International Journal of Education, Modern Management, Applied Science & Social Science (IJEMMASSS)
ISSN : 2581-9925, Impact Factor: 5.143, Volume 02, No. 03, July - September, 2020, pp.325-332

MACROPHYTIC DIVERSITY AND TEMPORAL SPECIES CHANGE OF LAST TWO QUARTERS IN DAL LAKE SRINAGAR

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ABSTRACT

Aquatic ecosystems directly or indirectly play a major role to stabilise environment by various natural processes. Macrophytes or wetland vascular plants mostly comprising of angiosperms and pteridophytes grow in aquatic ecosystems and possess outstanding ability for assimilating nutrients and creating favourable conditions for microbial decomposition of organic matter. The present floristic survey focuses on the diversity of macrophytes in Dal lake wetland of Kashmir. During the study tenure 46 species of macrophytes belonging to 24 families were recorded. The recorded species have been classified with the help of life forms, distribution patterns (common/rare), life patterns, dominant forms and habitat. The variation in the composition of Dal lake macrophytes have been documented via synthesizing and comparing the current species composition with the previous studies, which shows a significant alteration in the macrophytic composition of Dal lake during last 4-6 decades.

Keywords: *Macrophytic Vegetation, Srinagar, Dal Lake, Wetland*.

Introduction

Wetlands (aquatic ecosystems), the most productive ecosystems in the world, are ware repositories of flora and fauna (Parveen *et al*., 2014). They also influence the human society with the help of various important ecological services through biological diversity, biomass production and nutrient retention (Yoshimura *et al*., 2000). Wetlands contribute more to annually renewable ecosystem services irrespective of their area like biodiversity support, water quality improvement, food abatement and carbon sequestration among others (Zedler and Kercher, 2005). Aquatic ecosystems are also highly productive in the world and the macrophytes (or aquatic plants) have ability to adapt to both saltwater and freshwater environment via special adaptations for surviving as submerged, surface or in the vicinity plants. Such macrophytes mostly grow for atleast a part of their life cycle in water, either completely submerged, floating or emerged (Muenscher, 1944). Among the most common adaptations are development of aerenchyma, floating leaves and dissected leaves. These grow in water or in soil saturated with water, thus, called as common component of wetlands. Macrophytes are very remarkable due to their unique habitats in which they spent most of their lives. The common habitats are rivers, lakes, reservoirs, wetlands, ponds, ditches, pools and puddles. Macrophytes, play crucial role to provide support, shelter and oxygen to other organisms and balancing various aquatic food chains and food webs.The role of macrophytes in fresh water aquatic systems has received growing attention during last two decades mainly due to their wide spread decline in many lakes as a result of sustained cultural eutrophication (Egerston *et al.,* 2004). Macrophytes are excellent indicators of lake condition for many reasons including their relatively high levels of species richness, rapid growth rates, and direct response to environmental change. Aquatic macrophytes play an important role in regulating lake ecology (Steffen *et. al.,* 2013). The scientific value of plants also adds opportunity to study and determine ecological processes occurring naturally in these habitats. Macrophytes may either germinate in the water or on the substrate located in the water (Reid, 1961). Macrophytic vegetation can be categorised in ecological groups as: (a) Emergent forms (rooted in shallow water soil and generally rise above the water level, (b) Submerged forms (rooted in submersed soil but never rise above the water level, and (c) Floating forms (remain at the water level, they may be rooted in soil beneath or may not be, hence divided into two categories as Free floating type and Rooted and leaf floating type).

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Macrophytes diversity in wetlands influences the sustainable production of food, water and purification by retention of pollutants and sediments (Nagasaka *et al.,* 2002) and it has also been found to play a role in organic matter decomposition and nutrient cycling. The submerged macrophyte communities and the micro flora adhered to them are essential in structuring microbial metabolism and biogeochemical cycling at ecosystem level of organization (Sondergaard, 2013). Apart from this, the nutrient assimilating ability and microbial organic matter decomposition ability of macrophytes can also be exploited in the restoration process of natural streams and waste product utilization as a resource. One or few macrophyte species dominate most of the wetlands and these plants provide habitats and chemical conditions suitable for a wide range of vegetal, faunal and microbial survival (Viaroli *et al.,* 2016).

