.	<i>Coix lacryma-jobi</i> L.	Poaceae	Wet Patches	V
84.	<i>Dichanthium aristatum</i> (Poir.) C.E. Hubb.	Poaceae	Wet Patches	VI
85.	<i>Digitaria ciliaris</i> (Retz.) Koeler	Poaceae	Dry Mud patches	VI
86.	<i>Eragrostiella brachyphylla</i> (Stapf.) Bor.	Poaceae	Dry Mud patches	VI
87.	<i>Heteropogon contortus</i> (L.) Pal.-Beauv.	Poaceae	Dry Mud patches	VI
88.	<i>Oplismenus compositus</i> (L.) Pal.-Beauv.	Poaceae	Dry Mud patches	VI
89.	<i>Paspalidium flavidum</i> (Retz.) A.	Poaceae	Wet Patches	VI
90.	<i>Paspalidium geminatum</i> (Forssk.) Stapf.	Poaceae	Wet Patches	VI
91.	<i>Pennisetum pedicellatum</i> Trin.	Poaceae	Dry Mud patches	VI
92.	<i>Panicum miliare</i> Lamk.	Poaceae	Dry Mud patches	VI
93.	<i>Setaria verticillata</i> (L.) Pal.-Beauv.	Poaceae	Dry Mud patches	VI
94.	<i>Themeda triandra</i> Forssk.	Poaceae	Dry Mud patches	VI
95.	<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Margin of Lake	VI
96.	<i>Eragrostis gangetica</i> (Roxb.) Steud.	Poaceae	Margin of Lake	VI
97.	<i>Eragrostis aspera</i> (Jacq.) Nees.	Poaceae	Margin of Lake	VI
98.	<i>Setaria intermedia</i> Roem. &Schult.	Poaceae	Margin of Lake	VI
99.	<i>Polygala arvensis</i> Willd.	Polygalaceae	Moist Places	VI
100.	<i>Polygonum glabrum</i> Willd.	Polygonaceae	Dry Mud	V
101.	<i>Potamogeton nodosus</i> Poir.	Potamogetonaceae	Submerged	I
102.	<i>Potentilla supine</i> L.	Rosaceae	Dry Mud patches	VI
103.	<i>Dentella repens</i> (L.) Forst.	Rubiaceae	Moist Places	VI
104.	<i>Oldenlandia corymbosa</i> L.	Rubiaceae	Margin of Lake	VI
105.	<i>Striga densiflora</i> (Benth.) Benth.	Scrophulariaceae	Wet Patches	VI
106.	<i>Sopubia delphiniifolia</i> (L.) G.Don.	Scrophulariaceae	Moist Places	VI
107.	<i>Lindernia crustacea</i> (L.) F.V. Muell.	Scrophulariaceae	Moist Places	VI
108.	<i>Limnophila heterophylla</i> (Roxb.) Benth.	Scrophulariaceae	Wet mud	IV
109.	<i>Buchnera hispida</i> Buch.-Ham.	Scrophulariaceae	Moist Places	VI
110.	<i>Bacopa monnieri</i> (L.) Wettstein	Scrophulariaceae	Wet mud.	VI
111.	<i>Verbascum chinense</i> (L.) Santapau	Scrophulariaceae	Margin of Lake.	VI
112.	<i>Trapa natans</i> L.	Trapaceae	Surface of Lake	III
113.	<i>Typha angustata</i> Chaubard & Bory	Typhaceae	Wet mud.	V
114.	<i>Phyla nodiflora</i> (L.) Greene	Verbenaceae	Moist Places	VI

Note: I) Submerged anchored, II) Free Floating, III) Floating leaved anchored, IV) Floating shoot anchored, V) Emergent anchored and VI) Helophytes

Table 2. Statistical analysis showing percentage of Dicotyledonous and Monocotyledonous families, genera and species

	Dicots.		Monocots.	
	No.	%	No.	%
Families	23	69.70	10	30.30
Genera	59	62.76	35	37.23
Species	67	58.77	47	41.22
Total		114

Figure 3. Pi diagram showing the composition of life form of aquatic macrophytes of the wetlands of the study area

