

Diversity and distribution of vascular macrophytes in Ansupa Lake, Odisha, India

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Abstract. Panda M, Samal RN, Bhatta KS, Lenka S, Rout J, Patra HK, Nanda S. 2018. Diversity and distribution of vascular macrophytes in Ansupa Lake, Odisha, India. *Bonorowo Wetlands* 8: 1-12. Macrophytes are an indispensable component of any wetlands. They are the base of the trophic structure and variously affect the function of the aquatic ecosystem. To identify the causative plant species, extensive invasion of macrophytes was enforced for present studies in Ansupa Lake, the largest freshwater lake of the state Odisha (India). Regular field inspection, quadratic sampling, and specimen collections were carried out to identify the present macrophytes of the lake and their quantitative aspects like frequency of occurrences, abundance, values of diversity indices, adaptation and growth forms, species distribution, etc. 244 macrophyte species were identified, including 182 semi-aquatic and 62 obligatory aquatic macrophytes. The latter group had 35% submerged, 15% free-floating, 31% rooted floating, and 19% marshy plant species. The comparison of growth form showed 66% annuals and the remaining 34% perennial plants. The diversity indices resulted, Simpson, complement index-0.561, Shannon-Weiner index-1.367, Species richness index 3.079, and Species evenness index-0.156. The study showed that the lake provides suitable habitats for the existence of a diverse group of macrophytes. Still, the extensive invasion of a few species has threatened the lake, which needs to be appropriately managed to restore the health of this natural resource for the benefit of humanity.

Keywords: Ansupa Lake, conservation, macrophyte diversity, species invasion

INTRODUCTION

Wetlands are the hotspots of biological diversity and invaluable for sustainable living. Plants in water are called macrophytes (Dodds 2002). They act as “biological engineers” restoring water quality (Byers et al. 2006). It includes flowering and non-flowering plants that start their lives in and around water bodies (Chambers et al., 2008). Some 2,614 aquatic vascular macrophytes occur globally, representing only 1% of the total number of vascular plants (Ansari et al., 2017). The total number of aquatic plant species in Indian freshwaters exceeds 1,200 (Gopal 1995). Many aquatic plant species are invasive species (Oyedeggi and Abowei 2012). These plants cause local loss of species diversity and alter ecosystem structure, resulting in a significant negative impact on aquatic biodiversity and water quality (Brundu 2015; Chamier et al. 2012; Wang et al. 2016; Zedler and Zedler and Kercher 2004). In India, over 140 aquatic plants are reported to have attained the status of aquatic weeds in different situations (Gupta 2012; Naskar 1990; Shah and Reshi 2012; Varshney et al. 2008).

Ansupa Lake, the present study site, is the largest freshwater lake of the state Odisha (India) (Mohanty and Das 2008) and a lake of national importance (Das and Mohanty 2008). The lake provides livelihood provisions like fishing, i.e., small indigenous fishes, table-sized fishes, ornamental fishes; agriculture, i.e., rice cultivation; edible aquatic plants, and ecotourism due to its unique

biodiversity and natural scenery (Sarkar et al. 2015). More than 25,000 fishermen and local residents live on the lake water (Das and Mohanty 2008; Mohanty and Das 2008). The average water depth of the lake was 4 meters (Das and Mohanty 2008). The lake receives annual rainfall between 800mm to 1300mm (Das and Mohanty 2008; Panda et al. 2016) and most during July and August each year. It hosts 44 species of phytoplankton, 32 species of zooplankton, and 30 species of fishes (Patra and Patra 2007). For the first time, Panda et al. (2016) reported the occurrence of *Hygroryza aristata* (Retz.) Nees. ex Wt. and Arn., a wild relative of edible rice in Ansupa Lake, as the only habitat in the state for this species. There are few published works on Ansupa Lake, and the macrophytes study is very poorly reported (Das and Mohanty 2008; Mohanty and Das 2008; Varshney et al. 2008; Sarkar et al. 2015; Panda et al. 2016). All previous studies reported the progressive degradation conditions of the lake due to siltation, shrinkage of water spread area, and invasions of aquatic plants (Das and Mohanty 2008; Mohanty and Das 2008; Sarkar et al. 2015; Panda et al. 2016).

Knowing the importance of Ansupa Lake, present studies were designed to identify the macrophyte diversity. These problematic weeds need to be appropriately managed to conserve indigenous biota and create better livelihood opportunities from the lake.

MATERIALS AND METHODS

Study area

Ansupa Lake is the largest freshwater lake of Odisha State, India, situated between latitude 20° 26' 21" to 20° 28' 52" N and 85° 36' 25" to 85° 36' 0" E longitude on the riverbank of Mahanadi (Figure 1). The lake area is around 375 acres and 385 acres during the dry and rainy seasons, respectively (Mohanty and Das 2008).

Field data collection and floristic study

The floristic studies were carried out during November 2014 and extensive regular fieldwork from April to November 2017. The recorded macrophytes were identified with the help of available regional and international scientific literature (Calvert and Liessmann 2014; Campbell et al. 2010; Crow and Hellquist 2000; Das 2012; Gerber et al. 2004; Ghosh 2005; Gupta 2012; Haines 1921-1925; Naskar 1990). The scientific name and author citation were checked with, The plant list (<http://www.theplantlist.org/>) and International Plant Names Index (<http://www.ipni.org/ipni/plantnamesearchpage.do>). Quantitative status and ecological parameters were

calculated from 25 fixed random plots, i.e., size 1m × 1m (Figure 1).

Data analysis

The quadratic parameters like Frequency and Abundance (Upadhyay et al. 2009), Whitford's index (A/F) (Whitford 1949), Species richness index (Margalef 1958), Simpson complement index (1-D_s) from Simpson Dominance index (Simpson 1949), Shannon-Wiener index (Shannon and Wiener 1963) and Species evenness index (J) (Pielou 1975) were calculated as follows:

$$\text{Frequency} = \frac{\text{No. of plots in which a species occurs}}{\text{Total no of plots sampled}} \times 100$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Number of quadrates in which the species occurred}}$$

$$\text{Species dispersion or Whitford's index (A/F)} = \frac{\text{Abundance}}{\text{Frequency}}$$

$$\text{Species richness Index (RI)} = \frac{S - 1}{\ln N} \text{ as per Margalef (1958)}$$

Where, S is the total number of species in the community and N is the total number of individuals of all species of a community.

