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CURRENT STATUS OF AQUATIC MACROPHYTES IN LAKE MANSAR- A RAMSAR SITE IN THE SIWALIK BELT OF JAMMU REGION, JAMMU & KASHMIR, INDIA

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Abstract

The present investigation deals with the documentation of the aquatic macrophytes from Mansar lake- an important subtropical monomictic lake in the Siwalik hills of Jammu region. Macrophytic survey was carried out in the littoral zone of lake Mansar for a period of two years *viz*. January 2014 to December 2015 and showed the presence of 26 macrophytic species belonging to 19 genera and 14 families. Among various ecological groups, emergent with 15 species showed qualitative dominance over submersed (8 species) and rooted floating-leaved types (3 species). Two macro-algal species (*Chara vulgaris and Nitella hyalina*) showed their absence during the first year whereas one species (*Najas indica*) showed its complete absence during the second year. Based on the Importance value index (IVI), *Ipomea carnea* was the dominated species in Mansar lake during the two years study period. The diversity indices have confirmed the increased species diversity during summer followed by monsoon and winter. In the present study, the collected macrophytic data was classified under different lifeforms classification as given by Raunkiaer (1934) and the biological spectrum was compared with Raunkiaer's normal biological spectrum. Four recorded life form categories showed dominance of Therophytes followed by Cryptophytes (geophytes > helophytes = hydrophytes), Hemicryptophytes and Chamaephytes. Among the recorded life forms, Therophytes and Cryptophytes dominated over the other life forms classes. Therefore, the present lake may be designated as Thero-cryptophytic type of phytoclimate. Comparison of present macrophytic data with the earlier reports from Mansar lake showed considerable decline in macrphytic diversity over a period of time.

Key words *:* Exotic fish stocking, Life form, Macrophytic diversity, Ramsar site, wetlands, management.

Introduction

Wetlands are considered to be the most productive ecosystems in the world and are ware repositories of plants and animals (Parveen *et al*., 2014). Wetlands in our country are under tremendous anthropogenic pressures and facing marked decline in the biological diversity due to encroachments, increased deforestation, heavy use of fertilizers for agricultural purpose and waste and sewage disposal into these waterbodies in absence of proper sewer system. Wetland degradation has serious impact on diversity of flora and fauna and requires continuous monitoring. Aquatic macrophytes are important component of aquatic ecosystem and the functional status of the littoral zone of lakes depends on the presence of these aquatic plants. These macrophytes are the most important constituents of the aquatic ecosystem and have been frequently used in limnology as bio-indicators of habitat conditions and water quality (Pandit, 1984, Steffen *et al.,* 2013). Ecologically, macrophytes provide multitude of benefits in an aquatic ecosystem. Besides being oxygen source, these acts as water filters and pollutant absorbers for the in flowing water from catchment, thus helping in nutrient cycling. These also stabilize littoral zone against the waves and water currents (Ellis *et al*., 1994; Hans, 1997; Engelhardt and Ritchie 2001; Caraco *et al*., 2006; Madsen, 2009). From biological view point, these are important primary producers in an aquatic ecosystem, also providing food and shelter to fish and other aquatic organisms. These even act as nesting, resting and breeding grounds for residential and migratory birds (Lacoul and Freedman, 2006). Macrophytes are important for human welfare as source of food, raw material for cottage industry, source of fuel etc. Although some earlier studies on macrophytic

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diversity have been conducted from various temperate wetlands in Kashmir (Zutshi *et al*., 1972, Kak, 1987, Ravinder and Pandit, 2005) and subtropical lakes of Jammu (Kant and Anand, 1978, Anand and Sharma, 1991 and Sharma, 2008) but no recent attempt has been made to study the status of macrophytic diversity from this subtropical part of the country. Analysis of the structure and dynamics of vegetation prior to any extensive ecological work on any ecosystem provides an indication of the nature of the biological and physical environment. The qualitative analysis of vegetation include the floristic composition, life form analysis and growth form classification. The life form of the plants signifies the adaptational features of the plant to the change in climate (Raunkiaer, 1934).

Study Area

Mansar lake in Siwalik belt of Jammu region, is located about 52km from Jammu city. It is situated at 75^0 23'E Longitude; $32^0$48'N Latitude, at an elevation of 666m amsl with a maximum depth of 38m (Fig. 1). Main sources of water to the lake are subterranean springs, rain water and runoff from the surrounding catchment area. The lake is the habitat of numerous fishes, two species of turtles and nesting and feeding grounds for winter migratory birds. Fishing in the lake due to religious restrictions, is not permitted. The lake water is used for drinking purposes and is life line for the inhabitants in the area.

