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Study on Phytosociology and Biomass changes (above-ground and below-ground) of Emergent macrophytes in Hokersar wetland of Kashmir Himalaya.

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Abstract: *Wetlands are highly productive ecosystems as they represent the transition zone between terrestrial and aquatic ecosystems. They are lowlands which receive huge nutrient inputs from the catchment areas. The present study envisages the phytosociology and biomass changes of emergent macrophytes in the Hokersar wetland during the study period (Jan 2012-Dec 2012). The phytosociological studies showed that Phragmites australis Sparganium erectum, and Typha angustata were the most diverse emergent species growing in the wetland. The biomass of emergent macrophytes showed great fluctuation over different seasons and also great variation was seen in biomass allocation between above-ground and below-ground components of the emergents. The results of the present study show great implication for the Carbon Sequestration Potential of emergent macrophytes keeping in view their larger cover percentage and huge carbon fixation capacity.*
Keywords*: Hokersar wetland, phytosociology, biomass allocation, Carbon Sequestration Potential, cover percentage.*

I. Introduction

Macrophytes form a major part of highly productive wetland ecosystems. They comprise of vascular plants, bryophytes and macro-algae growing in wetlands. They are considered one of the productive communities on Earth (Ondiviela *et al.*, 2014) forming the base of herbivorous and detritivorous food chains. They are the primary producers in trophic food chains. Macrophytes take the nutrients from water and sediments and thus influence water and sediment qualities of the wetland ecosystem. Biogeochemical processes in the water column and sediments are to a large extent influenced by the presence/absence and type of macrophytes. The response of biotic components of an ecosystem to the abiotic factors is a matter of fluctuation (Harold, 1958). The magnitude of these responses is studied through the changes in the number of individuals per unit area. Therefore in this study an attempt is made to study the phytosociology and biomass changes in the macrophytes over the changing seasons in the wetland ecosystem.

II. Study Area

The Hokersar wetland also known as 'Queen of Wetlands' lies between 34°.6`N latitude and 74°.12`E longitude at an altitude of 1584m above mean sea level. It is situated in the District Budgam, 10 km west of Srinagar. The wetland has undergone different land use and land cover (LULC) changes over the years and the present boundary of the wetland is shown in Fig 1. The average rainfall during the study period (2012) was 51.76 which ranged between 0.65 (Dec) to 124.578 (Feb). The average maximum temperature ranged from 2.205 (Feb) to 25.705 (Jun) and the average minimum temperature ranged from -1.049 (Dec) to 15.203 (Aug). The wetland is abode to splendid diversity of resident and migratory avifauna. The water body is evolving into a eutrophic system and supports rich biodiversity, especially the macrophytic diversity. The wetland has a great socio-economic importance as livelihood of various families in the catchment hamlets are directly and indirectly linked with the system.

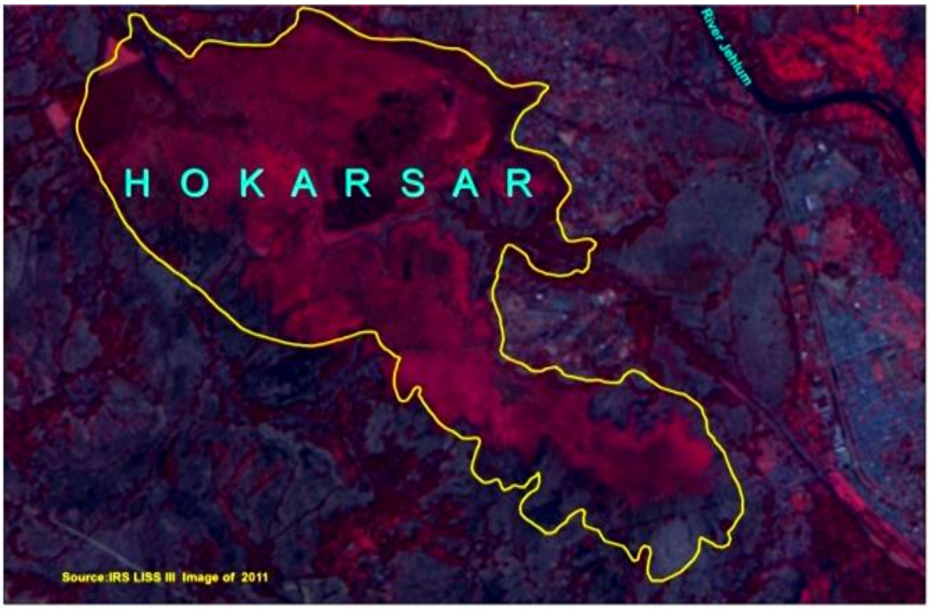

Fig 1: Current boundary of the Hokersar wetland (2011).