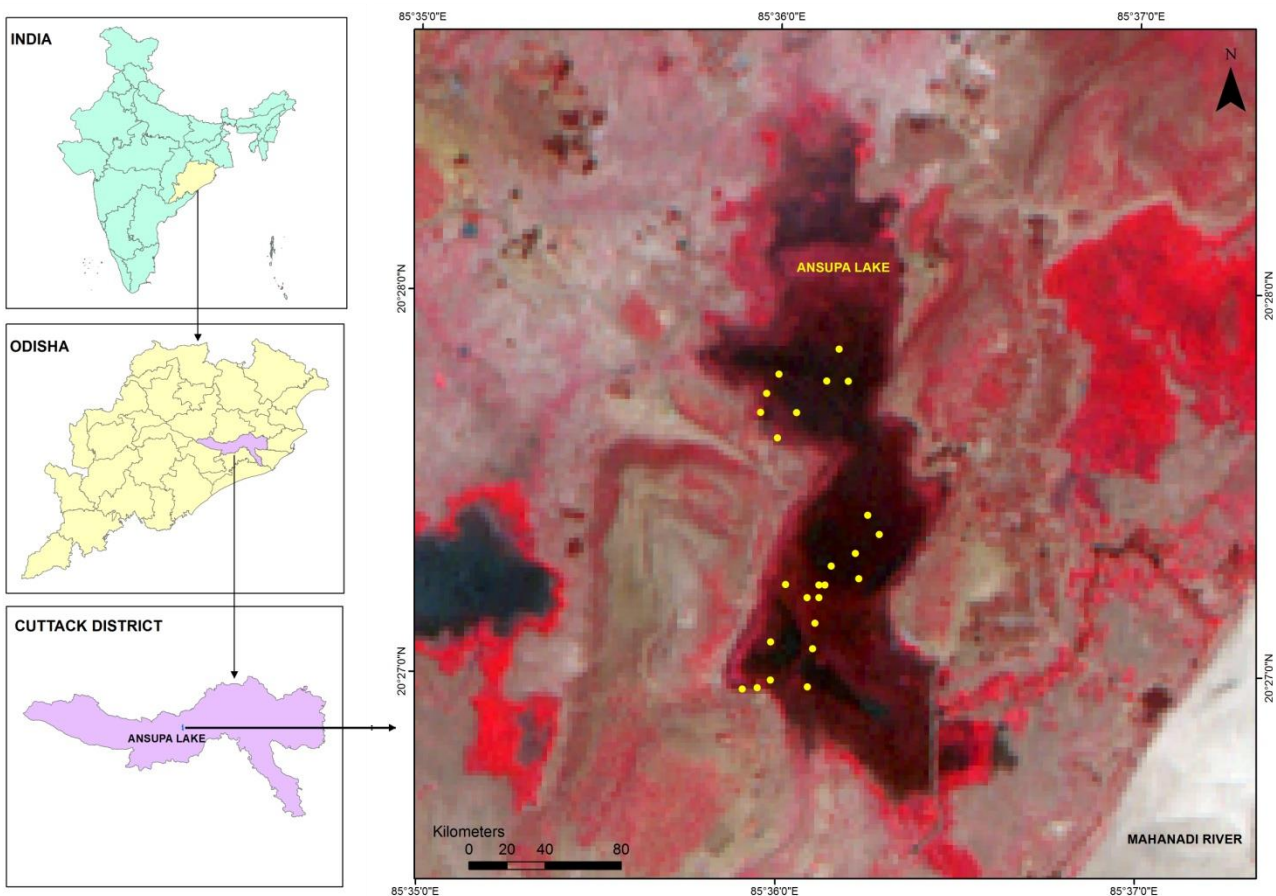


Figure 1. Location map of Ansupa Lake, Cuttack District, Odisha, India

Simpson dominance index (D_s) = $\sum Pi^2$ as per Simpson (1949)

Shannon – Wiener index = $-\sum Pi \log_n Pi$ as per Shannon – Weiner (1963)

Where, $Pi = \frac{\text{Number of individual of one species}}{\text{Total number of all individuals}}$

Species Evenness Index (EI) = $\frac{H'}{\ln S}$ as per Pielou (1975)

Where, H' is the Shannon-Weiner index of the community and S is the total number of species in the community.

RESULTS AND DISCUSSION

A total of 244 vascular macrophytes were identified to occur in shoreline areas of the lake. Out of the total record, 238 species were of flowering plants, i.e., Angiosperms (Table 1), and 6 species of non-flowering macrophytes, i.e., Pteridophyte (Table 2). All six pteridophytes were strictly aquatic species; they belong to only two families (i.e., Marsileaceae and Salviniaceae) except *Azolla microphylla* Kaulf, an annual species others were perennial in their growth form (Table 2). The angiospermic macrophytes belong to a total of sixty families. Poaceae and Cyperaceae were recorded as the most diversified families among these families (Figure 2). The classification of all the recorded macrophytes based on habitat preference showed 182 (75%) semi-aquatic species and 62 (25%) aquatic species (Figure 3). Categorization of total angiosperms revealed 137 (58%) dicot species and 101 (42%) monocot species (Figure 4). Among the dicot group, only 26 (19%) species were strictly aquatic, and 111 (81%) species were semi-aquatic plants (Figure 5). Similarly, the monocot group had 30 species (30%) and 71 species (70%) as aquatic and semi-aquatic plants, respectively (Figure 6). The comparison of growth form showed 160 species (66%) annual and the remaining 84 species (34%) as perennial macrophytes (Figure 7). The classification of total aquatic species displayed 35% submerged, 15% free-floating, 31% rooted floating, and 19% marshy plant species (Figure 8). The study of nativity resulted in 56 species out of 244 species as exotic or nonnative macrophytes of India (Table 1 and Table 2). The quadratic study revealed the quantitative status of 28 common macrophytes (Table 3). Maximum species diversity was recorded in the peripheral or shoreline plots. The most frequent and abundant species were *Ceratophyllum demersum* L., *Hydrilla verticellata* (L.) Pers., *Nelumbo nucifera* Gaertn., *Najas* sp., *Utricularia* sp., *Eichhornia crassipes* (Mart.) Solm-Laub. and *Salvinia molesta* D. S. Mitch from the lake's interior. Other species like *Polygonum barbatum* L., *Hymenachne amplexicaulis* (Rudge) Nees, *Cyperus iria* L., *Alternanthera philoxeroides* A. St-Hil., *Cyperus rotundus* L. were more abundant at the land water interface (i.e., marshy areas). The distribution pattern (i.e., Whitford's index) showed all species with more or less contiguous types of distribution ($A/F > 0.05$). The diversity indices study showed Simpson complement index-0.561, Shannon-Weiner index-1.367, Species richness index 3.079, and Species evenness index-0.156 (Figure 9).