Materials and Methods

Macrophytic analysis

For the present macrophytic study, various sites were selected based on seeming differences of topography, soil conditions, floral characteristics and human impacts. For qualitative analysis, monthly harvest method was employed in the selected sites at regular intervals by using 0.5×0.5m quadrats for a period of two years (January 2014 to December 2015). In field, macrophytes were washed thoroughly to get rid of adhering material, separated and brought to laboratory for identification. The macrophytes were identified by using standard literature (Biswas and Calder, 1954; Ward and Whipple, 1959; Subramanyam, 1974; Adoni *et al*., 1985; Cook, 1996) as well as consulting taxonomic expertise. The phytosociological attributes like frequency, density and dominance were calculated following Curtis (1956), Philips (1959) and Misra (1968). Importance Value Index of a species in the community gives the idea of relative importance of the species as compared to other species (Curtis, 1959) and is obtained by summing up the relative density, relative frequency and relative dominance. The species diversity of aquatic macrophytes was calculated by using following formulas:

Shannon and Weiner diversity index (H) by using following formula given by Shannon and Weiner (1963)

$H = - \Sigma$ Pi ln Pi Where, Pi(importance probability for each species) = ni / N,

ni= importance value for each species,

N = total of importance values

Simpson diversity index (Ds) = 1-Cd

where Cd is concentration of Dominance (Cd) calculated by using the formula given by Simpson (1949)

$Cd = \Sigma (Pi)^2$ Where, Pi = ni / N

Macrophytes collected from the field were classified after Raunkiar's life-forms classification as modified by Ellengberg and Muller –Dombois (1967) and Muller – Dombois and Ellenberg (2003). The height, form, habit and nature of perennial buds together with occurrence of each species were studied in the field and compared with earlier studies for confirmation (Raunkaier 1934; Kambhar and Kotresha, 2012; Devi *et al*., 2015). Based on the studied life forms, biological spectrum of Mansar lake was prepared using following formula:

$$\text{Biological Spectrum}(\%) = \frac{\text{Total No. of species in a life form class}}{\text{Total No. of species found in the study area}} \times 100$$

The biological spectrum for the area has been compared with the Raunkiaer's normal biological spectrum (Fig. 2).

Results and Discussion

A total of twenty six macrophytic species belonging to 14 families and 19 genera have been observed during the two year study period (Table 1). Among these, 23 species belonged to 12 different families of the angiosperms, 2 to macro-algal group and 1 to Pteridophyta. Of the 23 reported angiosperm macrophytic species, 14 species belonged to monocots and 9 to dicots, thereby showing the dominance of monocot flora in the lake Mansar. Among the 14 families observed in the lake there is dominance of Potamogetonaceae and Cyperaceae (04 species each) followed by Polygonaceae (03 species); Poaceae, Menyanthaceae, Characeae and Hydrocharitaceae (02 species each); and Nelumbonaceae, Ranunculaceae, Amaranthaceae, Convolvulaceae, Typhaceae, Araceae, and Equisetaceae (01 species each). An overall macrophytic analysis has shown the dominance of emergent type (15 species) followed by submersed (08 species) and rooted floating-leaved types (03 species). During the first year, two species (*Chara vulgaris* and *Nitella hyaline*) were not recorded and during the second year one species (*Najas*