III. Material and Methods

The field studies were carried 3-6 times per season. The wetland was broadly divided into three different sampling sites depending on the water depth and the vegetation type viz; deep water site, shallow water site and open water site. From each study site about 10-15 composite samples of macrophytes were collected. Phytosociological studies on macrophytes and the spatial spread of the species were undertaken. The frequency percentage, abundance and cover percentage (Curtis and Mc Intosh, 1950; Misra, 1968) were measured across sites using standard quadrat sizes of 0.25 m^2, 0.5 m^2 and 1 m^2 for free floating, submerged and emergent macrophytes, respectively.

Biomass was estimated by Harvest method. The macrophytes falling in randomly laid quadrats were brought to the laboratory in poly bags, washed and air-drained to remove the excess of water adhered to them. The dry weight was determined by drying the plants to a constant weight in an oven. Biomass samples (both above ground and below ground components) were dried to a constant weight for 24 hours and measured as a dry weight (DW). The dry weight was thus established by drying the samples between 60 and 80°C in an oven until a constant weight is achieved (Allen, 1989).

IV. Results

During the present study a total of 57 species belonging to 48 genera and 32 families were collected (Table 1) from the wetland. The phytosociological studies of the macrophytes were carried out during the study period. The results showed that during the study period, the highest values of diversity among the emergents were shown by *Phragmites australis* and lowest by *Alisma plantago-aquatica*. Similarly among rooted floating leaf types, the highest value was shown by *Trapa natans* and lowest by *Marsilia quadrifolia*. Among free floating types *Lemna minor* was most diverse species and *Wolffia arrhiza* was least diverse species in the wetland. Among submergeds *Myriophyllum spicatum* showed maximum diversity values while minimum values were shown by *Utricularia aurea*. Of these macrophytic species, 36 were emergents, 6 each were rooted floating leaf type and free floating leaf type and 9 were submersed ones (Table 1). Hence, majority of the wetland species belonged to emergent category followed by submersed ones. The macrophytes were also classified into different groups on the basis of their invasion status which include Casual aliens (Cs), Casual or naturalized aliens (Cn), Naturalized aliens (Nt) and Invasive aliens (In). Only few species were natives. The dry matter accumulation/m^2 also varied significantly among the different individual macrophytic species of the wetland depending upon their size and spread, with a maximum accumulation of 4398.22 g/m^2shown by macrophytes during summer and a minimum of 1224.41g/m^2 during winter season when the senescence of almost all the above ground parts took place (Table 1). Amongst the emergent macrophytes, three contributed to the maximum dry matter accumulation in all the four seasons viz; *Phragmites australis, Sparganium erectum* and *Typha angustata*. The maximum dry matter of 1954.44 g/m^2 was accumulated by the macrophytes of the wetland during the month of September and the minimum (357.65g/m^2) during the month of Feburary (Fig 1).

Table 1: Species composition, life-form, invasion status and seasonal dry matter (g /m^2) accumulation by the macrophytes of Hokersar wetland.

