Diversity and Distribution of Macrophytic Vegetation in Dal Lake, Kashmir, India

Heena Nisar[1], Saleem Farooq*[1], Suheel Ahmad[1], A. K. Pandit[2] and Baba Uqab[1]

[1]Department of Environmental Sciences, University of Kashmir, Srinagar-190006, J & K, India
[2]Centre of Research for Development, University of Kashmir, Srinagar-190006, J & K, India
***Corresponding author: rathersaleem111@gmail.com**

Abstract

The present study deals with the species diversity, density, abundance and frequency of macrophytic vegetation in Dal lake. During the current study a total of 24 species belonging to submerged, rooted-floating leaf type, free-floating type, and emergent were recorded. Among 24 observed species, the maximum number of species were recorded at site 4 (Gagribal basin B) and Site 3 (Gagribal basin A) followed by Site 2 (Nishat basin) and then site 1 (Hazratbal basin). Highest species diversity was found at Site 4. *Nymphoides peltatum* recorded highest density, frequency, and abundance at Site 1 and Site 2. *Salvinia natans* recorded highest density, frequency and abundance at site 3. Nymphaea mexicana recorded highest frequency, density, and abundance at Site 4. The overall percentage contribution in terms of population density of the four classes of macrophytes at all four studied sites were as submerged 32%, rooted floating-leaf type 28%, emergent 28% and 12% were free-floating.

Keywords: Macrophytes, submergeds, emergents, rooted-floating leaf type.

Introduction

Macrophytes play an important role in the structure and functioning of an aquatic ecosystem (Pandit, 1984). They greatly influence nutrient chemistry within the water by acting as nutrient sinks, uptaking nutrients from the water column and at the same time acting as a source of nutrients to the sediment (Carignan and Kalff, 1980; Pandit, 1984). Aquatic plants also serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity (Dennison *et al*., 1993) and nutrient levels (Pandit *et al*., 2010) and are often used for monitoring heavy metals and other pollutants present in the water and submerged sediments (Bernez *et al.*, 1999). They also respond to the changes in water quality and have been used as indicator of pollution in several cases (Best, 1982). There are various features in aquatic system which gets influenced by macrophytes, besides having socio-ecological values they contribute to biotopes by way of their primary production (Adams and Mc-Craken, 1974), detritus formation (Wetzel *et. al*., 1972) and also serve as substrate for the development of periphyton and phytophilous invertebrates (Pandit, 1984; Jones, 2002; Bhat, 2014). Aquatic vesicular plants are important indicator of water pollution (Seddon, 1972; Shimoda, 1984). Aquatic plants are important because they serve as substratum to different micro and macro fauna (Raut and Pejawar, 2005).

The function of macrophytes in aquatic ecosystems is related to their structural attributes like species composition, distribution, abundance and diversity which in turn depend on myriad of factors such as light, water temperature, substrate composition, disturbance, competitive interactions, herbivory, epiphyte loading, water levels, quality of the lake water and sediment nutrients (Pandit, 1984). This realization of multiple ecological and socio-economical importances of macrophytes as generated a great interest towards better understanding of their diversityand role in natural ecosystems, thus paving a way for scientific management of macrophyte dominated ecosystems-the wetlands (Pandit, 1999).

Material and Methods

Study lake and sampling sites

Dal lake is situated at an altitude of 1584 m above mean sea level between 34°6′N and 34°13′N latitude and 74°50′E and 74°54′E longitude in the north-east of Srinagar city. The lake is probably of fluviatile origin, formed from the meandering of river Jhelum. At present, it covers about 21.1 km^2 and has a maximum depth of 5.4 m, and a shoreline of 15.4 km. Of the total area, only about 11.4 km^2 is open water and the rest is under floating gardens most of which has now settled permanently. The lake has a large mountainous catchment spread over 316 km^2. For carrying out the study on macrophytic vegetation, four sampling sites were site 1 (Hazratbal Basin), site 2 (Nishat Basin), site 3 (Gagribal basin A) and site 4 (Gagribal basin B) **(Figure. 1).**

The community features of macrophytes were worked out on monthly basis for a period of four months from June 2013 to October 2013, using the Random Quadrat Method (Misra, 1968). The macrophytes falling in each quadrat were sorted species-wise and the numbers of individuals of each species were counted for working out various phytosociological features (Misra, 1968). Ekman dredge was used to collect the submerged species falling in each quadrat. The identification was carried out using standard taxonomic works of (Correll and Correll, 1972, Kak, 1978 and Fasset, 1998). For *Nymphoides peltatum* three leaves were taken as one individual while for *Nymphaea mexicana* one leaf was taken as one individual. In case of *Ceratophyllumdemersum* (submerged species) one meter length of the plant along with all its branches was taken as a unit to represent one individual.