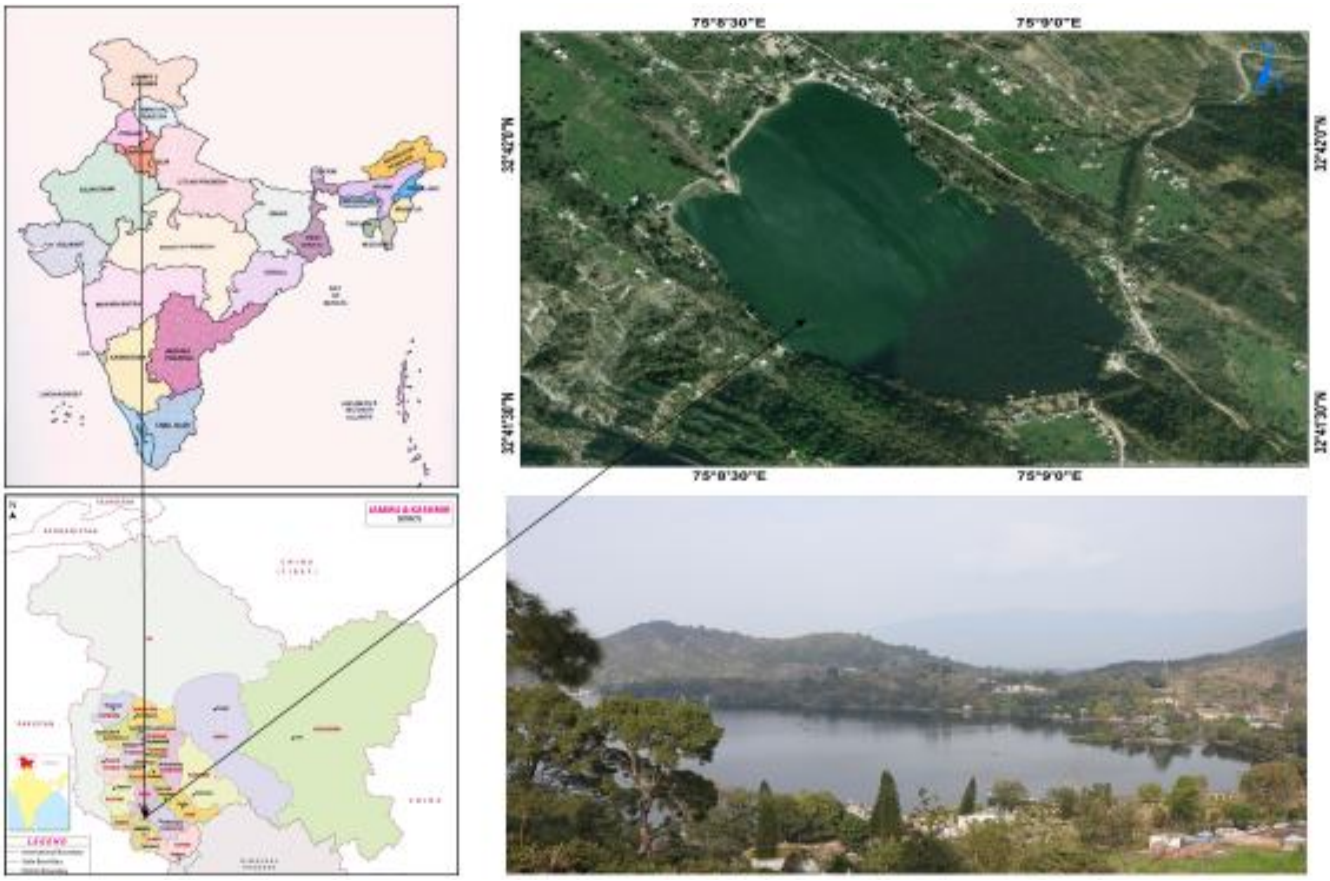

Fig. 1: Map showing location of Mansar lake in J&K and satellite imagery showing the littoral zone.

indica) was found absent. Seasonally, all the species observed similar pattern of variations during the two year study period with high diversity was observed during summer and monsoon, and lowest during winter (Table 1). The comparison of the present observations with the macrophytic studies carried out by earlier workers on lake Mansar have shown similar dominance trend with maximum diversity of emergent followed by submersed and rooted floating leaved types but with higher species diversity among various groups. Anand and Sharma (1991) reported 46 macrophytic species belonging to emergent (24 species), submersed (17 species) and rooted floating-leaved (05 species) types; Mohan (1993) observed 44 species belonging to emergent (26 species), submersed (13 species) and rooted floating-leaved (05 species); and Sharma (2008) enlisted 61 species belonging to emergent (33 species), submersed (21 species) and rooted floating leaf (07 species). The comparison of present study with earlier studies has shown a considerable decline in all the ecological groups. The decline in lake area by 6.9% since 1980 has been recorded during the present study (from 0.58Km^2 in 1980 to 0.54km^2 during the present study). Inflow and accumulation of sediments in littoral zone due to deforestation in the catchment for conversion of forest land into agricultural land, encroachments along the lake banks for construction of houses, hotels and other facilities, indiscriminate developmental activities, unscientific open dumping of muck and entry of sewage from households have resulted in fall in the littoral depth over a period of time. The increased sediments have resulted in disappearance of many littoral pockets which were once rich in macrophytic diversity. Also, increased population of exotic carps *viz*. *Cyprinus carpio* var. *communis* (Linnaeus, 1758) commonly known as common carp and *Cyprinus carpio* var. *specularis* (Lacepede, 1803) known as mirror carp, which were stocked in lake Mansar following the mass mortality of the trash fish in the year 1997 have crossed the bionomic norms (less than 250 kg/ha) and have resulted in ecological overshoot. Macrophytic decline with increased carp population is already on record (Van Zon, 1977). Naik *et al.,* (2015) reported that detritus formed maximum percentage of food of *Cyprinus carpio* var. *communis* (43.5%) followed by plant (31.21%) and animal matter (25.29%). As a result of overpopulation and benthic feeding habit of this fish, bottom in the littoral habitat is continuously disturbed and macrophytes are unable to grow in the shallow littoral zones. The increased turbid conditions in the littoral zone are also increased with the striking of waves and currents against the lake shore devoid of