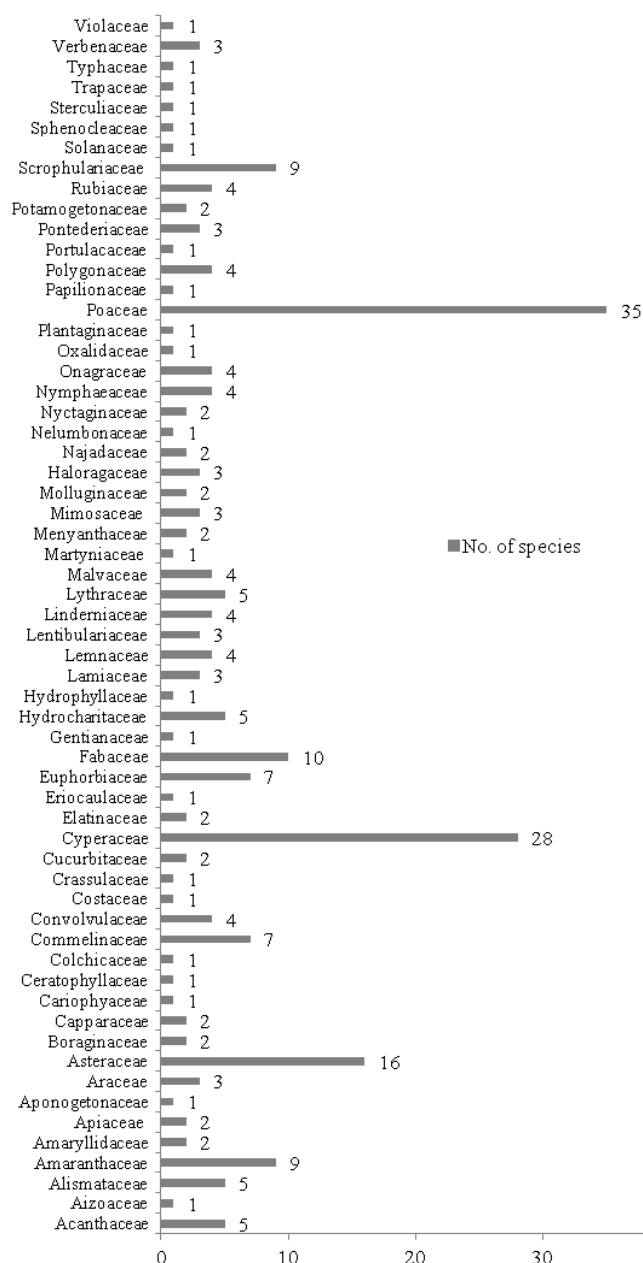


Figure 2. Family wise recorded number of angiospermic macrophytes species

The study found the occurrence of wide habitat variability that helped the establishment of a different group of aquatic and semi-aquatic vascular macrophytes in the lake. Many macrophytes showed seasonal changes of population status, influenced by water level (Dalu et al., 2012). This affects the value of the diversity index of the ecosystem, as calculated by the ratio between the number of species and the number of individuals in that community (Ansari et al., 2017). The low value of species evenness index showed the present species were not equally abundant; some species dominated over others. The lake hosts some unique macrophytes rarely found elsewhere in the state. *Hygroryza aristata* (Retz.) Nees. Ex Wt. & Arn. and *Oryza rufipogon* Griff., the wild

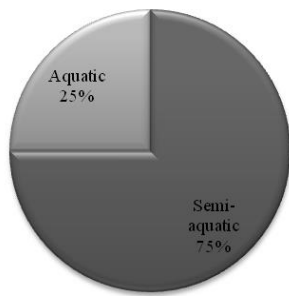


Figure 3. Classification as per habitat requirement: Aquatic and semi-aquatic plants (%)

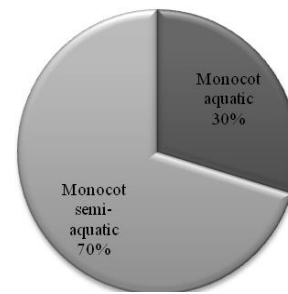


Figure 6. Classification of monocots into habitat groups: Aquatic and semi-aquatic monocots (%)

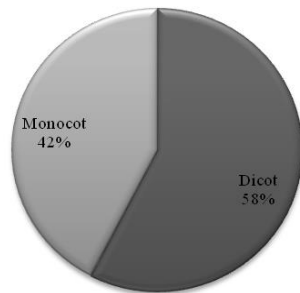


Figure 4. Classification into Angiosperm group: Diversity of dicot and monocot species (%)

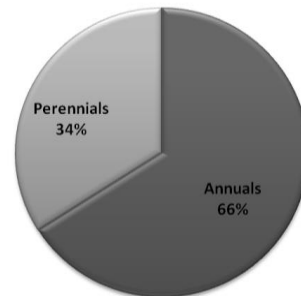


Figure 7. Classification of macrophytes into growth forms: Growth form of macrophytes (%)

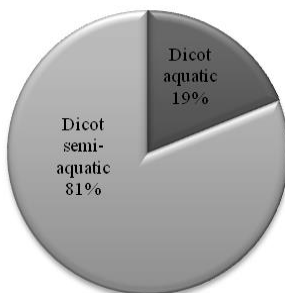


Figure 5. Classification of dicots into habitat group: Aquatic and semi-aquatic dicots (%)

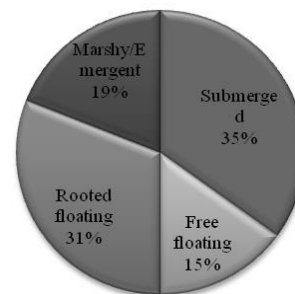


Figure 8. Classification of aquatic plants into their adaptation group: Adaptation forms of aquatic plants (%)

relative of edible rice was a common occurrence in the lake (Plate 1). The aesthetically essential and endangered plant species, *Gloriosa superba* L., has been recorded from shoreline areas of the lake for the first time (Plate 1). The semi-aquatic plants were diverse, and many showed seasonal growth. Many of them were small herbaceous annual plants.

Strong infestation of *Nelumbo nucifera* Gaertn., *Eichhornia crassipes* (Mart.) Solm-Laub., *Salvinia molesta* D. S. Mitch, *Ceratophyllum demersum* L., *Hydrilla verticillata* (L.f.) Royle, *Najas indica* (Willd) Cham.; *Hymenachne amplexicaulis* (Rudge) Nees, other grasses, and marshy vegetation were found negatively affecting the lake (Plate 2). Soil erosion from surrounding hills and siltation decreased water flow due to the closing of inlets and outlets with Mahanadi River; intensive fertilizer load is the possible factors for degradation of the lake.