Results and Discussion

Dal Lake presented a rich floristic composition. In all, 24 species of macrophytes were identified. Striking variability was recorded in composition, distribution and extent of colonization of macrophytes from the lake (**Table 1**).

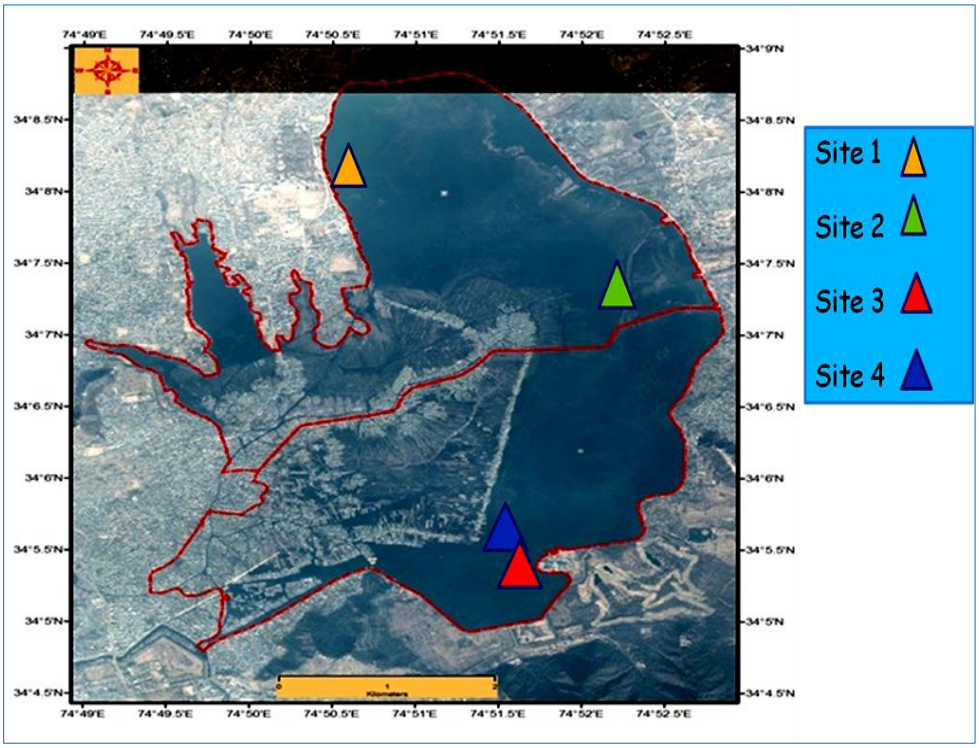


Figure 1: Showing study area and study sites

Site 1 (Hazratbal basin)

This site had a total of 11 species of macrophytes with 2 species of rooted floating-leaf type, 7 species of submerged and 2 species of free-floating type were recorded **(Table 1)**. *Nymphoides peltatum* recorded highest mean frequency at this site (72.5), followed by *Ceratophyllum demersum* (70), *Potamogeton lucens* (60) and *Potamogeton natans* (60) while as lowest value was obtained for *Nelumbo nucifera* (10). As against this, the highest value for density was recorded for *Nymphoides peltatum* in the month of October (**Table 2**). The overall Importance Value Index (IVI) at the Site varied from a mean value of 87.76 for *Nymphoides peltatum* to 6.68 for *Potamogeton pectinatus*. The species with appreciable mean IVI were *Nymphoides peltatum* (87.76), *Azolla cristata* (51.37) and *Ceratophyllum demersum* (30.59).

Site 2 (Nishat basin)

A total of 14 species of macrophytes with 2 species of emergents, 4 species of rooted floating-leaf type, 6 species of submergeds and 2 species of free-floating type were recorded in Dal Lake **(Table 1)**. *Nymphoides peltatum* recorded highest mean frequency at this site (77.5), followed by *Hydrilla*

verticillata (72.5), *Potamogeton lucens* (62.5) and *Potamogeton natans* (60) while as lowest value was obtained for *Eurayle ferox* (5). In general, mean density at Site 2 ranged between 11.65 (*Nymphoides peltatum*) and 0.5 (*Eurayle ferox*) (**Table 2**). The mean value for abundance fluctuated between 15.05 for *Nymphoides peltatum* and 0.5 for *Eurayle ferox.* The overall Importance Value Index (IVI) at the Site varied from a mean value of 87.38 for *Nymphoides peltatum* to 2.15 for *Eurayle ferox.* The species with appreciable mean IVI were *Nymphoides peltatum* (87.38), *Azolla cristata*(47.58) and *Hydrilla verticillata* (27.36).