Name of Species	Life-form	Invasion Status	Dry-matter/m^2 on seasonal basis			
			Spring	Summer	Autumn	Winter
Alisma plantago-aquatica	E	In	2.72	7.99	6.50	N.A
Altarnanthera sessilis	E	Nt	17.53	15.05	N.A	N.A
Azolla cristata	FF	In	N.A	N.A	N.A	N.A
Berula erecta	E	Nt	3.60	13.66	13.24	N.A
Bidens tripartita	E	Cn	2.04	11.29	19.85	N.A
Carex diluta	E	In	0.08	0.15	0.11	N.A
Ceratophyllum demersum	S	In	0.13	N.A	N.A	N.A
Cyperus difformis	E	In	1.15	1.74	1.18	N.A
Cyperus rotundus	E	In	1.09	1.92	1.41	N.A
Daucus carota	E	In	N.A	1.04	1.76	N.A
Echinochloa crus-galli	E	Nt	0.56	2.18	1.62	N.A
Eleocharis palustris	E	Nt	1.18	2.47	1.54	N.A
Epilobium hirsutum	E	In	7.80	110.45	246.16	N.A
Fimbristylis dichotoma	E	Nt	0.56	11.53	11.60	N.A
Gallium aparine	E	Cn	0.89	5.54	5.50	N.A
Hippuris vulgaris	E	In	9.52	18.56	10.53	N.A
Hydrocharis dubia	RF	In	3.43	54.12	40.77	N.A
Juncus articulatus	E	In	1.02	6.96	9.98	N.A
Lemna gibba	FF	In	N.A	N.A	N.A	N.A
Lemna minor	FF	In	N.A	N.A	N.A	N.A
Lemna trisulca	S	In	N.A	N.A	N.A	N.A
Lycopus europaeus	E	Nt	3.18	131.39	81.05	N.A
Marsilea quadrifolia	RF	In	N.A	N.A	N.A	N.A
Mentha arvensis	E	Nt	1.20	12.34	14.26	N.A
Menyanthes trifoliata	E	Cn	95.70	205.02	178.14	N.A
Myosotis sylvatica	E	Nt	4.39	7.68	7.60	N.A
Myriophyllum spicatum	S	In	76.76	166.40	102.76	69.55
Myriophyllum verticillatum	S	In	1.40	9.99	2.50	N.A
Nasturtium officinale	E	Nt	18.38	31.29	22.16	N.A
Nymphaea alba	RF	Nt	97.95	57.21	21.90	N.A
Nymphoides peltatum	RF	In	20.25	54.74	24.87	N.A
Paspalum paspalodes	E	Nt	2.63	30.89	15.70	N.A
Phalaris arundinacea	E	Nt	60.94	67.93	18.10	N.A
Phragmites australis	E	In	504.77	1278.08	961.54	619.79
Plantago major	E	In	2.50	11.12	N.A	N.A
Polygonum amphibium	RF	Nt	2.47	9.83	7.30	N.A
Polygonum hydropiper	E	In	2.26	11.32	3.74	N.A
Potamogeton crispus	S	In	0.67	N.A	N.A	N.A
Potamogeton lucens	S	Cn	N.A	N.A	N.A	N.A
Potamogeton pectinatus	S	In	N.A	N.A	N.A	N.A
Potentilla reptans	E	Nt	1.71	20.65	6.22	N.A
Ranunculus aquatilis	E	In	5.53	34.23	20.88	N.A
Ranunculus lingua	E	Nt	7.39	16.51	12.60	N.A
Ricciocarpus natans	FF	Nat	0.26	1.17	N.A	N.A
Roripa islandica	E	Nt	4.00	14.34	N.A	N.A
Rumex aquaticus	E	Nt	1.40	11.81	5.80	N.A
Saggitaria sagittifolia	E	In	4.21	27.68	19.68	N.A
Salvinia natans	FF	In	N.A	N.A	N.A	N.A
Scirpus triqueter	E	In	2.09	8.65	12.80	N.A
Sium latijugum	E	Nat	72.80	20.64	18.00	N.A
Sparganium erectum	E	In	512.87	852.78	1004.62	344.90
Trapa natans	RF	In	130	287.63	328.91	31.69
Typha angustata	E	In	407.41	561.62	601.75	158.48
Typha latifolia	E	Nt	105.20	177.25	64.60	N.A
Utricularia aurea	S	Nt	1.06	3.28	2.63	N.A
Veronica beccabunga	E	Nt	7.93	10.11	2.00	N.A
Wolffia arrhiza	FF	Nt	N.A	N.A	N.A	N.A
Total			2212.61	4398.22	3933.83	1224.41

Abbreviations
Life form: E = Emergent; RF= Rooted floating leaf type; FF= Free floating leaf type; S= Submerged.
Invasion status: Cn = Casual or naturalized aliens; Nt = Naturalized; In= Invasive aliens: Nat= Native.
N.A= Not found in the season.