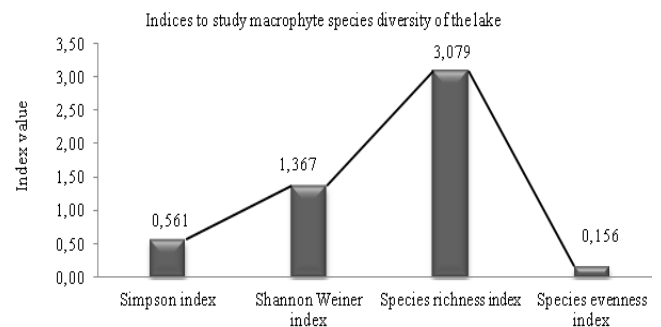


Figure 9. Diversity indices from quadrat data

Table 1. List of Angiospermic macrophyte recorded from Ansupa Lake, Odisha, India

Plant family	Si. No.	Plant species	Plant group	Macrophyte type	Life form
Acanthaceae	1	<i>Andrographis paniculata</i> (Burm.f.) Wall. ex Nees	D	Semi-aquatic	Annual
	2	<i>Hygrophila auriculata</i> (Schum) Heine	D	Semi-aquatic	Annual
	3	<i>Hygrophila schulli</i> (Buch.-Ham.) M.R.Almeida & S.M. Almeida	D	Semi-aquatic	Annual
	4	<i>Justicia diffusa</i> Willd	D	Semi-aquatic	Annual
	5	* <i>Ruellia tuberosa</i> L.	D	Semi-aquatic	Annual
Aizoaceae	6	* <i>Trianthema portulacastrum</i> L.	D	Semi-aquatic	Annual
Alismataceae	7	* <i>Alisma plantago-aquatica</i> L.	M	Aquatic (S)	Annual
	8	<i>Limnophyton obtusifolium</i> (L.) Miq.	M	Aquatic (S)	Annual
	9	<i>Sagittaria sagittifolia</i> L.	M	Aquatic (S)	Annual
	10	<i>Sagittaria guayanensis</i> var. <i>lappula</i> D. Don	M	Aquatic (S)	Annual
	11	<i>Sagittaria trifolia</i> L.	M	Aquatic (S)	Annual
Amaranthaceae	12	* <i>Achyranthes aspera</i> L.	D	Semi-aquatic	Annual
	13	<i>Aerva lanata</i> (L.) Juss. ex Schult.	D	Semi-aquatic	Annual
	14	* <i>Alternanthera paronychioides</i> A. St-Hil.	D	Semi-aquatic	Annual
	15	* <i>Alternanthera philoxeroides</i> (Mart.) Griseb.	D	Semi-aquatic	Annual
	16	* <i>Alternanthera sessilis</i> (L.) DC.	D	Semi-aquatic	Annual
	17	* <i>Amaranthus spinosus</i> L.	D	Semi-aquatic	Annual
	18	* <i>Amaranthus viridis</i> L.	D	Semi-aquatic	Annual
	19	* <i>Celosia argentea</i> L.	D	Semi-aquatic	Annual
	20	* <i>Gomphrena celosioides</i> Mart.	D	Semi-aquatic	Annual
	Amaryllidaceae	21	<i>Crinum latifolium</i> L.	M	Aquatic (S)
22		<i>Crinum viviparum</i> (Lam.) R.Ansari & V.J.Nair	M	Aquatic (RF)	Annual
Apiaceae	23	<i>Centella asiatica</i> (L.) Urb.	D	Semi-aquatic	Perennial
	24	* <i>Hydrocotyle modesta</i> Cham. & Schtdl.	D	Semi-aquatic	Perennial
Aponogetonaceae	25	<i>Aponogeton natans</i> (L.) Engl. & Krause	M	Aquatic (S)	Annual
	26	<i>Alocasia indica</i> (Roxb.) Schott	M	Semi-aquatic	Perennial
Araceae	27	<i>Colocasia esculenta</i> (L.) Schott	M	Semi-aquatic	Perennial
	28	* <i>Pistia stratiotes</i> L.	M	Aquatic (FF)	Perennial
Asteraceae	29	* <i>Ageratum conyzoides</i> L.	D	Semi-aquatic	Perennial
	30	<i>Blumea lacera</i> (Burm.f.) DC.	D	Semi-aquatic	Annual
	31	<i>Caesulia axillaris</i> Roxb.	D	Semi-aquatic	Annual
	32	* <i>Chromolaena odorata</i> (L.) King & H.E. Robins.	D	Semi-aquatic	Perennial
	33	<i>Cyanthillium cinereum</i> (L.) H. Rob	D	Semi-aquatic	Annual
	34	* <i>Eclipta alba</i> (L.)	D	Semi-aquatic	Annual
	35	<i>Eclipta prostrata</i> (L.) L.	D	Semi-aquatic	Annual
	36	<i>Enydra fluctuans</i> Lour.	D	Aquatic (S)	Annual
	37	<i>Emilia sonchifolia</i> (L.) DC	D	Semi-aquatic	Annual
	38	* <i>Gnaphalium polycaulon</i> Pers.	D	Semi-aquatic	Annual
	39	<i>Grangea maderaspatana</i> L.	D	Semi-aquatic	Annual
	40	* <i>Mikania cordata</i> (Burm.f.) Robinson	D	Semi-aquatic	Annual
	41	<i>Sphaeranthus indicus</i> L.	D	Semi-aquatic	Annual
	42	<i>Spilanthes paniculata</i> Wall. Ex DC.	D	Semi-aquatic	Annual
	43	* <i>Synedrella nodiflora</i> (L.) Gaertn.	D	Semi-aquatic	Annual
	44	* <i>Xanthium strumarium</i> L.	D	Semi-aquatic	Annual
	Boraginaceae	45	<i>Coldenia procumbens</i> L.	D	Semi-aquatic
46		<i>Heliotropium indicum</i> L.	D	Semi-aquatic	Annual
Capparaceae	47	<i>Cleome monophylla</i> L.	D	Semi-aquatic	Annual
	48	<i>Cleome viscosa</i> L.	D	Semi-aquatic	Annual
Cariophyaceae	49	* <i>Polycarpon prostratum</i> (Forssk.) Asc. & Sch.	D	Semi-aquatic	Annual
Ceratophyllaceae	50	<i>Ceratophyllum demersum</i> L.	D	Aquatic (S)	Perennial
Colchicaceae	51	<i>Gloriosa superba</i> L.	M	Semi-aquatic	Perennial
Commelinaceae	52	<i>Commelina benghalensis</i> L.	M	Semi-aquatic	Perennial
	53	<i>Commelina erecta</i> L.	M	Semi-aquatic	Perennial
	54	<i>Commelina longifolia</i> Lam.	M	Semi-aquatic	Perennial
	55	<i>Cyanotis axillaris</i> (L.) D.Don ex Sweet	M	Semi-aquatic	Perennial
	56	* <i>Evolvulus nummularius</i> (L.) L.	M	Semi-aquatic	Perennial
	57	<i>Murdannia nudiflora</i> (Linn.) Brenan.	M	Semi-aquatic	Annual
	58	<i>Murdannia spirata</i> (L.) Bruckn.	M	Semi-aquatic	Annual
	Convolvulaceae	59	* <i>Ipomoea aquatica</i> Forssk.	D	Aquatic (RF)
60		* <i>Ipomoea carnea</i> Jacq. ssp. <i>Fistulosa</i> (Mart. ex Choisy) Austin	D	Semi-aquatic	Perennial

