A Depth based Community Architectural account of some Macrophytes in Anchar Lake of Kashmir Valley, India

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ABSTRACT

The present paper reports on the community features of rooted floating-leaf type macrophytes in relation to water depth in Anchar lake. A total of six macrophyte species represented by *Nymphoides peltatum, Potamogeton natans*, *Trapa natans*, *Nelumbo nucifera*, *Nymphaea alba* and *Hydrocharis dubia* were registered across three different depth ranges in the Lake ecosystem. The plant species were found to be well adapted at D_1 (0-100 cm) and D_2 (101-200 cm) depth zones while a significant effect of water depth was observed on the plants at a depth range of 201-300 cm (D_3), as it witnessed a scanty distribution of plant species in the water body.

Keywords: Eutrophication, community features, distribution, density, lake ecosystem

INTRODUCTION

Aquatic macrophytes in different growth forms represent the most important biotic element in a lake ecosystem (Khanday *et al*., 2015a). Macrophytes are excellent indicators of the ecological state of water bodies, mainly because they integrate environmental changes over periods of a few years, and reflect the cumulative effects of successive disturbances (Tremp and Kohler, 1995). Distribution of these macrophytes in water bodies and their coexistence can be determined by tolerance to drought and flooding (Smith and Brock, 1996). Knowledge about responses of individual species to hydrological conditions may enable more efficient restoration or promote ecologically sensitive hydrological management (Khanday *et al*., 2015b). Long-term data are essential to understand the trajectory of changes in macrophytic communities and their ability to take up nutrients, particularly in water bodies exposed to human pressures (Hellsten *et al*., 1996; Egertson *et al.,* 2004). Macrophytes are involved in several feedback mechanisms that tend to keep the water clear even in relatively high nutrient loadings (Moss, 1990). In addition, macrophytes have been reported to notably affect the lake nutrient status, resuspension of bottom material and water turbidity (James and Barko, 1990; Horppila and Nurminen, 2001). Aquatic plants and their communities may furthermore be good indicators of the changes occurring in lakes because of human-induced acidification and eutrophication (Roelofs, 1983; Lehmann and Lachavanne, 1999). Moreover, macrophytes provide shelter for invertebrates and small fishes, and form spawning substrates for many fishes. Because of these key functions, aquatic plants are essential for getting the good ecological status of aquatic ecosystems, and it is therefore necessary to preserve such communities in freshwaters. Such preservation implies good knowledge on how plant communities are controlled by the various abiotic parameters that characterize aquatic ecosystems. Of all potential abiotic factors, water regimes have generally been shown to correlate most strongly with the community structure of a shallow lake (Keddy, 2000; De Steven and Toner, 2004; Yan *et al*., 2014). Water regime, is defined as the integration of continuously changing depth over time, is a major determinant of plant community development and patterns of plant zonation (Rea and Ganf, 1994). Water level directly affects plants through changes in for example net photosynthesis. It also indirectly affects plants through changes in sediment characteristics, water clarity and wind/wave exposure (Scheffer, 1998). Changes in water regimes, either short term (seconds to hours) or long-term (days to years), can result in both direct and indirect responses in the biotic conditions (Hofmann *et al*., 2008). An increasing number of studies have shown that the growth, production, and community structure of macrophytes (Paillisson and Marion, 2011), phytoplankton (Elliott and Defew, 2012), zooplankton (Fantin-Cruz *et al*., 2010), benthic animals (Free *et al*., 2009), and fish (Mims and Olden, 2013), as well as their interactions, trophic structure, and ecosystem processes (Mclaughlin and Cohen, 2013), have a significant relationship to water regimes. Consequently, the aim of this paper was to determine how different community features of some aquatic plants change with water level in a temperate freshwater lake ecosystem.

MATERIALS AND METHODS

Study Area

The Anchar, a hyper-eutrophic lake, is about 14 km to the northwest of summer capital Srinagar, at an altitude of 1584 m (amsl). The lake is having a surface area of 6.6 km^2. Presently the open water represents only about 1.69 km^2, the remaining portion having been transformed into a marshland due to increased human perturbations of the ecosystem (Khanday *et al*., 2016). The lake is receiving water in its northern side from the Sind stream and a channel from Khushalsar Lake on its southern side. The excess water of the lake flows through Shalabugh wetland into the River Jhelum. Four sampling sites, A1-A4 were identified in the lake for the collection of the data (Fig.1).