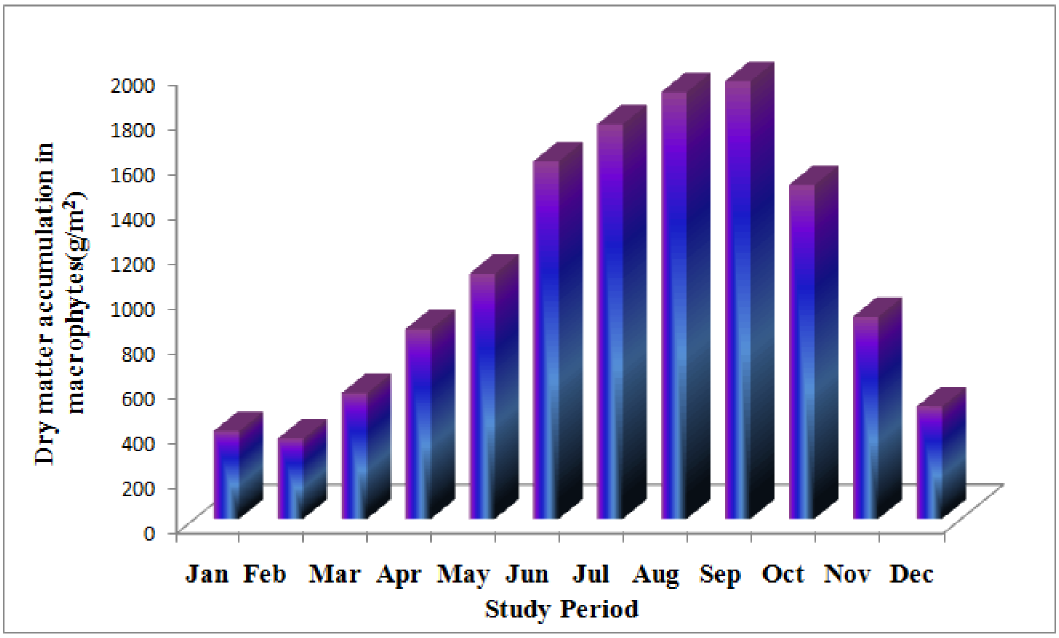

Fig 1: Dry matter (g/m^2) accumulation by the macrophytes during the study period.

V. Dry matter allocation

The dry matter accumulated by the macrophytes was partitioned between above and below-ground compartments. This partitioning, however, varied during different seasons of the year (Fig 2). The data revealed that maximum dry matter partitioning to the above-ground components of the macrophytes took place during summer season (2931.14 g/m^2) and the minimum during the winter season (213.91 g/m^2).On the other hand, maximum dry matter partitioning to the below-ground components of the macrophytes was observed during autumn season and the minimum during the winter season with a final figures of 1890.07 g/m^{2}and 1010.50 g/m^2, respectively.