Table 1: Presence (P) and absence (A) of various macrophytic species during Summer(S), Monsoon(M), Winter(W) seasons in Lake Mansar during 2014-2015.

Ecological groups/family/species	S	M	W	S	M	W
Submersed	**2014**			**2015**		
Family Potamogetonaceae						
Potamogeton crispus Linn.	P	P	P	P	P	P
Potamogeton sp.	P	P	P	P	P	P
Potamogeton lucens Linn.	P	P	P	P	P	P
Potamogeton natans Linn.	P	P	P	P	P	P
Family Hydrocharitaceae						
Vallisneria spiralis Linn.	P	P	P	P	P	A
Najas indica (Wild) Cham.	A	P	P	A	A	A
Family Characeae						
Chara vulgaris L.	A	A	A	P	P	A
Nitella hyalina(DC) C. Agardh	A	A	A	P	P	A
Submersed total	5	6	6	7	7	4
Rooted floating leaved Family Nelumbonaceae						
Nelumbo nucifera Gaertn.	P	P	A	P	P	A
Family Menyanthaceae						
Nymphoides cristata(Roxb) Kuntze	P	P	P	P	P	A
Nymphoides indica(L.) Kuntze	P	P	P	P	P	P
Rooted floating leaved total	3	3	2	3	3	1
Emergent Family Cyperaceae						
Carex fedia Nees.	P	P	P	P	P	P
Cyperus difformis Linn.	P	P	A	P	P	A
Cyperus glomeratus Linn.	P	P	A	P	P	A
Fimbristylis bisumballeta (F)Bubani	P	P	A	P	P	A
Family Equisetaceae						
Equisetum diffusum D. Don	P	P	A	P	P	A
Family Convolvulaceae						
Ipomea carnea Jacq.	P	P	P	P	P	P
Family Poaceae						
Phragmites karka (Retz.)Trin. ex Steud.	P	P	A	P	P	A
Eichnochola crus-galli(L.)	P	P	A	P	P	A
Family Polygonaceae						
Polygonum barbatum Linn.	P	P	P	P	P	P
Polygonum glabrum Willd.	P	P	A	P	P	A
Polygonum hydropiper L.	P	P	A	P	P	A
Family Amaranthaceae						
Alternanthera sessilis (L.)R.Br. ex DC	P	P	A	P	P	P
Family Ranunculaceae						
Ranunculus sceleratus L.	P	P	P	P	P	P
Family Araceae						
Colocasia esculenta (Linn) Schott	P	P	P	P	P	P
Family Typhaceae						
Typha domingensis Pers.	P	P	A	P	P	A
Emergent total	15	15	5	15	15	6
Grand Total	23	24	13	25	25	11

macrophytes (Januszko, 1974). High turbidity and siltation is detrimental to macrophytic diversity. Macrophytic decline due to turbidity has been reported in earlier studies (Tarver, 1980, Winkel and Meulemans, 1984 and Slathia *et al.*, 2018). The loss in biodiversity due to unprecedented human interventions modify ecosystem processes and alter the resilience of ecosystems to environmental changes (Cardinale *et al.*, 2012; Schneider *et al.*, 2018). The importance of environmental regulations on macrophytic life forms is considered to be strong where environmental conditions are reported to be the major forces structuring macrophyte community.

The seasonal and overall dominance of species on the basis of Importance value index (IVI) is presented in table 2. Based on the IVI values, emergent was the most dominant group followed by submersed and rooted floating-leaved types. Among the species, *Ipomea carnea* among emergent, *Nymphoides indica* among rooted floating-leaved type and *Potamogeton crispus* among submersed group were the dominated species in Mansar lake during the two years study period.

