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Floristic diversity and vegetational composition of Waskura lake, Kashmir

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Abstract
The present investigation was carried out on Waskura lake, Kashmir. The focal objective of the study was to evaluate the quantitative characters of the aquatic macrophytes viz., frequency, density abundance, relative frequency, relative density, relative abundance and importance value index (IVI). The study was carried out for a period of one year (2017-2018). During the present study a total of 13 aquatic macrophytes belonging to 12 different families which include six submerged, five rooted with floating leaves and two submerged species were found. Overall, emergent vegetation were dominant throughout the lake while rooted and submerged macrophytes showed the moderate abundance. The dominance pattern of macrophytes was recorded inorder of submerged>floating>emergents.

Keywords: aquatic macrophytes, Waskura, biodiversity, Kashmir

Introduction
Aquatic macrophytes also known as Hydrophytes are aquatic photosynthetic organisms, that are large enough to see with the naked eye and grow permanently or periodically submerged below, floating on, or growing up through the water surface (Chambers, *et al.*, 2008) [5]. Together with microscopic algae, they are the most important primary producers in lakes (Krause-Jensen & Sand-Jensen 1998 [17], Noges *et al.*, 2010) [24]. The growth of large number of hydrophytes has drawn the attention of ethno-medico botanical survey throughout India (Abubakr *et al.*, 2011) [1]. The macrophytes stabilize the ambient environment and therefore play a sanative role in reducing the ion concentration and release of nutrients from the sediments under toxic conditions (Abubakr, 2010) [2]. Eutrophication of waterbodies has been a matter of serious concern over several decades which has not only affected the use of natural waters for human use but also severely adversed the conditions of freshwater biota including the distribution of macrophytes both spatially and temporally. Ecological and floristic assessment is necessary for the management of both water quality and aquatic biological resources for sustainable development. Detailed accounts of vegetation communities reveal the conservation status of various species and are of major concern in macrophyte management. This study is expected to be helpful in designing a plan for the sustainable management of the waterbodies. A lot of research have been carried on different aspects of macrophytes, however, scanty literature is available on the floristic diversity and distribution of macrophytes of rural lakes of Kashmir. The present investigation has been carried with an aim to study the the floristic composition, distribution and percentage cover of aquatic macrophytes, of a rural waterbody, the Waskura Lake.

Study Area
Waskura lake (alt. 1590 m. a. s. l.) is a rural lake situated about 26 km in the north of Srinagar in District Ganderbal, within the geographical coordinates of 34°-16 N, 74°-39 E (Kundangar, 1982) [20]. It lies close to the right bank of river Jhelum with which it is connected by a small channel. Waskura is a semi-drainage lake (Zutshi and Khan, 1978) [35] with no inflow water channel. The water to the lake is mainly supplied by the springs present within the basin and along the periphery in addition to it precipitation (rain, snow) also contributes considerable quantity of water. A number of ephemeral small channels from agricultural fields and human settlements also drain into the lake. The surface area of the lake is 52.7 ha and the maximum water depth 6m. For the present study five sites were selected which differ in their locale (Figure 1), so as to cover entire lake basin for assessment of macrophytic studies.

Fig 1: Showing Waskura Lake, Kashmir.

Materials and Methods

The survey and analysis of the present lake was carried out monthly basis for a period of one year (2017-2018) covering all four seasons (Autumn, Winter, Spring and Summer). The macrophytes were grouped into emergent, submerged, rooted with floating leaves and free floating plants. The random quadrat method was followed for studying various community features of macrophytes (Misra, 1968; Gupta, 1999 and EPA, 2007) [23, 14, 10]. Quadrats of definite size (1m^2) was laid down randomly at each selected sites. 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. Long handle rake was used to collect the submerged species falling in each quadrat. The identification was carried using standard taxonomic works of Kak (1978) [15], Cook (1996) [7], Fasset (1998) [11] and Kumar (2009) [19]. For assessing quantitative macrophytic characteristics following parameters were studied:

$$\text{Abundance} = \frac{\text{Total no.of individuals of a species in all the quadrats}}{\text{Total no.of quadrats in which the species occured}} \times 100$$

$$\text{Density} = \frac{\text{Total no.of individuals of a species in all the quadrants}}{\text{Total no.of quadrats studied}}$$

$$\text{Frequency} = \frac{\text{Total no.of quadrats in which the species occured}}{\text{Total no.of quadrats studied}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Total frequency of all the species}} \times 100$$

$$\text{Relative density} = \frac{\text{Density of a species}}{\text{Total density of all the species}} \times 100$$

$$\text{Relative Abundance} = \frac{\text{Abundance of a species}}{\text{Total abundance of all the species}} \times 100$$

Importance Value Index (IVI) = Relative Density + Relative Frequency + Relative Cover

Results

During the year long study, a total of 13 aquatic macrophytes belonging to 12 different families were found distributed all over the Waskura Lake. The aquatic macrophytes found in the lake were categorized into three sub-categories viz., (a) Submerged (b) Rooted with floating leaves and (c) Emergents. No free floating macrophytes were recorded during the present study. The emergent vegetation were found dense throughout the lake, mostly dominating littoral zones, while rooted floating and submerged macrophytes were moderately spread covering both littoral and lentic zones A total of 6 species of submerged macrophytes were recorded during the study period from Waskura lake. Among rooted with floating leaves 5 number of species were recorded from the lake during the study, while 2 number of emergent macrophytic species were recorded from the lake. The detailed list of aquatic macrophytes recorded during the present study is presented in Table 1.