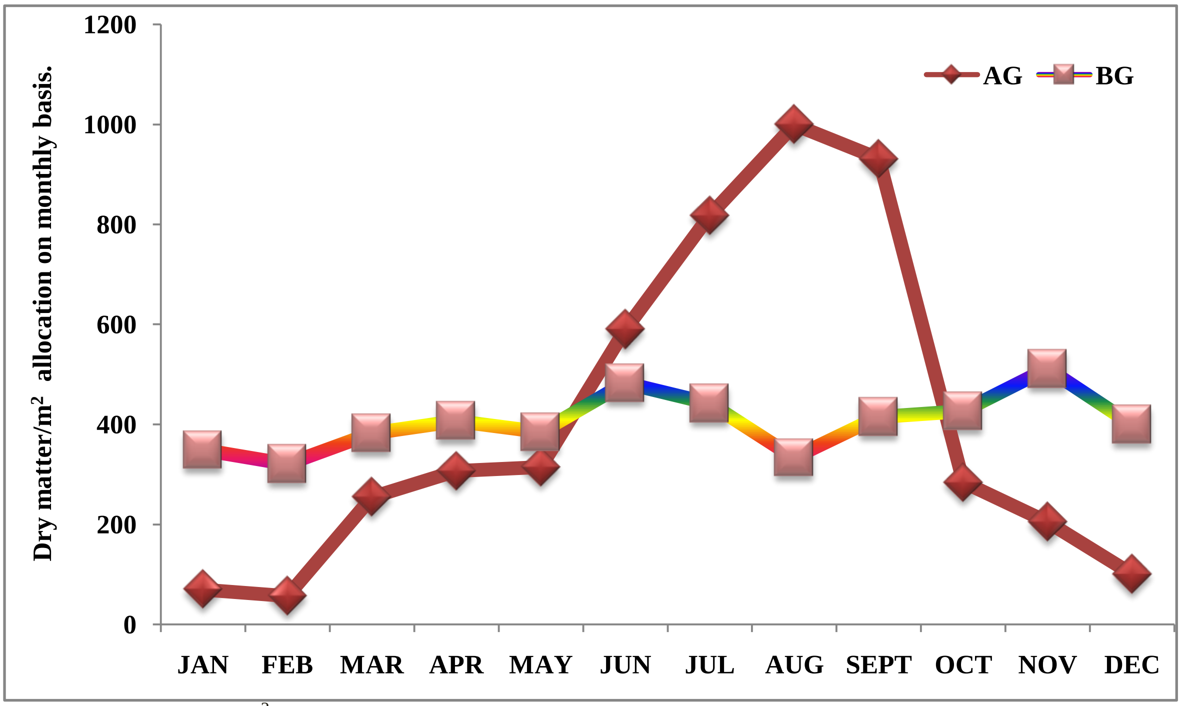

Fig 2: Dry matter (g/m^2) partitioning between above-ground (AG) and below-ground (BG) components of the Emergent macrophytes during the study period.

VI. Discussion

The macrophytic species composition of the wetland seems to have responded to the changing land-use patterns and different anthropogenic pressures. The emergent macrophytes such as *Sparganium erectum, Phragmites australis, Typha angustata* and *Menyanthes trifoliate* grow intensively in the littoral zone followed by the second concentric ring of rooted-floating leaf types with predominance of *Trapa natans, Nymphoides peltatum, Hydrocharis dubia* and *Polygonum amphibium*. Free-floating macrophytes with a significant coverage in the limnetic zone were mainly represented by *Salvinia natans, Ricciocarpus natans, Lemna minor* and *Azolla cristata*. The dominant submerged macrophytes growing profusely in the limnetic zone included *Ceratophyllum demersum, Myriophyllum spicatum* and *Potamogeton pectinatus*. Though the number of species seemed to have increased from 47 (Khan *et al*., 2004) to 76 (Kumar, 2008), most of the new species are aliens rather than natives (Shah and Reshi, 2014). The decrease in the species richness during the present study can be attributed to the increased invasion of the wetland by alien species (Odum, *et al.*, 1984; Chambers, *et al.*, 1999; Mayerson, *et al.*, 2000). It is pertinent to mention that changing species composition and abundance pattern of macrophytes has direct implications for wetland productivity. A noteworthy fact is that some of the species reported earlier in the wetland including *Eurale ferox*, *Nelumbio nucifera, Barbarea vulgaris, Nymphaea stellata* have almost completely disappeared. On the other hand, a number of new species such as *Menynanthes trifoliate* (Kaul and Zutshi, 1967), *Ricciocarpus natans, Bidens cernua, Hydrocharis dubia, Lemna trisulca, Wolffia arrhiza* and *Azolla cristata* have colonized the wetland. There has been a change in the biomass of aquatic plants and later their species composition owing to the nutrient enrichment of waters (Pandit, 2010).

One must not ignore the fact that the macrophytic biomass is generally more partitioned to the below-ground component than to the above-ground one. Besides, the dry matter partitioning varies among different macrophytes in different seasons of the year also (Fig 2). The Hokersar wetland, however, had an approximate total biomass of about 47.8% contained below the surface and 52.19% contained in the above-surface components. The ratio of the above to below surface productivity of the macrophytes (emergents) was calculated as 1.09. The results clearly show that major portion of the organic matter in the form of below-ground biomass is under the wetland soils which signify that macrophytes act as a huge carbon sink and their capacity of long-term carbon storage depends on the anoxic condition prevailing in the wetland soils.

VII. Conclusion

Hokersar wetland being rich in macrophytes is highly productive but contrary to this the number of invasive species is more compared to the native ones which is detrimental to the overall wetland ecology. Measures are to be taken to maintain the trophic status of the wetland to prevent its conversion into a terrestrial ecosystem as the depth of the wetland is decreasing continuously. If not managed properly we are in the risk of losing a highly productive wetland with a large carbon sequestration potential.

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