	61	* <i>Ipomoea pes-tigridis</i> L.	D	Semi-aquatic	Perennial
	62	<i>Merremia tridentata</i> (L.) Hall. f.	D	Semi-aquatic	Perennial
Costaceae	63	<i>Costus speciosus</i> (J.Koenig) Sm.	M	Semi-aquatic	Perennial
Crassulaceae	64	<i>Bryophyllum calycinum</i> Salisb.	D	Semi-aquatic	Perennial
Cucurbitaceae	65	<i>Mukia maderaspatana</i> (L.) M. Roem.	D	Semi-aquatic	Annual
	66	<i>Cucumis melo</i> L.	D	Semi-aquatic	Annual
Cyperaceae	67	<i>Cyperus alopecuroides</i> Rottb.	M	Semi-aquatic	Annual
	68	* <i>Cyperus brevifolius</i> (Rottb.) Hassk.	M	Semi-aquatic	Perennial
	69	<i>Cyperus cephalotes</i> Vahl	M	Semi-aquatic	Perennial
	70	<i>Cyperus compressus</i> L.	M	Semi-aquatic	Annual
	71	<i>Cyperus corymbosus</i> Rottb.	M	Semi-aquatic	Perennial
	72	<i>Cyperus difformis</i> L.	M	Semi-aquatic	Annual
	73	<i>Cyperus haspan</i> L.	M	Semi-aquatic	Annual
	74	<i>Cyperus imbricatus</i> Retz.	M	Semi-aquatic	Perennial
	75	<i>Cyperus iria</i> L.	M	Semi-aquatic	Annual
	76	<i>Cyperus platystylis</i> R. Br.	M	Semi-aquatic	Perennial
	77	<i>Cyperus polystachyos</i> Rottb.	M	Semi-aquatic	Perennial
	78	<i>Cyperus rotundus</i> L.	M	Semi-aquatic	Perennial
	79	* <i>Cyperus strigosus</i> L.	M	Semi-aquatic	Perennial
	80	<i>Eleocharis acutangula</i> (Roxb.) Schult.	M	Aquatic (RE)	Perennial
	81	<i>Echinochloa crus-galli</i> (L.) P. Beauv.	M	Semi-aquatic	Annual
	82	<i>Eleocharis dulcis</i> (Burm.f.) Trin. ex Henschel	M	Semi-aquatic	Perennial
	83	<i>Fimbristylis dipsacea</i> (Rottb.) C.B. Clarke	M	Semi-aquatic	Annual
	84	<i>Fimbristylis ferruginea</i> (L.) Vahl.	M	Semi-aquatic	Perennial
	85	<i>Fimbristylis littoralis</i> Gaudich.	M	Semi-aquatic	Annual
	86	<i>Fimbristylis miliacea</i> (L.) Vahl	M	Semi-aquatic	Annual
	87	<i>Fuirena ciliaris</i> (L.) Roxb.	M	Semi-aquatic	Annual
	88	* <i>Kyllinga tenuifolia</i> Steud.	M	Semi-aquatic	Annual
	89	<i>Lipocarpha chinensis</i> (Osbeck) J.Kern.	M	Semi-aquatic	Annual
	90	<i>Cyperus compactus</i> Retz.	M	Semi-aquatic	Annual
	91	<i>Pycnus pumilus</i> (L.) Nees	M	Semi-aquatic	Annual
	92	<i>Schoenoplectus articulatus</i> (L.) Palla	M	Semi-aquatic	Annual
	93	<i>Schoenoplectus grossus</i> (L.f.) Palla	M	Semi-aquatic	Perennial
	94	<i>Schoenoplectiella supina</i> (L.) Lye	M	Semi-aquatic	Annual
Elatinaceae	95	* <i>Bergia ammannioides</i> Roxb. ex Roth	D	Semi-aquatic	Annual
	96	<i>Bergia capensis</i> L.	D	Semi-aquatic	Perennial
Eriocaulaceae	97	<i>Eriocaulon quinqueangulare</i> L.	M	Semi-aquatic	Perennial
Euphorbiaceae	98	<i>Acalypha indica</i> L.	D	Semi-aquatic	Annual
	99	* <i>Croton bonplandianus</i> (Baill.) Kuntze	D	Semi-aquatic	Annual
	100	<i>Euphorbia hirta</i> L.	D	Semi-aquatic	Annual
	101	* <i>Euphorbia prostrata</i> Aiton.	D	Semi-aquatic	Annual
	102	<i>Jatropha gossypifolia</i> L.	D	Semi-aquatic	Perennial
	103	* <i>Phyllanthus tenellus</i> Roxb.	D	Semi-aquatic	Perennial
	104	* <i>Ricinus communis</i> L.	D	Semi-aquatic	Perennial
Fabaceae	105	<i>Aeschynomene aspera</i> L.	D	Semi-aquatic	Annual
	106	<i>Aeschynomene indica</i> L.	D	Semi-aquatic	Annual
	107	<i>Alysicarpus vaginalis</i> (L.) DC.	D	Semi-aquatic	Annual
	108	* <i>Cassia tora</i> L.	D	Semi-aquatic	Annual
	109	* <i>Crotalaria pallida</i> Aiton	D	Semi-aquatic	Perennial
	110	<i>Crotalaria quinquefolia</i> L.	D	Semi-aquatic	Perennial
	111	<i>Zornia diphylla</i> (L.) Pers.	D	Semi-aquatic	Annual
	112	<i>Senna obtusifolia</i> (L.) H.S.Irwin. & Barneby	D	Semi-aquatic	Annual
	113	* <i>Senna occidentalis</i> (L.) Link	D	Semi-aquatic	Annual
	114	<i>Sesbania bispinosa</i> (Jacq.) W.F. Wt.	D	Semi-aquatic	Annual
Gentianaceae	115	<i>Hoppea dichotoma</i> Willd.	D	Semi-aquatic	Annual
Hydrocharitaceae	116	<i>Blyxa echinosperma</i> (Clarke) Hook.f.	M	Aquatic (S)	Annual
	117	<i>Hydrilla verticillata</i> (L.f.) Royle	M	Aquatic (S)	Perennial
	118	<i>Nechamandra alternifolia</i> (Roxb. ex Wight) Thw.	M	Aquatic (S)	Perennial
	119	<i>Ottelia alismoides</i> (L.) Pers.	M	Aquatic (S)	Perennial
	120	<i>Vallisneria spiralis</i> (L.) H. Hara	M	Aquatic (S)	Annual
Hydrophyllaceae	121	<i>Hydrolea zeylanica</i> (L.) Vahl.	D	Aquatic (RE)	Annual
Lamiaceae	122	<i>Anisomeles indica</i> (L.) O. Kuntze.	D	Semi-aquatic	Perennial
	123	<i>Leucas aspera</i> (Willd.) Link	D	Semi-aquatic	Annual
	124	<i>Pogostemon quadrifolius</i> (Benth.) F. Muell.	D	Semi-aquatic	Annual
Lemnaceae	125	* <i>Spirodela polyrrhiza</i> (L.) Schleid.	M	Aquatic (FF)	Perennial
	126	<i>Lemna gibba</i> L.	M	Aquatic (FF)	Annual