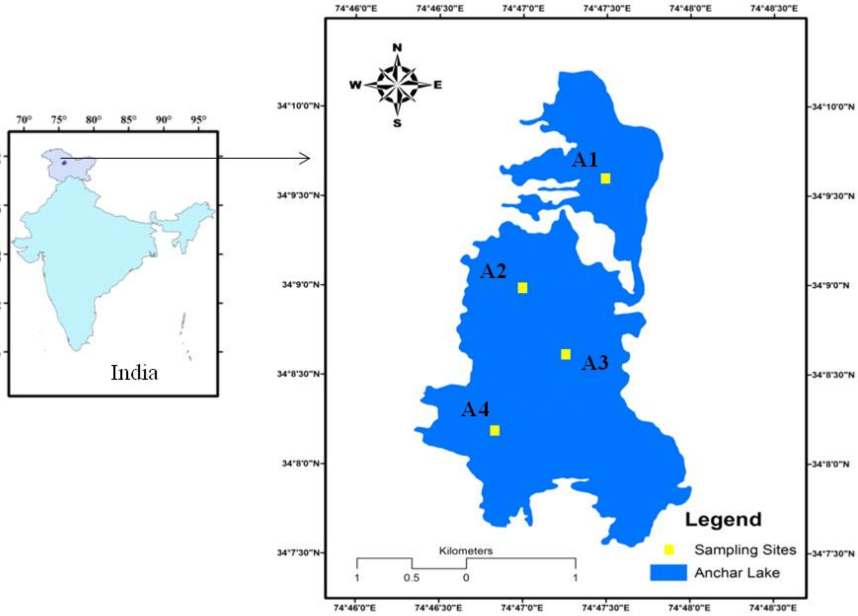

Figure.1: Location map of the area showing study sites

Community architectural features

Quadrat method (Misra, 1968) was followed to study various community features of selected macrophyte species. A wooden quadrat frame of 1m^2 size was placed first in D_1(0-100cm) depth range followed by D_2 (101-200cm) and D_3 (201-300cm) depth zones at the four selected sampling sites in each lake. The depth was measured by a lead weight (1 kg). One petiole/shoot was considered as one plant except *Nymphoides peltatum* in which three petioles were taken as one plant (Zutshi, 1982). The plants which occurred in each quadrat were sorted species wise and the number of individuals of each species was counted for various community features (Misra, 1968). The frequency was determined by the ratio of number of quadrats in which species occurred to the number of quadrats studied, while as ratio of number of individuals of a species to the total number of quadrats considered was used to calculate the density. Similarly, the abundance of the various species was determined by the ratio of individuals of a species to the number of quadrats in which the species occur.

RESULTS

The Anchar lake despite being hyper-eutrophic in recognition, has got water depths at deeper patches well suited for the growth of rooted floating- leaf type macrophytes. At site A1, *N. peltatum* was found to cover significant area and register highest mean density value of 3.62 at depth D_1 against *N. nucifera*, with lowest mean density value of 1.06 at the same depth. Similarly, *N. peltatum* also was recorded to have a maximum value of 5.23 and 68.75 for abundance and frequency in D_1 depth zone respectively. While as the minimum values for abundance and frequency at the same site has been counted for *N. nucifera* (2.12) at D_2 and *T. natans* (21.87) at depth D_3 (Figure 2- 4).

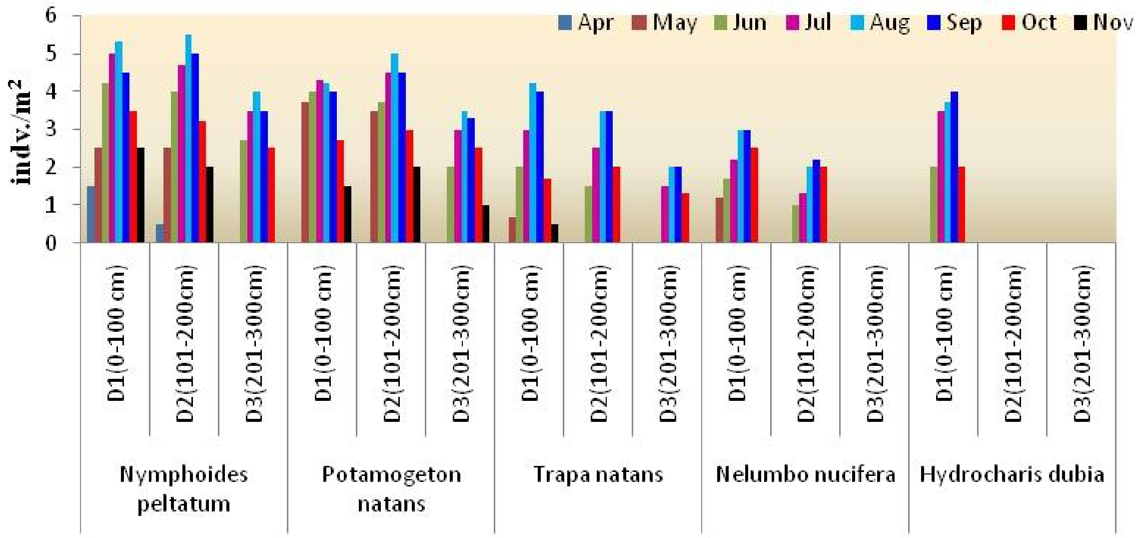

Figure 2: Monthly variation in density (indv./m^2) of macrophyte species in Anchar lake at Site A1