Table 1: Checklist Of Aquatic Macrophytes Recorded During The Present Study.

S. No.	Species	Family	Life form
1.	*Phragmites communis*	Poaceae	E
2.	*Typha angustata*	Typhaceae	E
3.	*Potamogeton natans*	Potamogetonaceae	R F
4.	*Nymphoids peltata*	Menyanthaceae	RF
5.	*Nymphaea alba*	Nymphaeceae	RF
6.	*Nelumbo nucifera*	Nelumbonaceae	RF
7.	*Trapa natans*	Trapaceae	RF
8.	*Potamogeton lucens*	Potamogetonaceae	S
9.	*Utricularia flexuosa*	Lentibulariaceae	S
10.	*Chara sps.*	Characeae	S
11.	*Ceratophyllum demersum*	Ceratophyllaceae	S
12.	*Hydrilla verticillata*	Hydrocharitaceae	S
13.	*Myriophyllum spicatum*	Haloragaceae	S

Where E Stands for Emergent macrophytes, RF stands for Rooted floating macrophytes and S stands for Submerged macrophytes.

Abundance of aquatic macrophytes is defined as the percent %) area of the quadrat occupied by a plant species. *P. communis* recorded maximum abundance (94) in the month of July, while *M. spicatum* were absent in the month of January during the study period. Minimum, maximum and mean values of abundance of each species within the lake are shown through graphical representation (Figure. 2). Overall the average total abundance of macrophytes recorded throughout the study period was 25.19 in Waskura Lake.

Density of aquatic macrophytes is defined as the number of in dividuals of a species per unit area. *Chara spp.* recorded maximum density (9.7 Plants/m^2) in the month of july, while *U. flexousa* were absent (0 Plants/m^2) in the month of January during the study period. Minimum, maximum and mean values of density of each species throughout the lake are shown through graphical representation (Figure. 3). Overall average total density of macrophytes recorded within the lake throughout the study period was 3.23 Plants/m^2.

Frequency of macrophytes is defined as the proportion of quadrats sampled in which species is represented. *P. communis* recorded maximum dominance in terms of frequency (48.8%) in the month of July, while *M. spicatum* recorded minimum frequency (0%) in the month of January during the study period. Minimum, maximum and mean values of frequency of each species throughout the lake are shown through graphical representation (Figure 4). Overall average total frequency of macrophytes recorded in Waskura lake during the study period (2017-2018) was 22.6%.

Importance Value Index (IVI) is defined as a measure of overall influence of a plant species in the community. Importance value ranges from 0-300. In general the maximum value of importance value index was recorded by *P.*

communis (292.8 bits/individual) in July, while *M. spicatum* recorded minimum IVI (0 bits/individual) in the month January. Overall average total importance value index of macrophytes recorded throughout the study period was 96.29 bits/individual in Waskura lake. Minimum, maximum and mean values of importance value index of each species throughout the lake are shown through graphical representation (Figure 5).