The computation of diversity indices (Shannon-weiner index and Simpson index of diversity) of macrophytes revealed that the species diversity was highest during summer followed by monsoon and winter during the two years study period (Fig. 2). This indicates significant seasonal change in the macrophytic community of the littoral zone of the Mansar lake.

In the present study, four types of Raunkiers life forms have been recognized among the 24 macrophytic species reported from Lake Mansar, Jammu (2 macro-algal species have been excluded) Table 3. The biological spectrum, of different life forms found in Mansar Lake has been depicted in Fig. 3 with highest percentage of Therophytes, followed by cryptophytes, chaemophytes and= Hemicryptophyte. No Errant vascular hydrophyte (free floating hydrophyte) was observed in the present study. Based on the percentage composition of different life-forms classes, the polyclimate of the lake

Table 2: Seasonal variations in Importance value Index (IVI) of macrophytic species of Mansar lake during two years study period.

Species name	2014				2015			
	Summer	Monsoon	Winter	Mean	Summer	Monsoon	Winter	Mean
Potamogeton crispus	18.94	19.52	21.19	19.88	13.92	19.58	17.67	17.06
Potamogeton sp.	8.52	9.96	13.55	10.68	10.28	9.16	9.47	9.64
Potamogeton lucens	16.12	16.96	19.76	17.61	12.88	13.73	15.33	13.98
Potamogeton natans	8.52	8.24	11.45	9.4	9.32	7.63	7.69	8.21
Vallisnaria spiralis	5.24	6.31	12.16	7.9	9.24	7.56	0	5.6
Najas indica	0	1.77	0	0.59	0	0	0	0
Chara vulgaris	0	0	0	0	5.38	4.36	0	3.25
Nitella hyalina	0	0	0	0	4.9	3.72	0	2.87
Total Submersed	**57.34**	**62.76**	**78.31**	**66.06**	**65.92**	**65.74**	**50.16**	**60.61**
Nelumbo nucifera	12.62	13.77	0	8.8	13.58	11.32	0	8.3
Nymphoides cristata	17.92	15.7	9.55	14.39	17.13	19.29	0	12.14
Nymphoides indica	14.96	13.52	27.21	18.56	22.42	21.14	33.1	25.55
Total Rooted floating leaved	**45.5**	**42.99**	**36.76**	**41.75**	**53.13**	**51.75**	**33.1**	**45.99**
Carex fedia	15.46	15.84	14.55	15.28	14.89	13.4	24.91	17.73
Cyperus difformis	4.32	6.51	0	3.61	9.06	6.84	0	5.3
Cyperus glomeratus	4.51	5.18	0	3.23	8.28	7.16	0	5.15
Fimbristylis bisumballeta	5.58	5.37	0	3.65	4.82	8.01	0	4.28
Equisetum diffusum	4.85	6.82	0	3.89	12.22	9.42	0	7.21
Ipomea carnea	63.97	56.76	112.01	77.58	29.21	32.05	100.61	53.96
Phragmites karka	9.87	14.93	0	8.27	12.32	13.21	0	8.51
Eichnochola crus-galli	3.77	4.06	0	2.61	5.2	5.95	0	3.72
Polygonum barbatum	20.35	17.78	26.97	21.7	25.39	22.56	36.3	28.08
Polygonum glabrum	12.62	9.61	0	7.41	11.85	9.33	0	7.06
Polygonum hydropiper	4.11	4.81	0	2.97	7.8	5.82	0	4.54
Alternanthera sessilis	8.64	8.39	0	5.68	9.05	11.61	13.83	11.5
Ranunculus sceleratus	8.65	8.91	17.66	11.74	9.54	13.6	21.46	14.87
Colocasia esculenta	16.39	10.25	13.94	13.53	13.42	11.4	19.63	14.82
Typha domingensis	14.07	19.05	0	11.04	7.9	12.16	0	6.69
Total Emergent	**197.16**	**194.27**	**185.13**	**192.19**	**180.95**	**182.52**	**216.74**	**193.42**

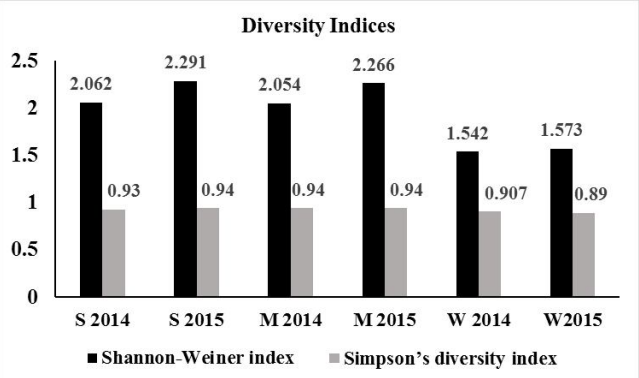

Fig. 2: Seasonal (S=summer, M=monsoon, W=winter) variation in diversity indices of macrophytes in Lake Mansar during the study period.