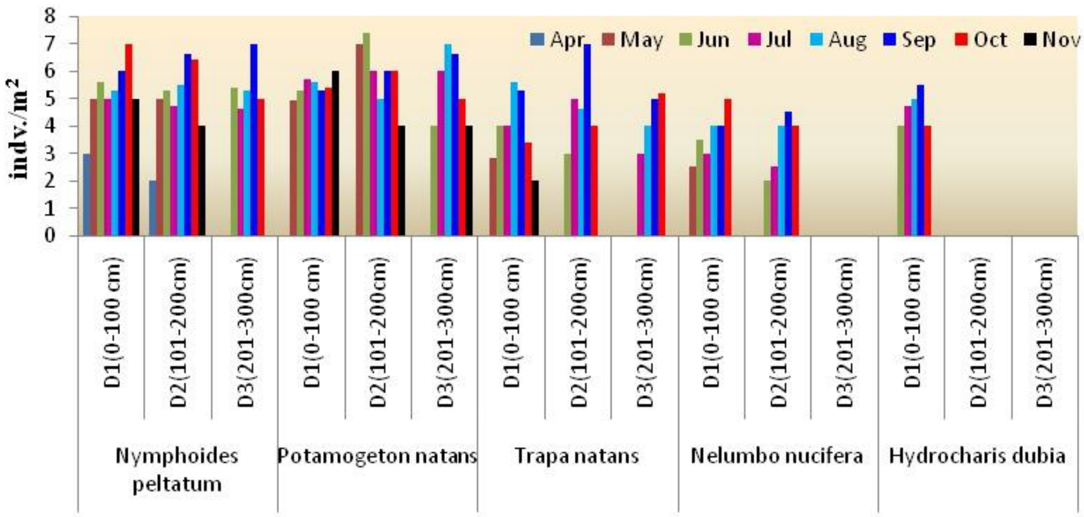

Figure 3: Monthly variation in abundance (indv./m^2) of macrophyte species in Anchar lake at Site A1

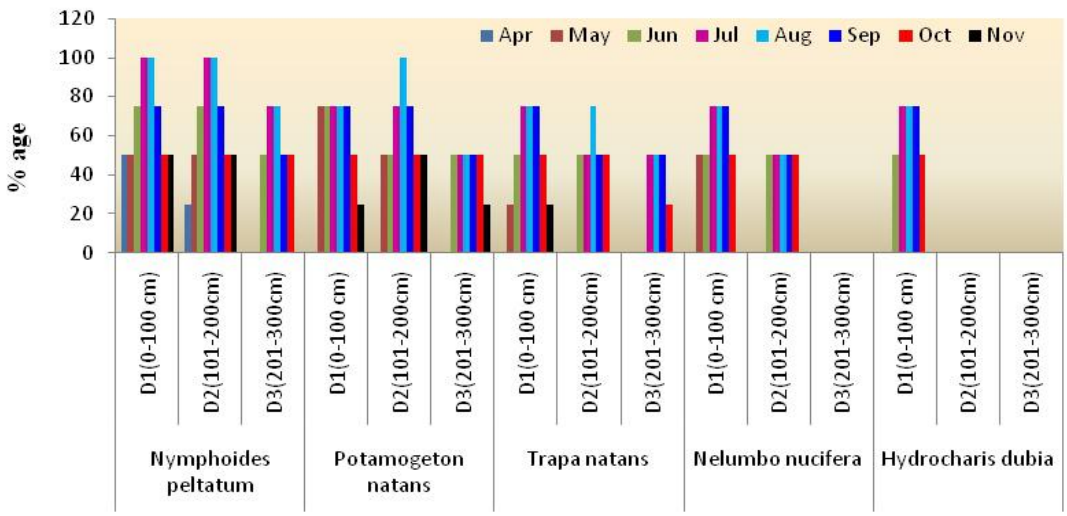

Figure 4: Monthly variation in frequency (%) of macrophyte species in Anchar lake at Site A1

Site A2 of Anchar lake recorded only *N. peltatum, P. natans* and *H. dubia*, each having a maximum value for mean density of 3.36, 2.38 and 1.83 in depth D_1 zone respectively, on the other hand, least values of 1.8 and 1.4 were observed at D_3 depth for each *N. peltatum* and *P. natans*. Again, *N. peltatum* registered a maximum value of 5.3 and 62.5 at depth D_1 (0-100cm) for abundance and frequency respectively, while as *H. dubia* (2.8) at D_1 and *P. natans* (28.12) at D_3 showed lowest values for abundance and frequency at the site (Fig.5-7).