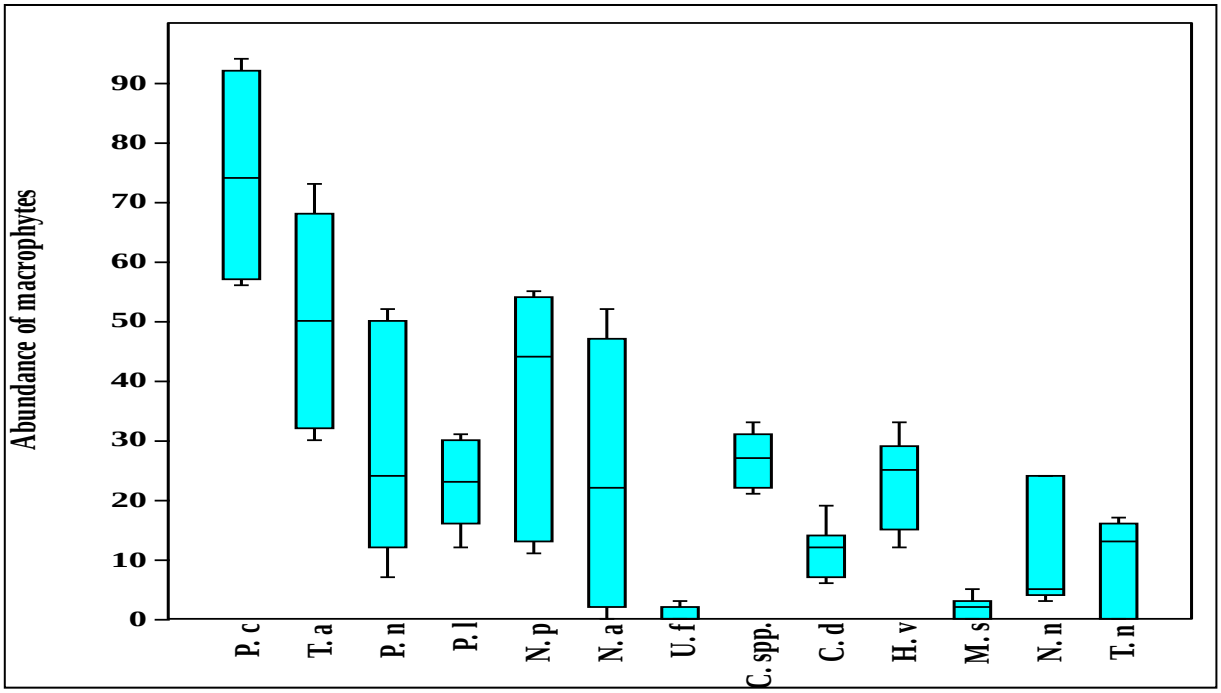

Fig 2: Box Plot for abundance of the aquatic macrophytes in Waskura lake, Kashmir.

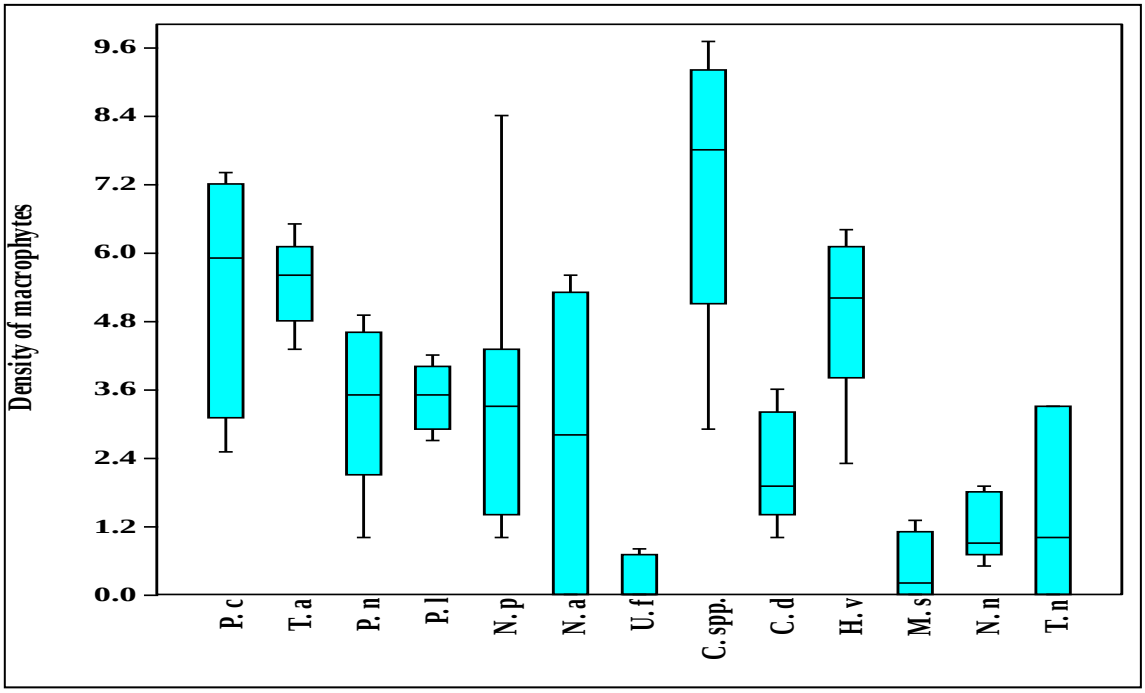

Fig 3: Box Plot for density of the aquatic macrophytes in Waskura lake, Kashmir.