Site 3 (Gagribal basin A)

A total of 18 macrophytic species with 4 species of emergents, 4 species of rooted floating-leaf type, 7 species of submergeds and 3 species of free-floating type were recorded at **site 3** in Dal Lake **(Table 1)**. The minimum number of 12 Species were recorded in October against the maximum number of 14 species being registered in July. *Salvinia natans* recorded highest mean frequency at this site (55), followed by *Azolla cristata* (50), *Hydrilla verticillata* (37.5) and *Ceratophyllum demersum* (37.5) while as lowest value was obtained for *Utricularia minor* (2.5). As against this, the highest value for density was recorded for *Salvinia natans* in the month of September (**Table 2**). In general, mean density at Site 3 ranged between 3.8 (*Salvinia natans*) and 0.075 (*Utricularia minor*). The mean value for abundance fluctuated between 6.57 for *Azolla cristata* and 0.5 for *Potamogeton pectinatus*. The overall Importance Value Index (IVI) at the Site varied from a mean value of 41.90 for *Azolla cristata* to 2.65 for *Menthasp*. The species with appreciable mean IVI were *Azolla cristata* (41.90), *Salvinia natans* (40.28) and *Lemna sp*. (38.17).

Site 4 (Gagribal basin B)

At site 4, a total of 18 species of macrophytes with 5 species of emergents, 6 species of rooted floating-leaf type, 5 species of submergeds and 2 species of free-floating type were recorded **(Table 1)**. The minimum number of 5 species was recorded in September against the maximum number of 12 species being registered in June. *Nymphaea mexicana* recorded highest mean frequency at this site (57.5), followed by *Hydrilla verticillata* (47.5), *Ceratophyllum demersum* (47.5) and *Nymphoides peltatum* (35) while as lowest value was obtained for *Batrachium trichophyllum* (5). As against this, the highest value for density was recorded for *Nymphoides peltatum* in the month of July (**Table 2**). The mean value for abundance fluctuated between 10.79 for *Phragmites australis* and 0.25 for *Lythrum salicaria*. The overall Importance Value Index (IVI) at the Site varied from a mean value of 38.79 for *Nymphoides peltatum* to 2.46 for *Lythrum salicaria*. The species with appreciable mean IVI were *Nymphoides peltatum* (38.79), *Phragmites australis* (36.34) and *Nymphaea mexicana* (29.72).

Table 1: Composition and distribution of different species of macrophytes at four sites of Dal lake

Name of species	SITE 1	SITE 2	SITE 3	SITE 4
Emergents				
Carex sp	-	-	-	+
Lythrum salicaria	-	-	-	+
Mentha sp	-	-	+	+
Myriophyllum verticillatum	-	-	+	-
Phragmites australis	-	+	+	+
Typha angustata	-	+	+	+
Free-floating type				
Azolla cristata	+	+	+	-
Lemna sp	-	-	+	+
Salvinia natans	+	+	+	+
Rooted-floating leaf type				
Eurayle ferox	-	+	-	-
Hydrocharis dubia	-	-	+	+
Nelumbo nucifera	+	-	+	+
Nymphaea alba	-	-	+	-
Nymphaea mexicana	-	+	+	+
Nymphoides peltatum	+	+	+	+
Potamogeton natans	+	+	+	+
Trapa natans	-	+	+	+
Submergents				
Batrachium trichophyllum	-	-	-	+
Ceratophyllum demersum	+	+	+	+
Hydrilla verticillata	+	+	+	+
Myriophyllum spicatum	+	+	+	-
Potamogeton crispus	+	+	-	-
Potamogeton lucens	+	+	+	+
Potamogeton pectinatus	+	-	+	-
Utricularia minor	-	-	+	+

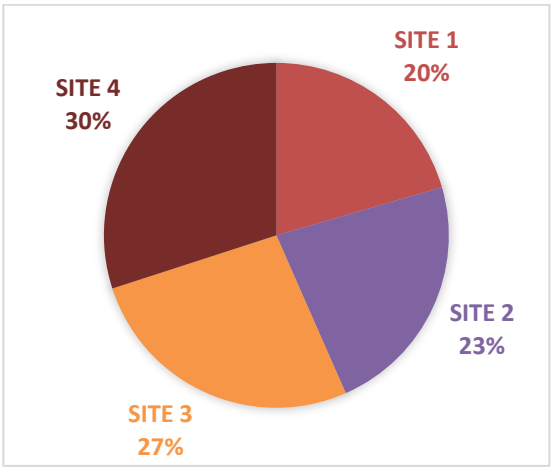
+ : Present and – : Absent

Table 2: Monthly variation in density of macrophytes at different sampling sites.