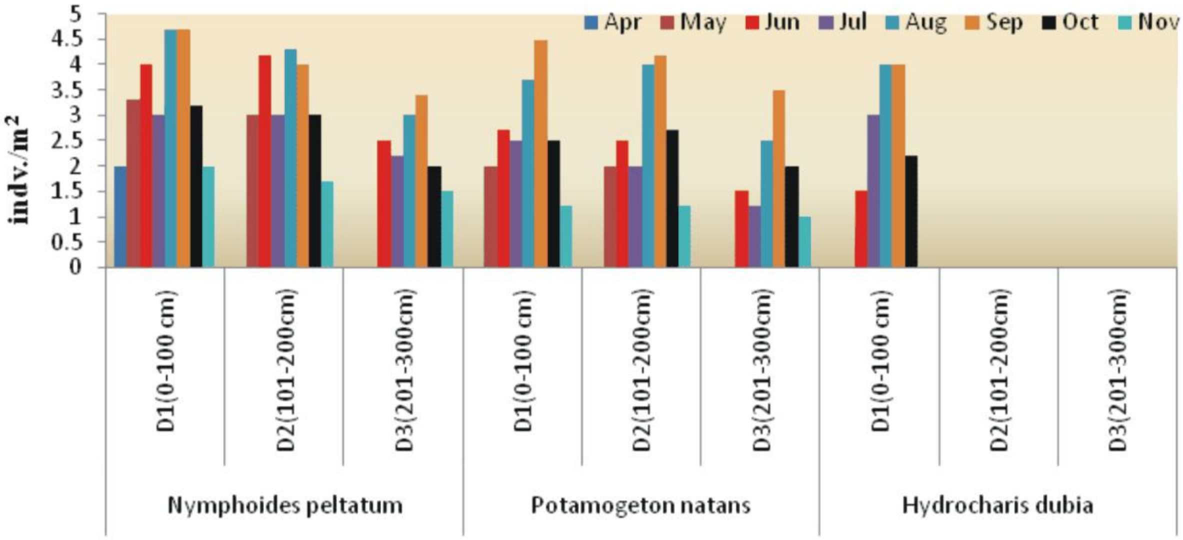

Figure 5: Monthly variation in density (indv./m^2) of macrophyte species in Anchar lake at Site A2

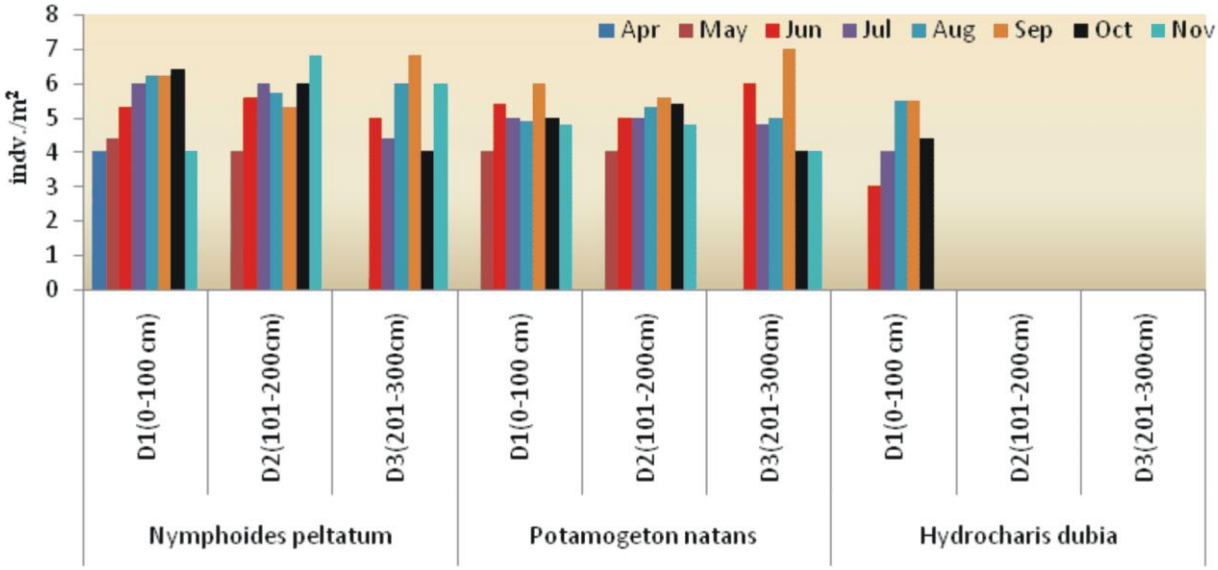

Figure 6: Monthly variation in abundance (indv./m^2) of macrophyte species in Anchar lake at Site A2