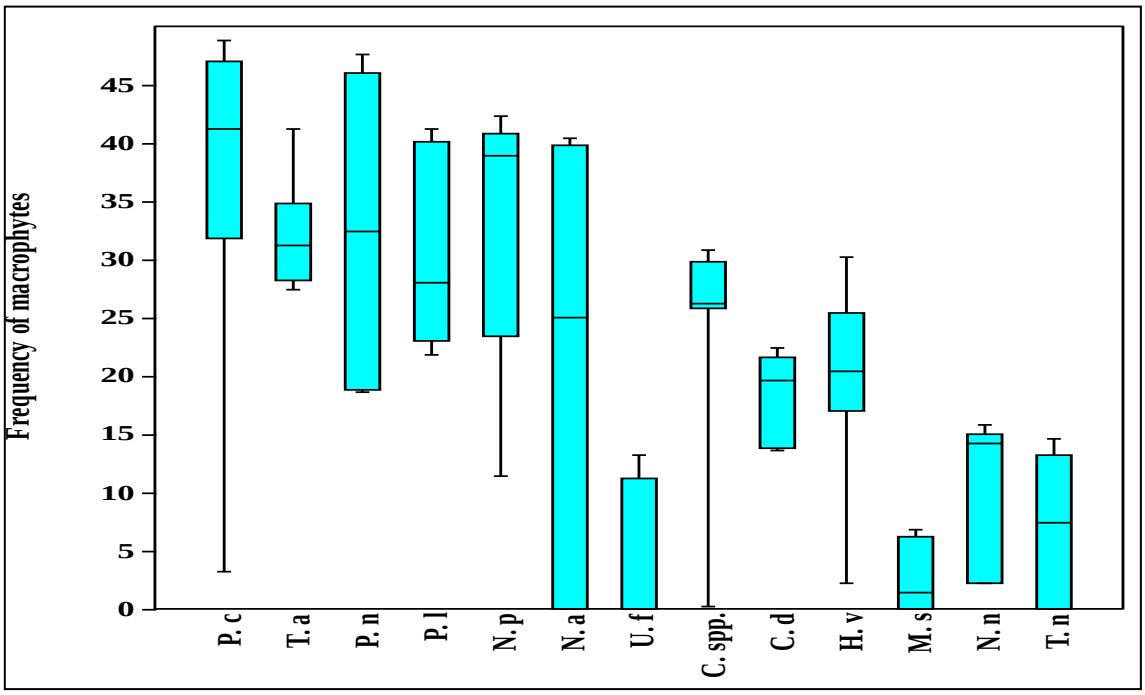

Fig 4: Box Plot for frequency of the aquatic macrophytes in Waskura lake, Kashmir.

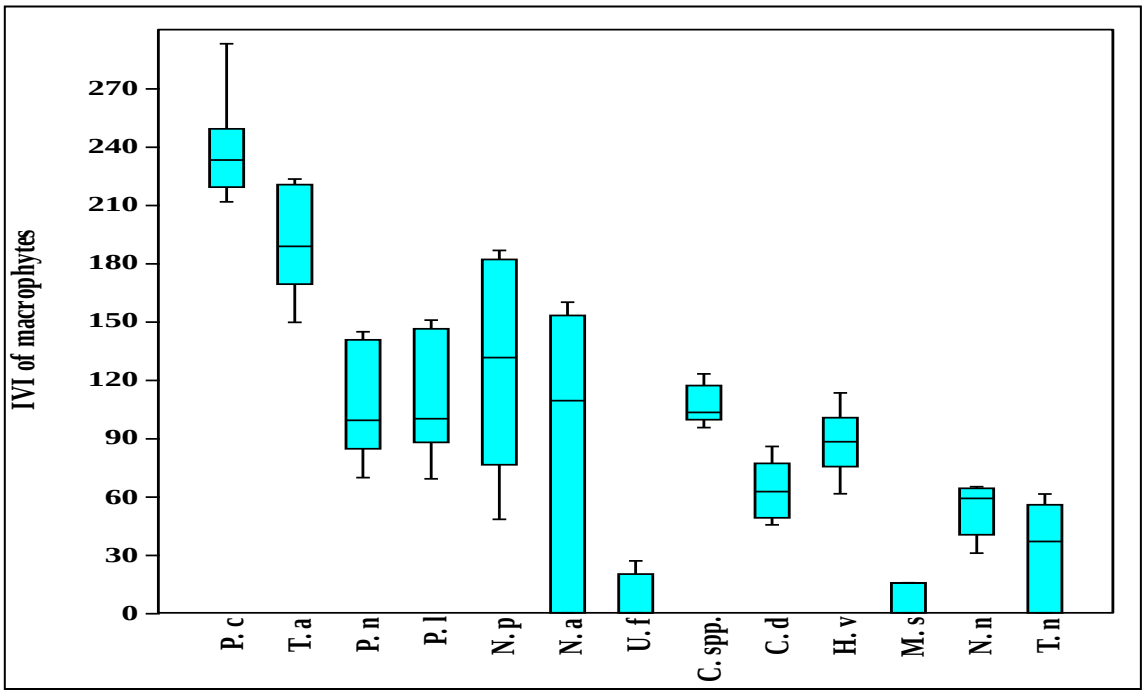

Fig 5: Box Plot for IVI of the aquatic macrophytes in Waskura lake, Kashmir.

Where, P. c = *Phragmites communis*, T. a = *Typha angustata*, P. n = *Potamogeton natans*, P. l = *Potamogeton lucens*, N. p = *Nymphoides peltata*, N.a = *Nymphaea alba*, U. f = *Utricularia flexousa*, C. d = *Ceratophyllum demersum*, H. v = *Hydrilla verticillate*, M. s = *Myriaphyllum spicatum*, N.n=*Nelumbo nucifera* T. n = *Trapa natans* and C.*Spp* = *Chara Spp* (Applicable to all figures).

Discussion

The present study on Waskura Lake revealed the presence of thirteen (13) aquatic macrophytes belonging to twelve (12) different families. The quatitative characters which comprise of frequency, density, abundance, relative frequency, relative density, relative abundance and importance value index (IVI) of the different macrophytic species in different study sites of the lake, recorded higher values during summer season and lower values during winter season. During summer months, more sunshine and longer photoperiod favours the growth of macrophytes. This is also supported by the works of Kundangar and Zutshi (1985) [21], who reported that in Kashmir lakes, the longer photoperiod and high water temperature during summer may be responsible for optimum growth, flowering and biomass of macrophytes. Singh *et al.* (2013) [31] also observed that the maximum number of individuals of macrophytes were observed in the summer while the lowest number were recorded during the winter season. In general, macrophytes recorded minimum number of individuals in winter. The obvious reason being that during winter season, usually aquatic macrophytes are in the stage of senescence and decomposition, which is also confirmed by

the studies of Kundangar and Zutshi (1985) [21]. Kumar and Pal (2015) [18] while working on Macrophytic diversity in different aquatic systems of Bundelkhand Region, Uttar Pradesh, India, also found seasonal variation in abundance of macrophytes.