Figure 4. Habit Sharing of flora in Gorewada Wetland

Table3. List of Dominating Wetland Plants with Indicator Category

Sr. No.	Scientific Names	Indicator Category
1.	<i>Bacopa monnieri</i> (L.) Wettstein	OBL
2.	<i>Eriocaulon cinereum</i> R.Br.	OBL
3.	<i>Phyla nodiflora</i> (L.) Greene	FACW
4.	<i>Typha angustata</i> Chaubard & Bory	OBL
5.	<i>Ipomoea fistulosa</i> Mart. ex Choisy	FAC
6.	<i>Vallisneria spiralis</i> L.	OBL
7.	<i>Hydrilla verticillata</i> (L.f.) Royle	OBL
8.	<i>Ottelia alismoides</i> (L.) Pers.	OBL
9.	<i>Najas minor</i> All.	OBL
10.	<i>Phoenix sylvestris</i> (L.) Roxb	UPL
11.	<i>Terminalia arjuna</i> (Roxb.) Wt. & Arn.	FACU
12.	<i>Aponogeton natans</i> (L.) Engl. & Kr.	OBL
13.	<i>Cleome chelidonii</i> L.f.	OBL
14.	<i>Crotalaria sericea</i> Retz.	FACW
15.	<i>Phyllanthus amarus</i> Schum. & Thn.	FAC
16.	<i>Nymphoides cristata</i> (Roxb.) O.Ktze	OBL
17.	<i>Lindernia crustacea</i> (L.) F.V. Muell.	OBL
18.	<i>Oldenlandia corymbosa</i> L.	OBL
19.	<i>Coix lacryma-jobi</i> L.	OBL
20.	<i>Smithia conferta</i> J.E. Sm.	UPL
21.	<i>Ludwigia octovalvis</i> (Jacq.) Raven.	FACU

Wetland Indicator Categories based on differences in expected frequency of occurrence of wetland plant species [34], probability of occurrence in wetlands as opposed to upland habitats, with obligate wetland species having a percentage probability of occurrence in wetlands (OBL) > 99%; facultative wetland species (FACW), 67% – 99%; facultative species (FAC), 34% – 66%; facultative upland species (FACU), 1% – 33%; and obligate upland species (UPL), < 1%. According to this, the dominant wetland plants were categorized. The OBL indicator category comprises *Bacopa monnieri* (L.) Wettstein, *Eriocaulon cinereum* R.Br., *Typha angustata* Chaubard & Bory, *Vallisneria spiralis* L., *Hydrilla verticillata* (L.f.) Royle, *Ottelia alismoides* (L.) Pers., *Najas minor* All., *Aponogeton natans* (L.) Engl. & Kr., *Cleome chelidonii* L. f., *Nymphoides cristata* (Roxb.) O. Ktze, *Lindernia crustacea* (L.) F.V. Muell., *Oldenlandia corymbosa* L.,

Coix lacryma-jobi L. Facultative wetland species (FACW) are *Phyla nodiflora* (L.) Greene and *Crotalaria sericea* Retz.; facultative species (FAC) with *Ipomoea fistulosa* Mart. ex Choisy and *Phyllanthus amarus* Schum. & Thn.; facultative upland species (FACU) are *Terminalia arjuna* (Roxb.) Wt.&Arn. and *Ludwigia octovalvis* (Jacq.) Raven. and obligate upland species (UPL) represented with *Phoenix sylvestris* (L.) Roxb. and *Smithia conferta* J.E. Sm. (Table.3).

Gorewada Lake is one of the important water reservoirs of the Nagpur, from where supply of the drinking water to the different parts of the city takes place. At the same time its expanded marshy land provides suitable habitats for breeding of number of water animals. Large population of macrophytes of wetlands is provider of not only habitat but also the much needed food for number of organisms.

4. Conclusions

Wetlands have a great diversity of plants needing wetness of diverging extents. These plants are accordingly adapted to the local availability of water and many show transitions between annual and perennial forms and also their type of growth forms. Weed, a controversial class of plants, its invasion is a major problem in wetlands resulting in increased competition for resources such as water, light, nutrients and space [34]. Wetland plants can be threatened by changes in both surface water and groundwater levels as a result of human activities. Wetland plants are sensitive to changes in hydrology which result in a wetland having too much or too little water. The anthropogenic activities like deforestation; overgrazing and developmental activities etc. are causative factors for the acceleration of soil erosion and consequent siltation of wetlands. For successful implementation of conservation, involvement of people and nongovernmental organizations is crucial. People can be involved in de-siltation of lake, afforestation in the catchment area and generating awareness

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Appendix

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