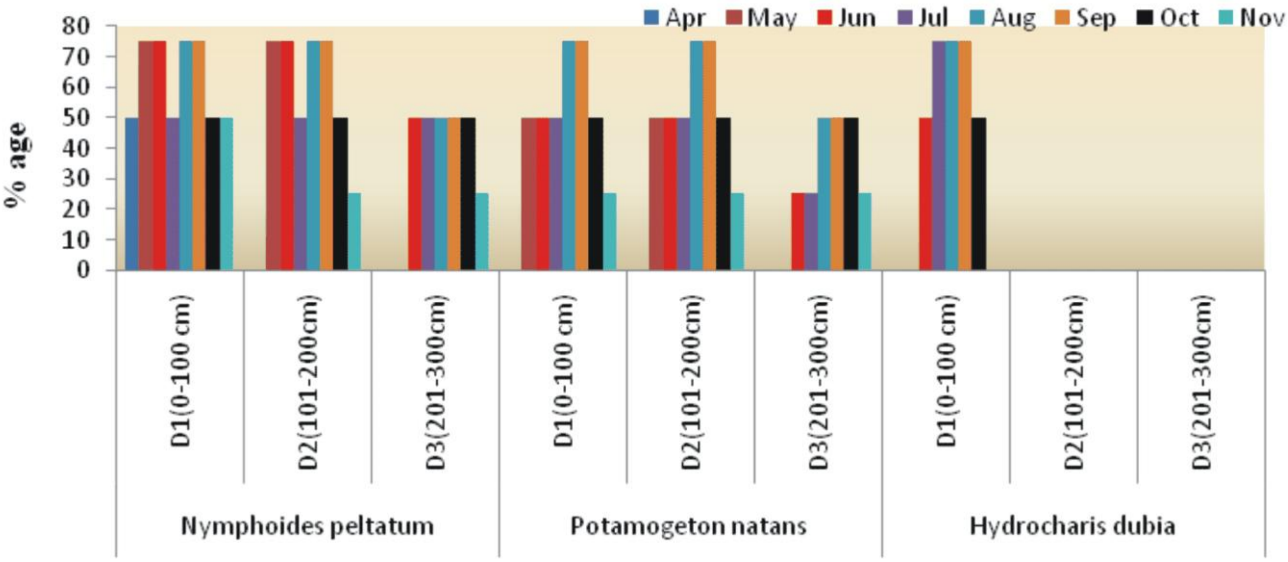

Figure 7: Monthly variation in frequency (%) of macrophyte species in Anchar lake at Site A2

At Site A3 in the lake, maximum mean density value was recorded for *N. peltatum* (3.67) followed by *P. natans* (2.98), and *T. natans* (2.33) each in D_1 depth zone and decreasing to a minimum of 1.03 for *T. natans* at depth D_3. The mean abundance on the other hand, also was recorded highest for *N. peltatum* (5.18) at D_1 followed by *P. natans* (4.6) and *T. natans* (4.2) again in the same depth zone, while the frequency varied between a mean value of 21.87 for *T. natans* at D_3 and 71.78 at depth D_1 for *N. peltatum* (Figure 8-10).

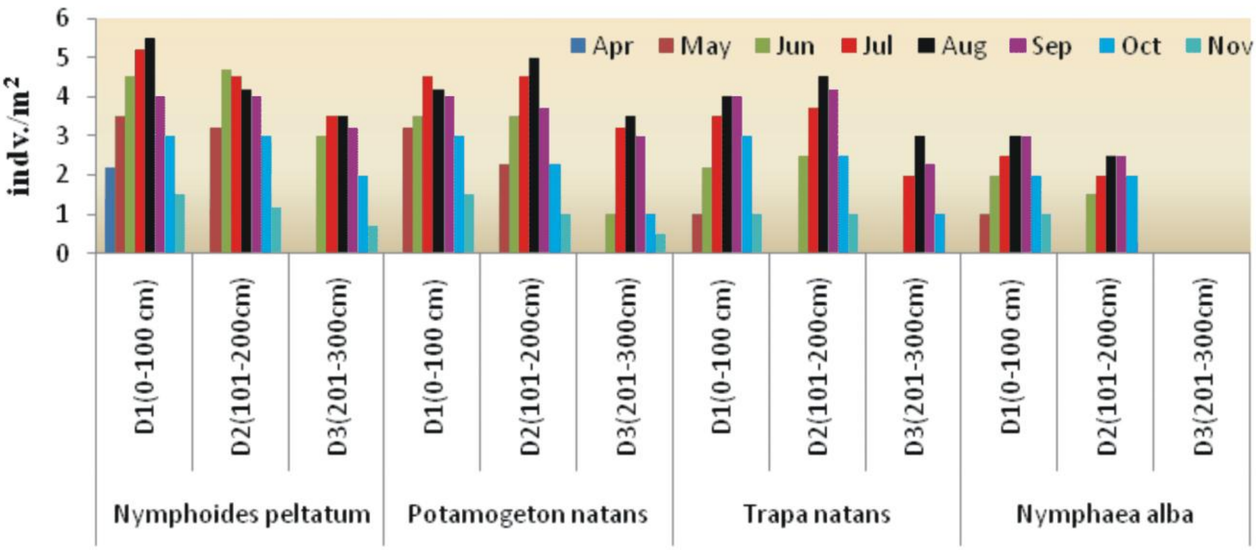

Figure 8: Monthly variation in density (indv./m^2) of macrophyte species in Anchar lake at Site A3