In India, macrophytic abundance and diversity is declining with an alarming rate due to decline and reduction in water bodies. Such problems are due to human interference as a result of population explosion, illegal encroachment, water pollution from various sources such as industries and oil spills. Thus, there is an urgent need to document the aquatic diversity and abundance scientifically in relation to much demanded need of conservation of aquatic plant diversity. The aforesaid reasons generated need for macrophytic plant assessment in world famous Dal lake, which is under threat from last few decades (it is shrinking at a faster rate due to unjustified interference and illegal encroachment) resulting in the loss to the naturally existing macrophytic plant diversity.

Material and Methods

Study Area

Srinagar (34º 5′ North latitude and 74º 47′ East longitude), one of the most beautiful cities in India, is commonly known as “Mr. City” and “City of Bridges” (Figure 1). It is a famous tourist destination because of various prime attractions like Nishat Garden, Shalimar Garden, Cheshma Shahi, Harwan, Pari Mahal, Nehru Park and Dal Lake. Its climate is humid subtropical with much more severe winter (due to high elevation and northern location) compared to rest of India. During extreme winter daytime average temperature fall upto 2.5ºC and night time temperature below the freezing point upto -11ºC. Summer is moderately warm with daytime average temperature 24ºC. Apart from large amount of annual snow fall (which keep on melting during summer and provide the available water), the long term average annual rainfall is about 700-750 mm. Its flora is significantly important from scientific, cultural and utilitarian view point. The occurrence of wide range of habitats helps in maintaining the high biological diversity. Botanically important locations of Srinagar city include Dal lake, Nigeen lake, Achar lake, Hokersar wetland, Gilsar, Tulip garden, Botanical garden etc.

The city is located on both the banks of river Jhelum commonly known as Vyath in Kashmir. The river passes through the city and meanders through the valley moving onward and deepening in the Dal lake. The Dal lake is the second largest fresh water lake (after the Wular which is largest freshwater lake) in India. Dal lake which is part of a wetland is about 20 sq km, out of which lake area is 16km^2. It also includes floating gardens commonly known as “Rad” in Kashmiri. Dal lake, located in the foothills of Zabarwan mountains also act as home for many migratory birds.

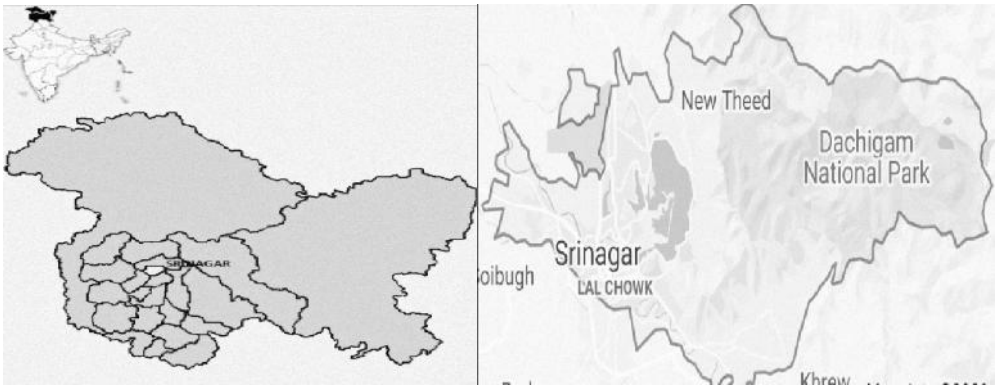

Figure 1: Location map showing Dal lake in Srinagar district of Kashmir valley.s

Methodology

Macrophytes represent an important component of freshwater ecosystems for being efficient and prime contributors of primary productivity especially for wetland and shallow lakes wherein the infestation of macro-vegetation is a common phenomenon. To document the comprehensive information