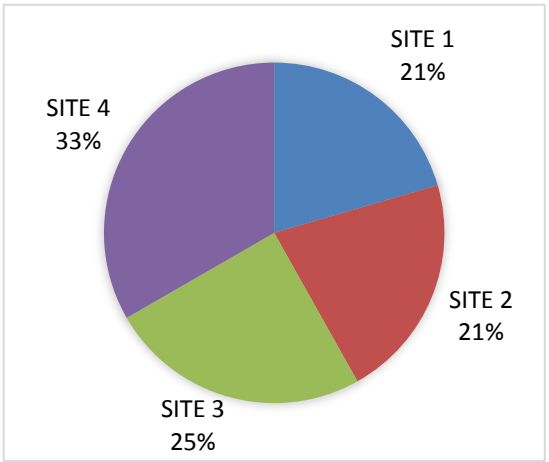
	DENSITY															
	MONTH	**June**				**July**				**September**				**October**			
	SITE	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**	**S1**	**S2**	**S3**	**S4**
I	**SPECIES EMERGENT**																
	Phragmites australis	-	-	-	1	-	-	-	-	-	1.2	-	1.9	-	-	0.6	2.1
	Typha angustata	-	-	0.3	-			0.4	-	-	0.5	-	0.5	-	-	-	-
	Menthe sp.	-	-	-	-	-	-	0.5	-								1.9
	Myriophyllum verticillatum	-	-	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-
	Carex sp.	-	-	-	-	-	-	-	-	-	-	-	0.7	-	-	-	1.6
	Lythrum salicaria	-	-	-	0.3	-	-	-	-	-	-	-	-	-	-	-	-
II	**ROOTED FLOATONGLEAF TYPE**																
	Nelumbo nucifera	-	-	0.9	1.2	0.8	-	1	1.8	0.4	-	0.2	-	0.4	-	-	-
	Nymphoides peltatum	9.4	13.2	-	4.5	8.8	11.4	-	5	10.3	6.3	-	-	15	15.7	1.8	1.4
	Potamogeton natans	2.2	1.8	0.2	0.8	2.4	1.9	-	0.8	-	0.5	2.1	-	1.4	1.5	1.6	0.4
	Trapa natans	-	-	1.2	0.7	-	0.9	1	0.8	-	0.7	0.4	-	-	-	-	0.4
	Hydrocharis dubia	-	-	1.3	0.6	-	-	1.7	0.4	-	-	1.1	-	-	-	-	0.4
	Nymphaea mexicana	-	1.3	0.8	2.2	-	1.7	0.4	2.8	-	-	0.4	-	-	0.6	1.2	2.2
	Eurayle ferox	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	-	-
III	**SUBMERGED**																
	Batrachium trichophyllum	-	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-
	Ceratophyllum demersum	1.6	2	0.9	1	1.7	1.5	1	1.6	3.1	1.3	0.4	-	1.4	0.4	1.9	1
	Hydrilla verticillata	1.4	1.2	0.5	1.5	1.8	1.2	0.2	2	1.4	2.9	3	-	1.4	3.4	1.4	1.3
	Myriophyllum spicatum	0.8	0.8	0.7	-	0.9	0.4	0.3	-	-	-	0.7	-	1.6	1.1	0.4	-
	Potamogeton crispus	1.3	1.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Potamogeton lucens	1.4	1.6	0.3	1.4	1.7	1.2	0.3	0.8	4.2	0.7	1.4	-	0.6	1.8	1.9	0.4
	Potamogeton pectinatus	-	-	-	-	0.4	-	-	-	0.7	-	-	-	-	-	0.4	-
	Utricularia minor	-	-	-	-	-	-	-	-	-	-	0.3	-	-	-	-	0.8
IV	**FREE FLOATING**																
	Azolla cristata	-	1.1	1.5	-	-	1.4	2.2	-	11.7	8.9	1.9	-	27	12.6	8.8	-
	Lemna sp	-	-	6.6	-	-	-	6.9	-	-	-	0.6	2.2	-	-	-	0.4
	Salvinia natans	-	0.5	6.2	0.9	-	0.6	7	-	0.4	6.2	1.3	1.5	2	0.9	0.7	-
TOTAL		**18.1**	**25.4**	**21.4**	**16.1**	**18.5**	**22.2**	**24.3**	**16.6**	**32.2**	**29.2**	**13.8**	**6.8**	**50.8**	**38.4**	**20.7**	**14.3**