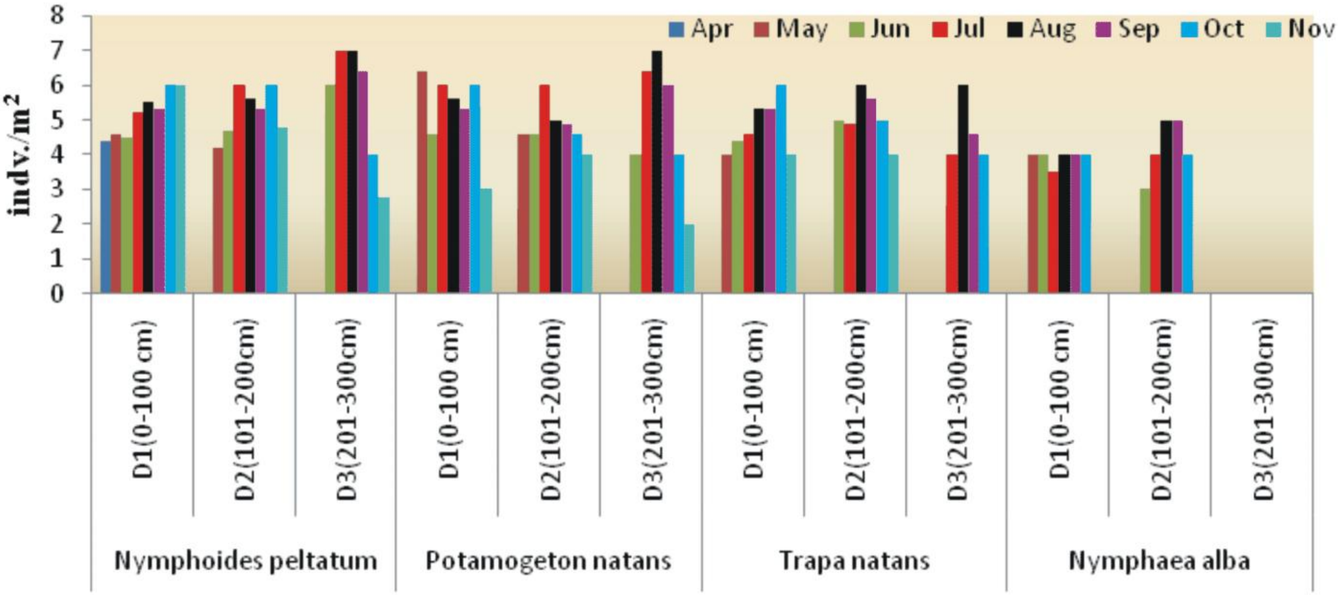

Figure 9: Monthly variation in abundance (indv./m^2) of macrophyte species in Anchar lake at Site A3

Site A4 in the lake recorded six plant species. The most dominant among which in terms of density were *N. peltatum, P. natans* and *N. alba* with mean density values of 3.7, 2.7 and 2.05 at D_1 depth range respectively. The mean abundance at the site fluctuated from a value of 1.3 for *N. alba* at D_3 and 5.28 for *N. peltatum* at D_1depth. The highest mean frequency values of 68.75, 50 and 46 were observed for *N. peltatum*, *P. natans* and *N. alba* each at D_1 depth respectively, while as lowest figure (15.6) for mean frequency was obtained for *N. alba* in D_3 depth zone (Figure 11-13).