related to the macrophytic vegetation of Dal lake, the lake area was divided into 5 main basins namely Hazratbal basin, Bod Dal basin, Gagribal basin, Boulevard basin and floating gardens (Table 1).The lake was surveyed during the growing season of the macrophytes (April-September 2019), in all sub-basins to collect the macrophytes with the help of local Dal dweller Irfan Hussain Tinda. Interviews and detail inventories were also conducted of locals (with emphasis on the senior citizens) and information was noted in the field book accordingly (Table 2). The slandered floras were utilized for the identification of macrophytes (Kaul and Zutshi, 1967;Kak, 1990; Gopal, 1990).

Results and Discussion

The macrophytic vegetation of study area was consisting of 46 species belonging to 24 different families (Table 3). Out of these 46 species, the number of monocot (26) species was higher compared to dicot (16) species. Four species represented the pteridophytes. Out of 24 families represented in the present study, Potamogetonaceae (7 species) and Cyperaceae (6 species) were pre-dominant families among the monocots, and Haloragaceae (2 species) and Polygonaceae (2 species) were predominant among the dicots. The four pteridophytes species belongs to four different families (with one species each). (Table 4) shows the list of dominant families along with their number of species. In terms of habitat based distribution of macrophytes, the emergent form (39% of the total) were most abundant, followed by the submerged (22%), free floating (15%), rooted and leaf floating (13%) and Marshy plant species (11%) (Figure 2). Out of studied species, bulk (78%) were Perennials, followed by perennials as well as annuals (15%) and Annuals (7%).

A comparison of present data with earlier study of Dal lake (Kaul and Zutshi, 1967) reveals that there has been a considerable change in the macrophytic diversity of this wetland. The comparison of present study with the Kaul and Zutshi (1967) is summarized in the (Table 5). Out of 51 species reported by Kaul and Zutshi (1967) only 21 species are common to the present study. Bulk species (30 species out of 51) have been eliminated from the Dal lake as they were absent during the present study, indicating huge disappearance of species (~60 species) due to various anthropogenic activities and global change. Noticeable is the recording of 25 new species in the present study (compared to study of 1967) suggesting gradual replacement of species in the dal lake as a result of secondary succession in response to variations in the habitat conditions. The present study suggest that Dal lake harbours rich natural aquatic vegetation in and around, but considerable changes have been taken place (both in terms of number of species and the replenishment of the previous species) therein probably due to various anthropogenic activities and significant reduction in the area (area reduced to its half in the last almost 50 years). Extra tourist load leading to pollution increase and illegal encroachments are the other important reasons for the loss of its diversity and aesthetic value, reduction in area and emergence of new species/weeds. As the aquatic ecosystem is so fragile, it's noteworthy that it should be conserved in time.

Conclusion

The present investigation suggests that both illegal encroachment by various agencies and different anthropogenic activities are the leading causes resulting in significant reduction of macrophytes and changing physico-chemical conditions of the lake body. Thus there is immediate need for the strict measures both at governmental and non-governmental levels to protect and conserve this famous aquatic body. Apart from conventional measures, there is also need for the public awareness in form of exhibitions, training camps and workshops involving botanists, agriculturists, foresters, and the locals.

Acknowledgements

The author is thankful to Mr. Irfan Hussain Tinda and other local Dal dwellers for their help and kind response whenever needed, during the course of this work. Author also express deep sense of gratitude to Dr. C.P Kushwaha (Professor Department of Botany, School of Applied Sciences, Shri Venkateshwara University Gajraula, District Amroha, U.P) for providing firm guidance, support and encouragement all along the lenth of successful completion of this project.