S= Site

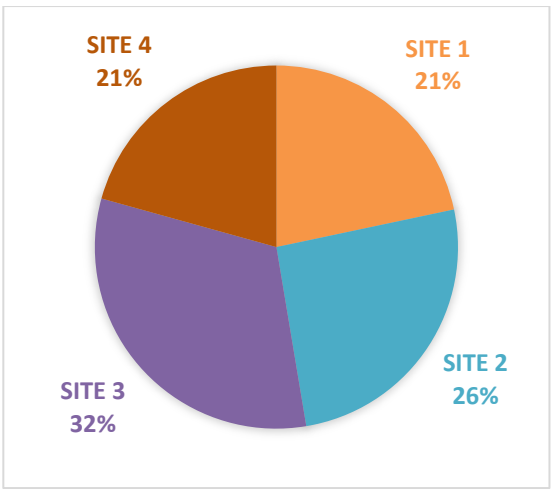
The lake has profuse growth of macrophytes (**Figure 2**). A marked difference in the distribution of macrophytes in the water body was observed. Emergent like *Phragmites australis* and *Typha angustata* were around along the shoreline and in patches near the floating gardens. A belt of plants with floating leaves composed of *Nymphoides peltatum, Nymphaea mexicana, Nelumbo nucifera* were observed in the open water area of the lake. In the deeper zones of the open water area, submerged plants like *Ceratophyllum demersum, Hydrilla verticillata* were found. The various life-form classes grow intermixed thus, resulting in complex physiognomy. Species diversity was found maximum at **site 4** and minimum at **site 1**.



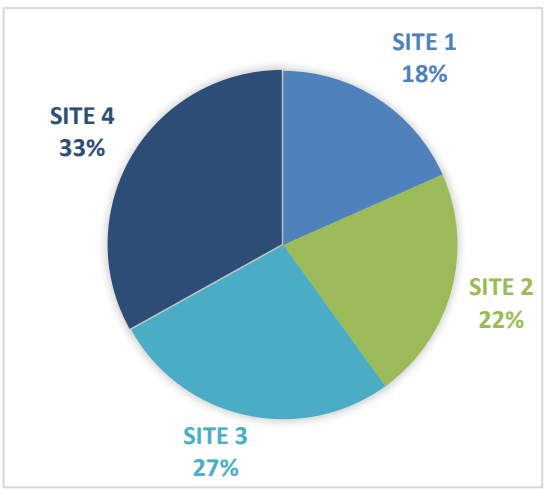
June



July



September



October

Figure 2: Showing monthly variations in species diversity index at four sites of Dal Lake

The present study on Dal Lake revealed clear differences in the community structure of macrophytes. Even though all the life-form classes viz., emergents, rooted floating-leaf type, submergeds and free floating type constituted macrophytic community of Dal lake, their contribution to overall community structure varied considerably. Significant differences were also observed regarding various community characteristics and, therefore, community architecture. The profound variations in the diversity, abundance and distribution of various macrophytes in Dal lake during the present study may be attributed to its nutrient rich water, favourable temperature during the growth period of macrophytes, varied water depths and alkaline nature of water (Khan *et al.*, 2001). During summer months prolific

growth of macrophytes was noticed which can be due to nutrients accumulated as a result of decomposition during autumn and winter as well as the entry from catchment area (Zutshi, 1989). Reduction in number of species obtained in the present study compared to earlier findings may be due to the decreased water transparency. According to Best **(**1982) water clarity has a direct relationship with the number of macrophytic species that a lake could support. High turbidity results in decreased light penetration in the lake waters, thereby, rendering the growth of plants difficult and chances of survival are significantly reduced. Emergent species dominated by *Typha angustata* and *Phragmites australis* and rooted floating-leaf type dominated by *Nymphoides peltatum*, *Potamogetan natans*, *Nymphaea mexicana* recorded prolific growth in the Dal lake probably due to perenating organs like bulbs, rhizomes etc buried deep under the sediment (Gopal, 1994) and due to broader leaves for perception of solar radiations (Kumar *et al.*, 2007) respectively.The explosive growth of *Ceratophyllum demersum* in some areas of Dal lake is an indication of eutrophication (Zutshi and Vass, 1982). The high incidence of *Salvinia natans* have been attributed to increasing levels of pollution by Zutshi and Vass (1971).

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