	127	<i>Lemna aequinoctialis</i> Welw	M	Aquatic (FF)	Annual
	128	<i>Wolffia globosa</i> (Roxb.) Hartog & Vander Plas	M	Aquatic (FF)	Annual
Lentibulariaceae	129	<i>Utricularia aurea</i> Lour.	D	Aquatic (S)	Annual
	130	<i>Utricularia inflexa</i> Forssk.	D	Aquatic (S)	Annual
	131	<i>Utricularia bifida</i> L.	D	Aquatic (S)	Annual
Linderniaceae	132	<i>Lindernia crustacea</i> (L.) F.Muell.	D	Semi-aquatic	Annual
Lythraceae	133	<i>Ammannia baccifera</i> L.	D	Semi-aquatic	Annual
	134	<i>Ammannia multiflora</i> Roxb.	D	Semi-aquatic	Annual
	135	<i>Ammannia octandra</i> L.f.	D	Semi-aquatic	Annual
	136	<i>Rotala densiflora</i> (Roth. ex Roem. & Schult.) Koehne	D	Semi-aquatic	Annual
	137	<i>Rotala indica</i> (Willd.) Koehne	D	Semi-aquatic	Annual
Malvaceae	138	<i>Abutilon indicum</i> (L.) Sweet	D	Semi-aquatic	Annual
	139	<i>Corchorus aestuans</i> L.	D	Semi-aquatic	Annual
	140	<i>Sida cordifolia</i> L.	D	Semi-aquatic	Annual
	141	<i>Urena lobata</i> L.	D	Semi-aquatic	Annual
Martyniaceae	142	* <i>Martynia annua</i> L.	D	Semi-aquatic	Annual
Menyanthaceae	143	<i>Nymphoides hydrophylla</i> (Lour.) Kuntze	D	Aquatic (RF)	Annual
	144	<i>Nymphoides indica</i> (L.) Kuntze	D	Aquatic (RF)	Annual
Mimosaceae	145	* <i>Mimosa pudica</i> L.	D	Semi-aquatic	Perennial
	146	<i>Neptunia oleracea</i> Lour.	D	Aquatic (RF)	Perennial
	147	<i>Neptunia plena</i> (L.) Benth.	D	Aquatic (RF)	Perennial
Molluginaceae	148	<i>Glinus oppositifolius</i> (L.) Aug. DC	D	Semi-aquatic	Annual
	149	<i>Mollugo pentaphylla</i> L.	D	Semi-aquatic	Annual
Haloragaceae	150	<i>Myriophyllum tetrandrum</i> Roxb.	D	Aquatic (RE)	Annual
	151	* <i>Myriophyllum aquaticum</i> (Vell.) Verdc.	D	Aquatic (RE)	Perennial
	152	<i>Myriophyllum verticillatum</i> L.	D	Aquatic (RE)	Annual
Najadaceae	153	<i>Najas faveolata</i> A. Br. ex Magam.	M	Aquatic (S)	Perennial
	154	<i>Najas indica</i> (Willd) Cham.	M	Aquatic (S)	Perennial
	155	<i>Najas marina</i> L.	M	Aquatic (S)	Perennial
Nelumbonaceae	156	<i>Nelumbo nucifera</i> Gaertn.	D	Aquatic (RF)	Perennial
Nyctaginaceae	157	<i>Boerhavia diffusa</i> L.	D	Semi-aquatic	Annual
	158	<i>Boerhavia repens</i> L.	D	Semi-aquatic	Annual
Nymphaeaceae	159	<i>Euryale ferox</i> Salisb.	D	Aquatic (RF)	Perennial
	160	<i>Nymphaea nouchali</i> Burm.f.	D	Aquatic (RF)	Perennial
	161	<i>Nymphaea pubescens</i> Willd.	D	Aquatic (RF)	Perennial
	162	<i>Nymphaea rubra</i> Roxb. ex Andrews	D	Aquatic (RF)	Perennial
Onagraceae	163	<i>Ludwigia prostrata</i> Roxb.	D	Semi-aquatic	Annual
	164	<i>Ludwigia adscendens</i> (L.) H. Hara	D	Aquatic (RF)	Perennial
	165	<i>Ludwigia octovalvis</i> (Jacq.) P.H. Raven	D	Semi-aquatic	Annual
	166	<i>Ludwigia perennis</i> L.	D	Semi-aquatic	Annual
Oxalidaceae	167	<i>Oxalis corniculata</i> L.	D	Semi-aquatic	Annual
Plantaginaceae	168	* <i>Scoparia dulcis</i> L.	D	Semi-aquatic	Annual
Poaceae	169	<i>Apluda mutica</i> L.	M	Semi-aquatic	Annual
	170	<i>Arundinella pumila</i> (Hochst. ex A.Rich) Steud	M	Semi-aquatic	Annual
	171	<i>Axonopus compressus</i> (Sw.) P.Beauv.	M	Semi-aquatic	Perennial
	172	<i>Brachiaria deflexa</i> (Schumach.) C.E.Hubb. ex Robyns	M	Semi-aquatic	Annual
	173	<i>Brachiaria mutica</i> (Forssk.) Stapf.	M	Semi-aquatic	Perennial
	174	<i>Brachiaria ramosa</i> (L.) Stapf	M	Semi-aquatic	Annual
	175	<i>Brachiaria reptans</i> (L.) C.A.Gardner & C.E.Hubb	M	Semi-aquatic	Annual
	176	* <i>Chloris barbata</i> Sw.	M	Semi-aquatic	Annual
	177	<i>Cyrtococcum longipes</i> (Hook.f.) A.Camus	M	Semi-aquatic	Perennial
	178	<i>Cynodon dactylon</i> (L.) Pers.	M	Semi-aquatic	Perennial
	179	* <i>Dactyloctenium aegyptium</i> (L.) Willd.	M	Semi-aquatic	Annual
	180	<i>Dichantherium</i> sp.	M	Semi-aquatic	Annual
	181	<i>Echinochloa colona</i> (L.) Link	M	Semi-aquatic	Annual
	182	<i>Echinochloa crus-galli</i> (L.) P.Beauv.	M	Semi-aquatic	Annual
	183	<i>Echinochloa stagnina</i> (Retz.) Beauv.	M	Semi-aquatic	Annual
	184	<i>Eleusine indica</i> (L.) Gaertn	M	Semi-aquatic	Annual
	185	<i>Elytrophorus spicatus</i> (Willd.) A. Camus	M	Semi-aquatic	Annual
	186	<i>Eragrostis ciliaris</i> (L.) R.Br.	M	Semi-aquatic	Annual
	187	<i>Eragrostis gangetica</i> (Roxb.) Steudel	M	Semi-aquatic	Annual
	188	<i>Eragrostis japonica</i> (Thunb.) Trin.	M	Semi-aquatic	Perennial
	189	<i>Eragrostis pilosa</i> (L.) P.Beauv.	M	Semi-aquatic	Annual
	190	<i>Eragrostis tenella</i> (L.) P.Beauv.ex Roem.& Schult.	M	Semi-aquatic	Annual
	191	<i>Hygroryza aristata</i> (Retz.) Nees ex Wight & Arn	M	Aquatic (RF)	Perennial
	192	* <i>Hymenachne amplexicaulis</i> (Rudge) Nees	M	Aquatic (RF)	Perennial
	193	<i>Leersia hexandra</i> Sw.	M	Semi-aquatic	Perennial