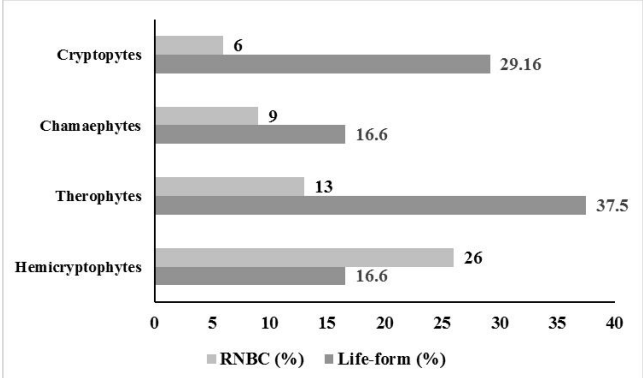

Fig. 3: Comparison of biological spectrum of Mansar Lake with Raunkiaer's normal biological spectrum.

was designated as the Thero-cryptophytic type. Dominance of therophytes indicates disturbed environmental conditions. Therophytes are best adapted to tide over unfavourable periods in form of seeds.

Table 3: Life-forms of various macrophytic species (Ellenberg & Mueller-Dombois 1967; Mueller Dombois & Ellenberg 1974) and biological spectrum of flora of Mansar Lake, Jammu.

S. No.	Lifeform	Position and degree of protection toperennating organ	Life-form	No. of species	Life-form (%)	RNBC (%)
1.	Hemicryptophytes	Perennating buds remain protected under soilsurface;may also remainon soil surface but arenever exposed and remainconcealed under dead plant material	*Vallisneria spiralis Carex fedia, Ipmoea carnea* and *Polygonum-glabrum*	4	16.6	26
2.	Therophytes	Plants survive unfavourable seasons in the form of seeds and complete their life-history during the favorable season.	*Najas indica, Alternanthera sessilis, Cyperus difformis*, *Cyperus glomeratus, Fimbristylis bisumballeta Polygonum hydropiper, P. barbatum*, *Ranunculus sceleratus and Eichnochola crus-galli*	9	37.5	13
3.	Chamaephytes	Plants with their buds perennating on the surface of the ground or just above it (not exceeding 25 cm above)	*Potamogeton sp., Potamogeton crispus, P. lucens* and *P. natans*	4	16.6	9
4.	Cryptopytes a. Geophyte b. helophyte c. hydrophyte	Buds on bulbs andrhizomes remain buried in soil or substratum a. These survive unfavourable seasons in the form of a rhizome, bulb, tuber or root bud. b. These grow in soil saturated with water or in water. leaf and flower bearing shoots rise above water c. Vegetative shoots sunk in waterbuds: permanently or temporarily on the bottom of the water.	*Colocasia esculentaNelumbo nucifera, Equisetum diffusum, Phragmites karka*, and *Typha domingensisNymhoides cristata, Nymhoides indica.*	7	29.16	6

Conclusion

From the forgoing discussion it is clear that there is rapid decline in macrophytic diversity in the lake Mansar. In the present study, eight new species which were not observed during the earlier studies conducted by various workers have been recorded. The presence of eighteen common species observed during all the studies indicate that these species are resistant and can tolerate wide fluctuations in environmental changes. This also shows that these macrophytes are less preferred food by fishes. Environmental changes have great influence on distribution of macrophytes. The study emphasizes on the urgent need to take efficient measures to revive the littoral zone of lake Mansar. Dredging and removal of sediments including revival of the dried pockets of the lake is immediately required. In order to prevent the soil erosion and siltation from the catchment hills afforestation and soil management is suggested. Besides this, transplantation of important macrophytes from other water bodies is also immediately required and application of best management practices for lake shore management can be helpful in regrowth of macrophytes. Constant monitoring and formulation of proper management strategies are of eminent importance for future lake protection and conservation. Proper conservation measures should be taken by state government to protect such a valuable biological resources of international importance.

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