Emergents were found abundant in all three seasons except winter. The abundance of emergent vegetation mostly along the lake periphery (littoral zone), the reason being that emergent vegetation usually prefers shallow depth of the lake basin. Among emergent vegetation *Phragmites communis* were found abundant at all the study sites which may be on account of shallow depth and probably due to the high nutrient condition of the lake. Wani and Pandit (2008) [34] also reported that the increasing abundance of emergent vegetation is related to water level fluctuations accompanied with decreasing depth and nutrient enrichment mainly by allocthonous material by way of sedimentation. From these results it can be inferred that the Waskura lake is evolving at a rapid pace, pointing towards increasing productivity of the lake ecosystem. The abundance of submerged macrophytes throughout the study period may be due to the less depth and the transparency of the lake.

The submerged vegetation (*Chara spp., H. verticillta, C. demersum* and *P. lucens,*) were abundant throughout the study period with dominant being: *Chara spp* > *Hydrilla verticillata* > *Ceratophyllum demersum*. Among the varied environmental factors affecting the distribution of submerged macrophytes water depth and water transparency associated with light availability are of paramount importance. In the present study, it also seems that the distribution of submerged macrophytes is mainly dependent on water depth and transparency. This is also supported by the works of Dhore *et al.*, (2013) [8] who reported that submerged species *Chara spp*., *Ceratophyllum demersum* and *Hydrilla verticillata* were abundant throughout the year.

Rooted floating macrophytes were abundant in summer and autumn and were less abundant or completely absent during winter. *Trapa natans, Nymphoides peltatum* and *Nelumo nucifera* among rooted floating macrophytes were found abundant during the summer and autumn season. The increased water depth at certain portions of the Waskura lake resulted in the establishment of rooted floating-leaf type macrophytes. It was also confirmed by positive corelation of rooted floating macrophytes with water depth (+0.468), which is further corroborated by the studies of Spence (1967, 1982) [32, 33] who suggested an adaptive connection between deep waters and broad-leaf species.

Abundance of macrophytes is an important parameter which is a relative representation of a species in a particular ecosystem. The average total abundance of macrophytes recorded throughout the study period were 25.19 plants/m^2 in Waskura Lake. Thirteen species present in Waskura Lake showed the varied abundance with respect to seasonal variations. This was statistically confirmed by ANOVA that there was a significant variation ($p<0.01$) in macrophytes at different sites of lake throughout the year. Emergents were found abundant in all three seasons except winter. The abundance of emergent vegetation mostly along the lake periphery is mainly due to the shallowness of the lake basin. Kumar and Pal (2015) [18] while working on Macrophytic diversity in different aquatic systems of Bundelkhand Region, Uttar Pradesh, India, also found seasonal variation in abundance of macrophytes. *Phragmites communis* were found abundant at all the study sites which may be on account of shallow depth and probably due to the high nutrient condition of the lake. Wani and Pandit (2008) [34] also reported that the increasing abundance of emergent vegetation is related to water level fluctuations accompanied with decreasing depth and nutrient enrichment mainly by allocthonous material by way of sedimentation.

Slope of the lake can also determine the presence, absence and dominance of macrophytes. Waskura Lake seems to have more gentle slope in its littoral zones, which is responsible for the presence and dominance of emergent vegetation at the littoral zones. According to Duarte and Kalff (1986) [9], abundance of macrophytes is inversely related to slope of the lake shore, as the difference in the relative area suitable for plant growth and in sediment stability and quality between gentle and steepy sloped littoral zones. The area of littoral zone available for emergent growth declines with increasing slope of the basin.

The submerged vegetation (*Chara spp., H. verticillta, C. demersum* and *P. lucens,*) were abundant throughout the study period with dominant being *Chara spp*. *Hydrilla verticillata* and *Ceratophyllum demersum*. Among the varied environmental factors affecting the distribution of submerged macrophytes water depth and water transparency associated with light availability are of paramount importance. In the present study, it also seems that the distribution of submerged macrophytes is mainly dependent on water depth and transparency. This is also supported by the works of Dhore & Lachure (2013) [8] who reported that submerged species *Chara spp*., *Ceratophyllum demersum* and *Hydrilla verticillata* were abundant throughout the year. Rooted floating macrophytes were abundant in summer and autumn and were less abundant or completely absent during winter. *Trapa natans, Nymphoides peltatum* and *Nelumo nucifera* among rooted floating macrophytes were found abundant during the summer and autumn season. The increased water depth at certain portions of the Waskura lake resulted in the establishment of rooted floating-leaf type macrophytes. It was also confirmed by positive corelation of rooted floating macrophytes with water depth (+0.468), which is further corroborated by the studies of Spence (1967, 1982) [32, 33] who suggested an adaptive connection between deep waters and broad-leaf species.

Relative abundance is an important parameter which measures the eveness of distribution of individuals among the species in a community. The average total relative abundance of macrophytes recorded throughout the study period was 7.42%. Emergents recorded maximum relative abundance followed by submerged and then rooted floating macrophytes.