	194	<i>Oryza rufipogon</i> Griff.	M	Semi-aquatic	Perennial
	195	<i>Panicum sumatrense</i> Roth	M	Semi-aquatic	Perennial
	196	* <i>Paspalum dilatatum</i> Poir	M	Semi-aquatic	Annual
	197	<i>Paspalum distichum</i> L.	M	Semi-aquatic	Perennial
	198	<i>Paspalum vaginatum</i> Sw.	M	Semi-aquatic	Annual
	199	<i>Setaria pumila</i> (Poir.) Roem. & Schult.	M	Semi-aquatic	Annual
	200	<i>Saccharum spontaneum</i> L.	M	Semi-aquatic	Perennial
	201	<i>Setaria glauca</i> (L.) Beauv.	M	Semi-aquatic	Annual
	202	<i>Sporobolus coromandelianus</i> (Retzi.) Kunth	M	Semi-aquatic	Annual
Papilionaceae	203	<i>Sesbania bispinosa</i> (Jacq.) W. Wight.	D	Semi-aquatic	Annual
Polygonaceae	204	* <i>Persicaria glabrum</i> (Willd.) M. Gomez	D	Semi-aquatic	Perennial
	205	* <i>Polygonum barbatum</i> L.	D	Semi-aquatic	Perennial
	206	<i>Polygonum plebeium</i> R. Br.	D	Semi-aquatic	Annual
	207	* <i>Rumex maritimus</i> L.	D	Semi-aquatic	Annual
Pontederiaceae	208	<i>Eichhornia crassipes</i> (Mart.) Solm-Laub.	M	Aquatic (RF)	Perennial
	209	<i>Monochoria hastata</i> (L.) Solm.	M	Aquatic (RF)	Perennial
	210	<i>Monochoria vaginalis</i> (Burm f.) Presl.	M	Aquatic (RE)	Perennial
Portulacaceae	211	<i>Portulaca oleracea</i> L.	D	Semi-aquatic	Annual
Potamogetonaceae	212	* <i>Potamogeton nodosus</i> Poir.	M	Aquatic (S)	Annual
	213	<i>Stuckenia pectinata</i> (L.) Börner	M	Aquatic (S)	Perennial
Rubiaceae	214	<i>Dentella repens</i> (L.) Forst. et Forst.	D	Semi-aquatic	Annual
	215	<i>Oldenlandia diffusa</i> (Willd.) Roxb.	D	Semi-aquatic	Annual
	216	<i>Mitracarpus hirtus</i> (L.) DC.	D	Semi-aquatic	Annual
	217	<i>Oldenlandia corymbosa</i> L.	D	Semi-aquatic	Annual
Scrophulariaceae	218	<i>Bacopa monnieri</i> (L.) Pennell.	D	Semi-aquatic	Annual
	219	<i>Dopatrium junceum</i> (Roxb.) Buch-Ham. ex Benth.	D	Aquatic (RE)	Annual
	220	<i>Limnophila aquatica</i> (Roxb.) Alston	D	Aquatic (RE)	Annual
	221	<i>Limnophila heterophylla</i> (Roxb.) Benth.	D	Aquatic (RE)	Annual
	222	<i>Limnophila indica</i> (L.) Druce	D	Aquatic (RE)	Annual
	223	<i>Limnophila sessiliflora</i> (Vahl) Blume	D	Aquatic (RE)	Annual
	224	<i>Lindernia anagallis</i> (Burm.f.) Pennel	D	Semi-aquatic	Annual
	225	<i>Lindernia antipoda</i> (L.) Alston	D	Semi-aquatic	Annual
	226	<i>Lindernia parviflora</i> (Roxb.) Haines	D	Semi-aquatic	Annual
	227	<i>Mecardonia procumbens</i> (Mills.) Small	D	Semi-aquatic	Annual
	228	<i>Scoparia dulcis</i> L.	D	Semi-aquatic	Annual
	229	* <i>Verbascum chinense</i> (L.) Santapau	D	Semi-aquatic	Annual
Solanaceae	230	<i>Physalis minima</i> L.	D	Semi-aquatic	Annual
Sphenocleaceae	231	<i>Sphenoclea zeylanica</i> Gaertn.	D	Semi-aquatic	Annual
Sterculiaceae	232	<i>Melochia corchorifolia</i> L.	D	Semi-aquatic	Annual
Trapaceae	233	<i>Trapa natans</i> L. var. <i>bispinosa</i> (Roxb.) Makino	D	Aquatic (RF)	Perennial
Typhaceae	234	* <i>Typha angustata</i> Bory & Chaub.	M	Aquatic (RE)	Perennial
Verbenaceae	235	* <i>Lantana camara</i> L.	D	Semi-aquatic	Perennial
	236	* <i>Lippia javanica</i> (Burm.f.) Spreng.	D	Semi-aquatic	Perennial
	237	<i>Phyla nodiflora</i> (L.) Greene	D	Semi-aquatic	Annual
Violaceae	238	<i>Hybanthus enneaspermus</i> (L.) F. Muell.	D	Semi-aquatic	Annual