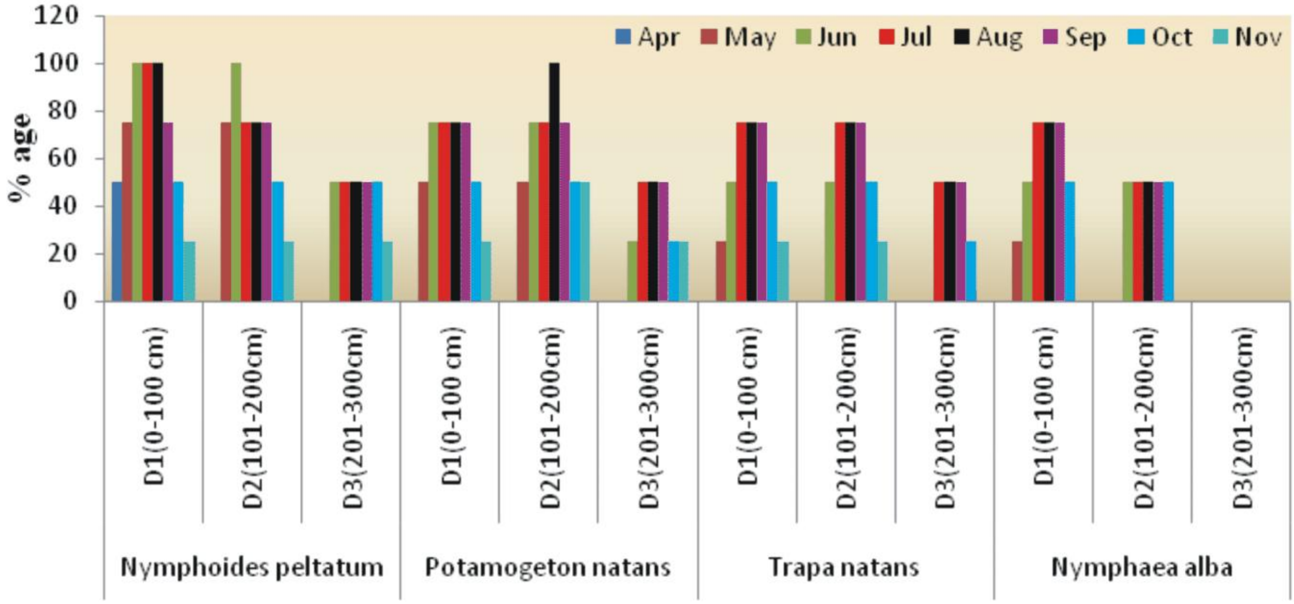

Figure 10: Monthly variation in frequency (%) of macrophyte species in Anchar lake at Site A3

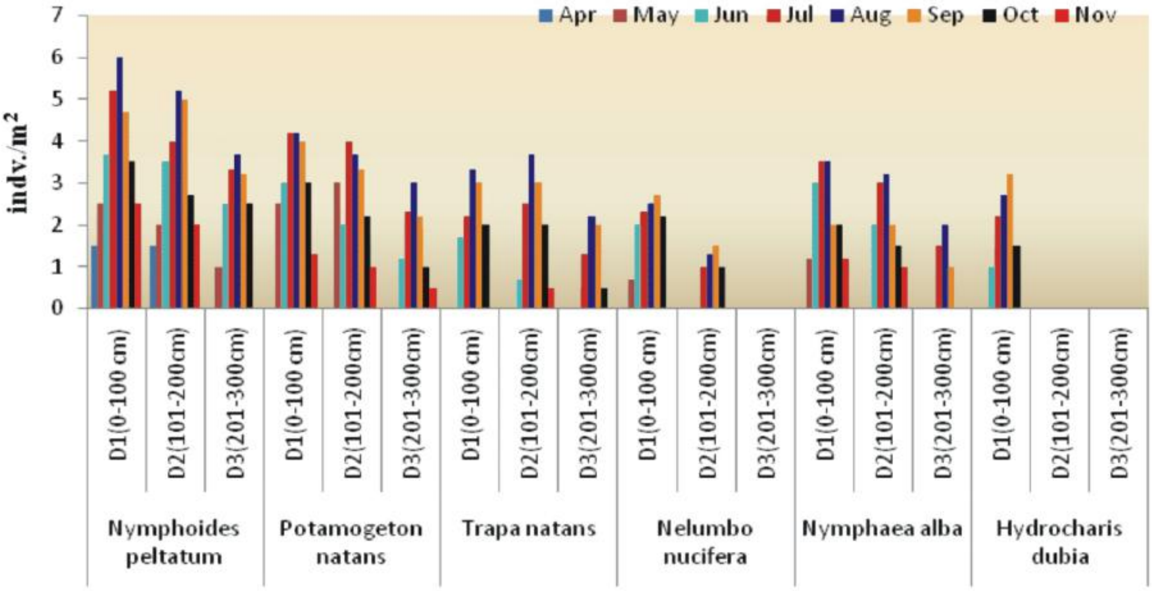

Figure 11: Monthly variation in density (indv./m^2) of macrophyte species in Anchar lake at Site A4

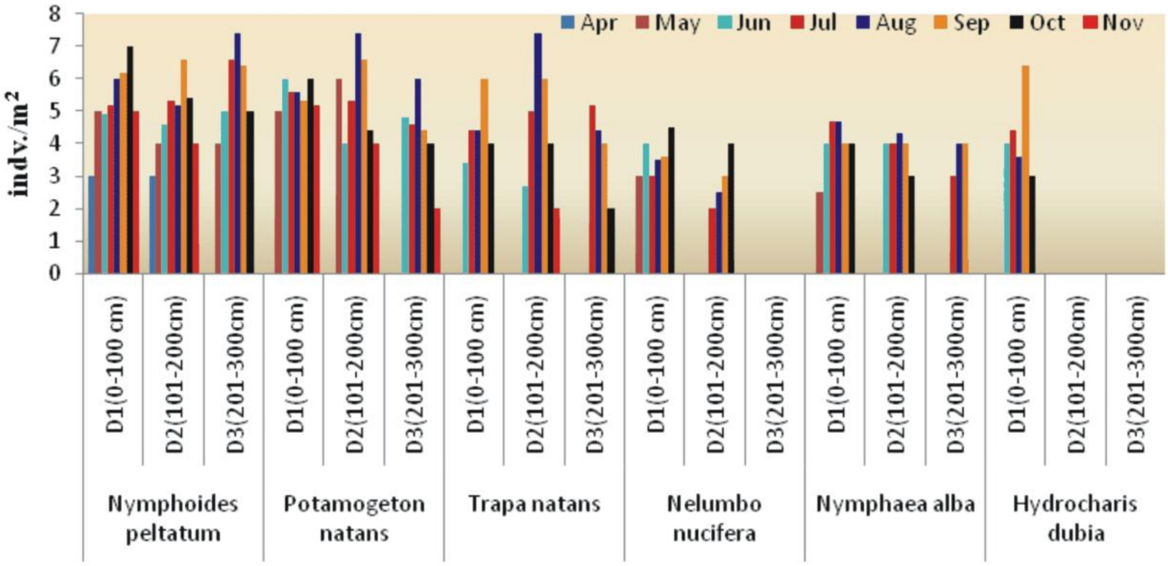

Figure 12: Monthly variation in abundance (indv./m^2) of macrophyte species in Anchar lake at Site A4