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Table 1: Area (sq. km) of various sub-basins of Dal Lake. Source: Hussain, M (2003)

Serial No.	Division	Open water Basin	Marshy Land	Total Area
1	Hazratbal Basin	5.6	3.2	8.8
2	Bod Dal Basin	4.2	-	4.2
3	Gagribal Basin	1.3	-	1.3
4	Boulevard Basin	0.3	0.2	0.5
5	Floating Gardens	0.3	4.5	4.8
	Total	11.7	7.9	19.6

Table 2: List of Various Macrophytes Recorded in Dal lake, Srinagar

S. No.	Botanical Name	Family	Habit	Frequency
Sub-merged				
01	Ceratophyllum demersumLinn.	Ceratophyllaceae	Perennial	Common
02	Myriophyllum spicatumLinn.	Haloragaceae	Perennial	Common
03	Myriophyllum verticullatumLinn.	Haloragaceae	Perennial	Common
04	Potamogeton crispusLinn.	Potamogetonaceae	Perennial	Common
05	Potamogeton lucensLinn.	Potamogetonaceae	Perennial	Common
06	Potamogeton pectinatusLinn.	Potamogetonaceae	Annual/Perennial	Common
07	Potamogeton perfoliatusLinn.	Potamogetonaceae	Perennial	Common
08	Potamogeton pusillusLinn.	Potamogetonaceae	Annual/Perennial	Common
09	Trapa natansLinn.	Trapaeceae	Perennial	Rare
10	Utricularia aureaLinn.	Lentibulariaceae	Annual/Perennial	Common
Emergent				
11	Butomus umbellatusLinn.	Butomaceae	Perennial	Rare
12	Carex wallichianaSpreng.	Cyperaceae	Perennial	Common
13	Cyperus glomeratus Linn.	Cyperaceae	Annual/Perennial	Common
14	Cyperus pumillaLinn.	Cyperaceae	Perennial	Common
15	Cyperus serotinusRottb.	Cyperaceae	Perennial	Common
16	Equistem debileDon.	Equistellaceae	Annual/Perennial	Rare
17	Hippuris vulgarisLinn.	Plantiginaceae	Perennial	Rare
18	Juncus inflexusLinn.	Juncaceae	Perennial	Common
19	Menyanthes trifoliataLinn.	Menyanthaceae	Perennial	Common
20	Persicaria hydropiperLinn.	Polygonaceae	Annual	Common
21	Phragmites australisTrin.	Poaceae	Perennial	Rare
22	Persicaria amphibiumLinn.	Polygonaceae	Perennial	Common
23	Scirpus lacustrisLinn.	Cyperaceae	Perennial	Common
24	Sparganium ramosumLinn.	Typhaceae	Perennial	Common
25	Typha latifoliaEdgew.	Typhaceae	Perennial	Common
26	Roripa indicaLinn.	Brassicaceae	Annual/Perennial	Rare
27	Typha augustataBory and Chaub.	Typhaceae	Perennial	Common
28	Sagittaria sagittifoliaLinn.	Alismataceae	Perennial	Rare
Free floating				
29	Azolla pinataR.Br.	Azollaceae	Perennial	Common
30	Lemna gibbaLinn.	Lemnaceae	Perennial	Common
31	Lemna minorLinn.	Lemnaceae	Perennial	Common
32	Salvinia natansLinn.	Salviniaceae	Annual	Rare

33	Batrachium trichophyllum V.D Borshe.	Ranunculaceae	Annual/Perennial	Rare
34	Wolfia polyrrhizaSchleid.	Lemnaceae	Perennial	Common
35	Spirodela polyrrhiza(L.) Schleid.	Lemnaceae	Perennial	Common
Rooted and leaf floating				
36	Nymphaea albaLinn.	Nymphaceae	Perennial	Common
37	Potamogeton natansLinn.	Potamogetonaceae	Perennial	Common
38	Potamogeton nodosusLinn.	Potamogetonaceae	Perennial	Common
39	Nymphaea stellataBurm.f.	Nymphaceae	Perennial	Common
40	Nymphoides peltataKintze.	Menyanthaceae	Perennial	Rare
41	Nelumbo nuciferaGaertn.	Nelumbonaceae	Perennial	Common
Marshy				
42	Cyperus defformisLinn.	Cyperaceae	Annual	Common
43	Juncus effuses Linn.	Juncaceae	Perennial	Common
44	Lycopus europaeusLinn.	Lamiaceae	Perennial	Rare
45	Marsilea quadrifoliaLinn.	Marsileaceae	Perennial	Rare
46	Nasturtium officinaleR.B.R	Brassicaceae	Perennial	Common

Table 3: Life form analysis of the observed macrophytic vegetation.