Density is an important parameter for aquatic vegetation measurements and refers to the number of plants per unit area. It is useful in detecting the response of plants to a given management action. The average total density of macrophytes recorded within the lake throughout the study period (2017-2018) was 3.23plants/m^2. The density was recorded maximum for submerged macrophytes, *Chara* spp. followed by *H.verticillata* and *C. demersum*. Submerged macrophytes cover the maximum lake area due to presence of optimal depth for its growth. This observation is further confirmed by the positive correlation of submerged macrophytes with transparency (+0.781) and water depth (+0.635). Spence, (1982) [33] Chambers and Kalff, (1985) [6] also during their research work reported that water depth, water transperancy associated with light availability favour dense growth of submerged macrophytes. Ghosh and Biswas (2015) [13] also

found the submerged macrophytes dominated the lake throughout the year due to presence of high silt and organic load.

Rooted floating macrophytes (*N.peltatum*, *T. natans* and *N.nucifera*) form widespread dense beds in Waskura lake recording high density at certain sites, which may be due to higher water depth at certain portions of the lake. High depth of lake at certain sites favours the presence and dominance of rooted floating macrophytes, which are directly related to their adaptive connections. This is also corroborated by the studies of Spence (1967, 1982) [32, 33] who suggested an adaptive connection between deep waters and broad-leaf species. The presence of rooted floating macrophytes with relatively higher densities have also been reported by Ahmad *et al.*, (2015) [3] and Rather *et al.*, (2007) [27]. They corroborated the presence of rooted floating macrophytes with deep waters and nutrient availability. Our observation is further confirmed by the positive correlation of rooted floating macrophytes with water depth (+0.468).

Emergent vegetation recorded maximum density along the periphery of the lake, possibly because the peripheral areas of the lake is shallow with gentle slope and richer in nutrients. Durate and Kalff (1986) [9] also reported that the slope of the lake basin are among the most important morphological features that influence the potential development of macrophytes in lakes. Galatowitsch *et al.*, (1999) [12] also confirmed that nutrient enrichment and shallowness results in growth of emergent vegetation. Several studies reported that the nutrient enrichment can cause significant changes in the density, species composition and richness of aquatic vegetation in lakes (Lougheed *et al.*, 2001; Rosset *et al.*, 2010; Alahuhta, 2011) [22, 28, 3]. Waskura lake showed the varied density of macrophytes with respect to seasonal variations, which was statistically confirmed using ANOVA ($p<0.01$). Seasonal variation in macrophytes from spring onwards results in change in temperature, which seems to have direct relationship with the growth of macrophytes.

The relative density is the study of numerical strength of a species in relation to total number of individuals of all species. The average total relative density of macrophytes recorded throughout the study period was 6.72%. The relative density was recorded maximum for submerged macrophytes followed by rooted floating and least for emergents.

Frequency is an important parameter which gives an idea about the occurrence (how often) of species within the quadrat. The average total frequency of macrophytes recorded within the lake throughout the study period was 22.6%. Rooted floating macrophytes recorded the highest mean frequency followed by submerged macrophytes and then emergents.

Among rooted floating macrophytes *N. peltatum*, *T. natans*, *P. natans*, *N. nucifera* and *N. alba* recorded the highest mean frequencies in summer and minimum or in winter. The possible reason being that during summer months the water temperature is appreciably high and day length is of 10-12 hours duration. The other reason being that the lake depth (approx.3m) favours the rooted floating macrophytes. Sharma (2008) [30], while working on macrophytic diversity of three lakes of Jammu, reported that species occurrence has been attributed to the depth, size, slope, morphometry of lake basin, physiography of the surrounding area and to the physico-chemical characteristics of habitat water and sediment. Similar observations were also reported by Kaul and Zutshi (1965) [16] while working on aquatic and marshland vegetation of Srinagar.

Among submerged macrophytes *Chara spp*., *P. lucens* and *H. verticillata* recorded highest frequency. The highest frequency of these species at specific sites of the lake seems to be governed by depth, sunlight, nutrient availability and sediment composition.

Emergents were dominat throughout the present study but reported only two species. Among emergents, *P. communis* recorded the highest frequency throughout the year. The increasing growth of emergents in the littoral may be due to water level fluctuations accompanied with decreasing depth and nutrient enrichment mainly by allochthonous material by the way of sedimentation. Wani and Pandit (2008) [34] while working on and floristic diversity Nilnag Lake also reported the same.

Moreover frequency of macrophytes showed seasonal variation. The maximum frequency was reported during summer and minimum in winter. The variation in frequency of macrophytes is governed by a number of environmental factors, among these factors water depth and its periodic fluctuation have been postulated to be most important factor that regulate the frequency of aquatic macrophytes. The ANOVA also revealed that there was a significant variation ($p<0.01$) in frequency of macrophytes reported from different sites of lake throughout the year.

Relative frequency is the frequency of given species expressed as a percentage of the sum of frequency values for all species present. The average total relative frequency of macrophytes recorded throughout the study period was 36.99%. Relative frequency of macrophytes revealed that rooted floating recorded maximum relative frequency followed by submerged and then emergents.