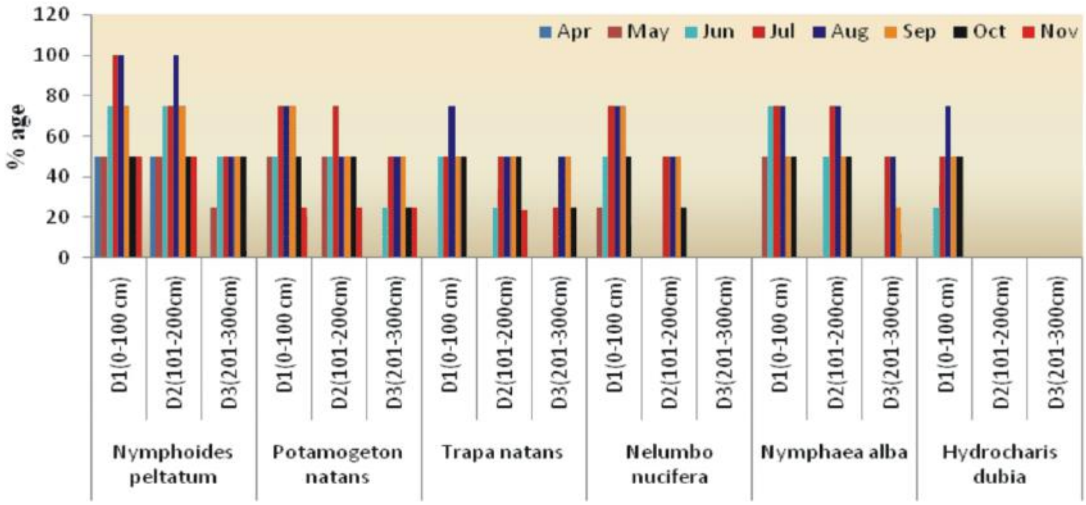

Figure 13: Monthly variation in frequency (%) of macrophyte species in Anchar lake at Site A4

DISCUSSION

The whole data reveals that the most important environmental factor for the vegetation differentiation is the water depth of the habitats. The attenuation of light causes the disappearance of these macrophyte species from deeper parts of the lake, which become abundant in the shallow parts and causes intense interspecific competition (Schmieder, 1996). According to Hrivnak (2009), species richness increases with decreasing water depth and it is due to the presence of true aquatic plants as well as marsh and wet meadow species in shallower waters, representing appropriate conditions for all species groups. This is possibly a reason for creating a mosaic vegetation appearance towards littorals (low depths) by the aquatic plants.

The selected species in the lake showed dominance in terms of density, abundance and frequency at D_1 (0-100 cm) and D_2 (101-200 cm) depth ranges. In fact, the plant species *Hydrocharis dubia,* was observed to be limited only within 0-100cm depths in the lake. The highest depth range (201-300cm) of the present hydro ecosystem was observed to have a scanty distribution of rooted floating macrophyte species and beyond this depth no such type of macrophyte was observed. The results of the present study are in consonance with the study of Spence (1982) and Keddy (2000). According to them, in lake gradients from shallow to deep water, emergents dominate in shallow water, floating-leaved aquatics dominate deeper water, and submerged aquatics are found in the deepest water. These patterns are hypothesized to represent either competitive exclusion at the shallower edge and physical constraints at the deeper edge of each zone (Keddy, 2000), or a trade-off between drought and flood tolerance (Luo *et al.,* 2008). Givnish (2002) has argued that the trade-offs that result in zonation involve differences in biomass investment in lamina support where emergents invest relatively more in petioles or stems that support laminae, while floating-leaved plants invest relatively less in petioles, which function as tethers rather than supported structures.

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CONCLUSIONS

The present study investigated the influence of water depth on community architectural features of rooted floating-leaf type vegetation in Anchar lake, Kashmir. The maximum density, frequency and abundance of selected plant species were observed in the depth range of 0-200 cm. Beyond this depth the growth of the species got severely retarded and above 300cm of water level the selected plant species were almost absent in the lake ecosystem. However, the plants in response to lower water depths were enable to obtain more light for photosynthesis and restore gas exchange quickly, resulting their highest presence. Thus, the data procured during the present study clearly indicates that an increase in water level affects the plant species in their distribution and could be used as a potential management strategy for controlling the studied species.

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