Group	Species	Families
Angiosperms-monocots	26	09
Angiosperms-Dicots	16	11
Pteridophytes	04	04
Total	46	24

Table 4: List of the Families dealt at the study site (Dal lake) in Srinagar

Serial No.	Name of the Family	Number of Species
01	Alismataceae	01
02	Azollaceae	01
03	Brassicaceae	02
04	Butomaceae	01
05	Ceratophylaceae	01
06	Cyperaceae	06
07	Equistellaceae	01
08	Haloragaceae	02
09	Juncaceae	02
10	Lamiaceae	01
11	Lemnaceae	04
12	Lentibulariaceae	01
13	Marsileaceae	01
14	Menyantheaceae	02
15	Nelumbonaceae	01
16	Nymphaceae	02
17	Plantaginaceae	01
18	Poaceae	01
19	Polygonaceae	02
20	Potamogetonaceae	07
21	Ranunculaceae	01
22	Salviniaceae	01
23	Trapaceae	01
24	Typhaceae	03

Table 5: Comparison of Present Data with Previous Data Collected by (Koul & Zutshi) in the year 1967

S. No.	Specie Name (Alphabetical Order)	In 1967 (Koul & Zutshi)	In Present Study
01	Alisma plantagoLinn.	✓	×
02	Amaranthus blitumLinn.	✓	×
03	Ammania auriculataWilld.	✓	×
04	Azolla piñata R.Br.	×	✓
05	Batrachium trichophyllumV.DBorshe	×	✓
06	Bidens tripartitaLinn.	✓	×
07	Butomus umbellatusLinn.	×	✓
08	Carex wallichianaSpreng.	×	✓
09	Ceratophyllum demersumLinn.	✓	✓
10	Cyperus defformisLinn.	×	✓
11	Cyperus glomeratusLinn.	×	✓
12	Cyperus iriaLinn.	✓	×
13	Cyperus pumillaLinn.	×	✓
14	Cyperus serotinusRottb.	×	✓
15	Equistem debileDon.	×	✓
16	Equistem diffusumD.Don	✓	×
17	Euryale feroxSalisb.	✓	×
18	Hippuris vulgaris Linn.	×	✓
19	Hydrilla verticillata (L.f.) Royle	✓	×
20	Hydrocharis dubia (Blume) Backer	✓	×
21	Juncus effuses Linn.	×	✓
22	Juncus glaucusSibth.	✓	×
23	Juncus inflexusLinn.	×	✓
24	Lemna gibbaLinn.	✓	✓
25	Lemna minor Linn.	✓	✓
26	Lemna trisulca Linn.	✓	×
27	Lycopus europaeusLinn.	✓	✓
28	Lythrium salicariaLinn.	✓	×
29	Marsilea quadrifoliaLinn.	✓	✓
30	Menyanthes trifoliate Linn.	✓	✓
31	Myriophyllum spicatumLinn.	✓	✓
32	Myriophyllum verticillatumLinn.	✓	✓
33	Najas gramineaDelile	✓	×
34	Najas major All.	✓	×
35	Nasturtium officinaleR.B.R	×	✓
36	Nelumbo nuciferaGaertn.	✓	✓
37	Nymphaea alba Linn.	✓	✓
38	Nymphaea stellataBurm.f.	✓	✓
39	Nymphoides peltatumKintze.	✓	✓
40	Persicaria amphibiumLinn.	×	✓
41	Pesicaria hydropiperLinn.	×	✓
42	Phragmites australis(Cav.) Trin. exSteud.	×	✓
43	Phragmites communisTrin.	✓	×
44	Polygonum amphibium (L.) Gray	✓	×
45	Polygonum glabrum (Willd.)M.Gomez	✓	×
46	Polypogon fugaxNees ex Steud.	✓	×
47	Polypogon littoralisSm.	✓	×
48	Potamogeton crispusLinn.	✓	✓
49	Potamogeton leucensLinn.	✓	✓
50	Potamogeton natansLinn.	✓	✓
51	Potamogeton nodosusLinn.	×	✓