Importance Value Index (IVI) is a standard tool used to measure how dominant a species is in a given area. The IVI is the sum of relative abundance, relative density and relative frequency. The average total importance value index of macrophytes recorded throughout the study period was 96.29 bits/individuals in Waskura Lake. The maximum IVI value for macrophytes during the present study followed the sequence as given below:

Rooted floating macrophytes > emergent macrophytes > submerged macrophytes.

Rooted floating macrophytes were the most dominant macrophytes throughout the year on the basis of IVI value. The dominance of rooted floating macrophytes during the present study is directly related to the depth of the lake. This was also statistically proved by positive corelation of rooted floating macrophytes (+0.468) with depth of the lake. Moreover, the depth value of 3m recorded during the present study seems to favour the dominance of rooted floating macrophytes. Sharma and Sing (2017) [29], while working on macrophytic diversity of Himalayan lake, Dodi Tal observed that the lake showed maximum IVI for emergent macrophytes followed by submerged and then by rooted floating. However, during the present study, maximum IVI was recorded by rooted floating macrophytes followed by emergents and the submerged. Papastergiadou and Babalonas (1992) [25] while working on aquatic macrophytes of Greek lakes, Lake Kerkini, also reported that the dense growth of rooted floating macrophytes depends upon the water depth.

After rooted floating macrophytes, emergents were dominant form throughout the year on the basis of IVI value. *Phragmites communis* was highly dominant throughout the year.

Submerged macrophytes showed the minimum value of IVI throughout the year. The most possible reason being that the depth of the lake supports maximum growth of rooted floating macrophytes rather than submerged macrophytes. IVI value recorded during the present study was directly related to different macrophytic groups, which in turn was related to the depth at particular site.

From the present result it can be concluded that presence or absence of macrophytes is directly related to depth values, as rooted floating macrophytes prefer lake sites with depth values of (0.5-3m), emergent macrophytes prefer lake sites with depth value (1-1.5m), while submerged macrophytes prefer lake sites with depth values of (>3m).

The dominance of rooted floating macrophytes during the present study is directly related to the depth of the lake. This was also statistically proved by positive corelation of rooted floating macrophytes (+0.468) with depth of the lake. Moreover, the depth value of 3m recorded during the present study seems to favour the dominance of rooted floating macrophytes. Papastergiadou and Babalonas (1992) [25] while working on aquatic macrophytes of Greek lakes, Lake Kerkini, also reported that the dense growth of rooted floating macrophytes depends upon the water depth.

Waskura lake showed the varied density of macrophytes with respect to seasonal variations, which was statistically confirmed using ANOVA ($p<0.01$). Seasonal variation in macrophytes from spring onwards results in change in temperature, which seems to have direct relationship with the growth of macrophytes. Several studies reported that the nutrient enrichment can cause significant changes in the density, species composition and richness of aquatic vegetation in lakes (Lougheed *et al.*, 2001; Rosset *et al.*, 2010; Alahuhta, 2011) [22, 28].

ANOVA test showed that there was a significant variation ($p<0.01$) among the different sites of the lake, and macrophytes were distributed all over the lake (except centre) and their distribution was directly related to the lake depth.

Conclusion

The 12 months of research on Waskura lake involved eight different quantitave characteristic viz., number of individuals of macrophytes, abundance, frequency, density, relative frequency, relative density, relative abundance and importance value Index (IVI). Considering the main aim of the study, the following conclusion can be drawn:

- The aquatic macrophytes found in the lake were categorized into only three sub-categories viz., (a) Submerged (b) Rooted with floating leaves and (c) Emergents, while no free floating macrophytes were recorded during the study.
- The lake depicted clear zonation of macrophytic vegetation with emergents forming the continuous belt along the periphery of the lake, followed by rooted with floating leaves and submerged occupying deeper portion of the lake. The occurrence and distribution of macrophytes in Waskura lake seems to be function of water depth.
- On comparing with earlier literature (Kundangar, 1982) [20], two macrophytes namely *Potamogeton pucillus* and *Potamogeton crispus* were not recorded during the present study. However, one new macrophyte *Chara spp*. has been recorded during the present study**,**wich is new entry to the lake.