Note: D= Dicot, M= Monocot, S= Submerged, FF= Free floating, RF= Rooted floating, RE= Rooted erect, *=Exotic or nonnative species (Un-marked species are native or indigenous to India)

Table 2. List of Non-flowering (Pteridophyte) macrophytes of Ansupa Lake (Odisha), India

Family	S. No.	Plant species	Habitat group	Life form
Marsileaceae	1	<i>Marsilea minuta</i> L.	Aquatic (RF)	Perennial
	2	<i>Marsilea quadrifolia</i> L.	Aquatic (RF)	Perennial
Salviniaceae	3	* <i>Azolla microphylla</i> Kaulf.	Aquatic (FF)	Annual
	4	<i>Azolla pinnata</i> R.Br.	Aquatic (FF)	Perennial
	5	* <i>Salvinia minima</i> Baker	Aquatic (FF)	Perennial
	6	* <i>Salvinia molesta</i> D.S. Mitch	Aquatic (FF)	Perennial

Note: RF=Rooted floating, FF=Free floating, *= Exotic or nonnative species (Un-marked species are native or indigenous to India)

Table 3. Quantitative status of important macrophytes of Ansupa Lake, Odisha, India

Macrophyte species	Total count	Total plots where recorded	Frequency	Abundance	Abundance/frequency (A/F)
<i>Eichhornia crassipes</i> (Mart.) Solm-Laub.	31	4	16	7.75	0.484
<i>Ipomoea aquatica</i> Forssk.	17	3	12	5.67	0.472
<i>Cyperus strigosus</i> L.	14	2	8	7.0	0.875
<i>Cyperus iria</i> L.	60	1	4	60.0	15.00
<i>Cyperus rotundus</i> L.	20	1	4	20.0	5.00
<i>Ludwigia adscendens</i> (L.) H. Hara	13	2	8	6.5	0.813
<i>Ludwigia perennis</i> L.	20	3	12	6.67	0.556
<i>Alternanthera philoxeroides</i> (Mart.) Griseb.	25	1	4	25.0	6.250
<i>Salvinia molesta</i> D.S. Mitch	37	3	12	12.33	1.028
<i>Salvinia minima</i> Baker	6	1	4	6.0	1.500
<i>Cyperus compressus</i> L.	62	2	8	31.0	3.875
<i>Kyllinga tenuifolia</i> Steud.	2	1	4	2.0	0.500
<i>Hydrilla verticillata</i> (L.f.) Royle	1240	12	48	103.33	2.153
<i>Ceratophyllum demersum</i> L.	4060	21	84	193.33	2.302
<i>Najas faveolata</i> A. Br. ex Magam.	335	9	36	37.22	1.034
<i>Nymphaea pubescens</i> Willd.	6	4	16	1.5	0.094
<i>Trapa natans</i> L. var. <i>bispinosa</i> (Roxb.) Makino	8	1	4	8.0	2.00
<i>Nelumbo nucifera</i> Gaertn.	57	16	64	3.56	0.056
<i>Pistia stratiotes</i> L.	11	3	12	3.67	0.306
<i>Spirodela polyrrhiza</i> (L.) Schleid.	54	4	16	13.5	0.844
<i>Utricularia</i> sp.	171	4	16	42.75	2.672
<i>Lemna gibba</i> L.	78	7	28	11.14	0.398
<i>Azolla pinnata</i> R Br.	29	5	20	5.8	0.290
<i>Polygonum barbatum</i> L.	38	1	4	38.0	9.500
<i>Marsilea quadrifolia</i> L.	20	3	12	6.67	0.556
<i>Aponogeton natans</i> (L.) Engl. & Krause	5	1	4	5.0	1.250
<i>Hygroryza aristata</i> (Retz.) Nees ex Wight & Arn	7	2	8	3.5	0.438
<i>Lindernia parviflora</i> (Roxb.) Haines	10	2	8	5.0	0.625

**Plate 1.** Some taxonomically important taxa from Ansupa Lake, Odisha, India. Note: A. *Oryza rufipogon*, B. *Hygroryza aristata*, C. *Ottelia alismoides*, D. *Gloriosa superba*



Plate 2. Invasive weed species of Ansupa Lake, Odisha, India. Note: A-B. *Eichhornia crassipes*, C-D. *Nelumbo nucifera*, E. *Salvinia molesta*, F. *Ceratophyllum demersum*, G. *Najas indica*, H. *Hymenachne amplexicaulis*

Besides having these troublesome weeds, the lake also hosts many macrophytes used as food, fodder, or medicine by the local households. Control of invasion and their management is tedious and needs multiple strategies. Management of this invasive grass must include a combination of techniques such as winter burning, herbicide application, and hydroperiod control. The floating rotted macrophyte *Euryale ferox* Salisb. once occurred in the lake (recorded in October 2014) is now extinct from the lake. Implementation of physical (mechanical) methods and dredging to required depth will reduce currently infested weeds and further regular monitoring, participation of both Governments agency and local community thought to restore a long-term functioning of the lake.

General comments

Aquatic macrophytes are an indispensable constituent of any wetland. They provide habitat to various aquatic fauna, act as primary producers, oxygenate the water, maintain water quality, do nutrient cycling, stabilize shoreline of lakes, provide substrate for growth of algae, provide shelter to benthic fauna and breeding ground for fishes, check the inflow of silt, reduce the nutrient load by self-utilizing, and minimize the development of algal blooms (Naskar 1990; Bornette and Puijalon 2009; Ansari et al. 2017). But, sometimes environments enforce and help invade exotic weeds in aquatic ecosystems, which negatively affect the entire ecosystem. These plants compete with native species and often facilitate the loss or extinction of less aggressive and indigenous species (Stallings et al., 2015). In many instances, they negatively affect human activities (e.g., fishing, swimming, navigation, and irrigation) and degrade the physical, chemical or biological aspects (Basak et al. 2015). In India, about 140 aquatic plants have been reported to have attained the status of aquatic weeds (Naskar 1990, Gupta 2012), many of them found in Ansupa Lake. The wetlands in India are also gradually shrinking and under severe anthropogenic pressure (Pattanaik et al., 2008; Udayakumar and Ajithadoss 2010). Regular physical visits, application of geospatial remote sensing techniques, monitoring change in floristic composition, maintaining required depth, reducing fertilizer use in agriculture in nearby cultivation lands, and creating green coverage in surrounding barren lands can save native biota from alien species to invade many aquatic ecosystems.

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