52	Potamogeton pectinatusLinn.	✓	✓
53	Potamogeton perfoliatusLinn.	×	✓
54	Potamogeton pusillusLinn.	×	✓
55	Potentilla reptans Linn.	✓	×
56	Ranunculus sceleratusLinn.	✓	×
57	Ranunculus trichophyllusChaix ex Vill.	✓	×
58	Ricciocarpus natans (L.) Corda	✓	×
59	Roripa indicaLinn.	×	✓
60	Roripa islandicaOeder	✓	×
61	Rotala densiflora (Roth)	✓	×
62	Rotala indica (Willd.) Koehne	✓	×
63	Rumex maritimusLinn.	✓	×
64	Sagittaria sagittifoliaLinn.	×	✓
65	Salvinia natansLinn.	✓	✓
66	Scirpus lacustrisLinn.	✓	✓
67	Sparganium ramosumLinn.	×	✓
68	Spiranthes sinensis(Pers.) Ames.	✓	×
69	Spirodella polyrhiza(L.) Schleid.	✓	✓
70	Trapa natansLinn.	✓	✓
71	Typha augustataBory and Chaub.	✓	✓
72	Typha latifoliaEdgew.	×	✓
73	Utricularia aureaLinn.	×	✓
74	Utricularia flexuosaVahl.	✓	×
75	Wolfia polyrrhizaSchleid.	×	✓
76	Xanthium strumariumLinn.	✓	×

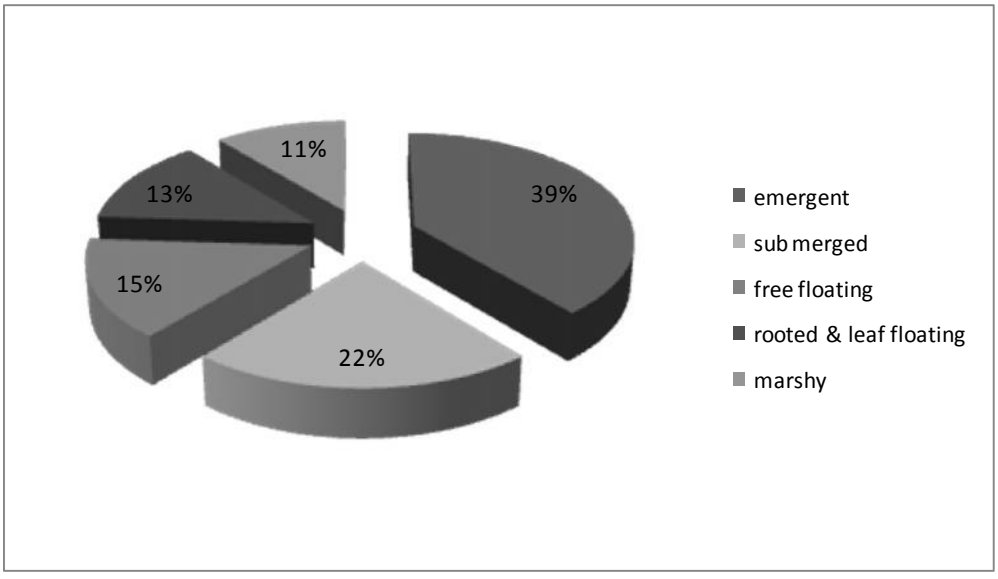

Figure 2: Habitat distribution of the observed macrophytic vegetation in Dal Lake, Srinagar

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