References

1. Abubakr A, Afsah N, Kundangar MRD. Ecological studies and uses of valued aquatic plants in Kashmir wetlands. Nature Environment and Pollution Technology 2011;10(1):115-118.
2. Abubakr A. Sanative role of macrophytes in aquatic ecosystems. Nature Environment and Pollution Technology 2010;9:(4):657-662.
3. Ahmad U, Parveen S, Hasan T, Bhat BN. Diversity of aquatic macrophytes of Aligarh, U. P. India. Int. J. Curr. Microbiol. App. Sci 2015;4(4):494-505.
4. Alahuhta J. Patterns of aquatic macrophytes in the boreal region: Implications for Spatial Scale Issues and Ecological Assessment. M.Sc dissertation University of Oulu, Linnanmaa 2011.
5. Chambers PA, Lacoul P, Murphy KJ, Thomaz SM. Global diversity of aquatic macrophytes in freshwater. Hydrobiologia 2008;559:9-26.
6. Chambers PA, Kalff J. Depth distribution and biomass of submerged aquatic macrophyte communities in relation to Secchi depth. Canadian Journal of Fisheries and Aquatic Sciences 1985;42:701-709.
7. Cook CDK. Aquatic and wetland plants of India. Oxford University Press, New York, NY, 1996, 385.
8. Dhore M, Dhore M, Lachure P, Dabhadkar D. Checklist of the aquatic macrophytes in certain wetland of Yavatmal District, Maharashtra State, India. International journal of education and research 2013.
9. Duarte CM, Kalff J. Littoral slope as predictor of the maximum biomass of submerged macrophytes communities. Limnol. Ocean Ogr 1986;31:1072-1080.
10. Environmental Protection Agency (EPA), Final survey of the nation's lakes field Operations Manual. Doc. EPA 841-B-07-004. Office of Water, Washington, D.C. 2007, 104.
11. Fasset, NC. A Manual of Aquatic Plants. Agrobios, India 1998.
12. Galatowitsh SM, Anderson NO, Ascher PD. Invasiveness in wetland plants in temperate North Anerica. Wetlands. 1999;19:733-755.
13. Ghosh D, Biswas JK. Biomonitoring dacrophytes Diversity and abundance for rating aquatic health of an oxbow lake ecosystem in Ganga River Basin. American Journal of Phytomedicine and Clinical Therapeutics 2015;602-621.
14. Gupta PK. Soil, plant, water and fertilizer analysis. Agro Botanica, India 1999, 356-357.
15. Kak, AM. Taxonomic studies of aquatic angiosperms of Kashmir. Ph. D. Thesis, University of Kashmir Srinagar, 1978.
16. Kaul V, Zutshi DP. A study of aquatic and marshland vegetation of Srinagar. Department of Botany, S. P. College, Srinagar, Kashmir, 1965, 33.
17. Krause-Jensen D, Sand-Jensen K. Light attenuation and photosynthesis of aquatic plant communities. Limnol. Oceanogr 1998;43:396-407.
18. Kumar R, Pal A. Macrophytic diversity in different aquatic systems of Bundelkhand Region, Uttar Pradesh, India. International journal of scientific research in environmental science 2015;3(10):0350-0356.
19. Kumar R. Ecological diversity and nutrient dynamics of dominant macrophytes in Hokersar, wetland Kashmir. Ph.D thesis, University of Kashmir Srinagar, 2009.
20. Kundangar MRD. Plankton ecology, macrophytic

vegetation and nutrient dynamics of two rural lakes of Kashmir. University of Kashmir, 1982.
21. Kundangar, MRD, Zutshi, DP. Environmental features and plankton communities of two rural lakes., In: A.D. Adoni(ed.) Proc. Natl. Sym. Pure and Appl. Limnol, Sagar, M.P, 1985, 40-47.
22. Lougheed, VL, Crosbie B, Chow-Fraser P. Primary determinants of macrophyte community structure in 62 marshes across the Great Lakes basin: latitude, land use, and water quality effects. Can. J Fish. Aquat. Sci 2001;58:1603-1612.
23. Misra R. Ecology workbook. Oxford and I.B.H Publishing Co., New Delhi, India, 1968.
24. Noges T, Luup H, Feldmann T. Primary production of aquatic macrophytes and their epiphytes in two shallow lakes (Peipsi and Võrtsjärv) in Estonia. Aquat. Ecol 2010;44:83-92.
25. Papastergiadou E, Babalonas D. Ecological studies on aquatic macrophytes of Dam Lake: Lake Kerkini, Greece. Arch Hydrobiol Suppl 1992;90(2):187-206.
26. Pratas J, Favas, PJ, Paulo C, Rodrigues N, Prasad MNV. Uranium accumulation by aquatic plants from uranium-contaminated water in Central Portugal. International Journal of Phytoremediation 2012;14:221-234.
27. Rather GH, Kumar R, Pandit AK. Distribution of Aquatic Vegetation in Ahansar, a Freshwater Lake in Kashmir Himalaya. Journal of Research & Development, 2007, 7.
28. Rosset V, Lehmann A, Oertli B. Warmer and richer? Predicting the impact of climate warming on species richness in small temperate waterbodies. Global Change Biology 2010;16:2376-2387.
29. Sharma RC, Sing S. Macrophytes of sacred himalayan lake Dodi Tal, India: Quantitative and Diversity Analysis. Biodiversity International Journal, 2017, 1 (4).
30. Sharma S. Macrophytic diversity and state of environment of three lakes of Jammu province. Proceeding of Taal 2007*:* the 12th world conference. 2008, 2081-2087.
31. Singh KK, Sharma, MB, Usha K. Inventory of aquatic macrophytes in Lake Kharungpat, India. Journal of Energy Technology and Policy 2013;3(11):2224-3232.
32. Spence DHN. Factors controlling the distribution of freshwater macrophytes with particular reference to the lochs of Scotland. J Ecol 1967;55:147-170.
33. Spence DHN. The zonation of plants in freshwater lakes. Adv. Ecol. Res 1982; 2:37-125.
34. Wani SA, Pandit AK. Ecological distribution and floristic diversity change in nilang, a high altitude himalayan lake under threat. Proceeding of Taal. 2007; the 12th world conference, 2008, 430-434.
35. Zutshi DP, Khan MA. On Lake Typology of Kashmir. In: Environment physiology and ecology of plants (Edt. by DN Sen and RP Bangal) B. Singh and M Pal Singh, Dehradun, 1978, 465-472.