

Full Length Research Paper

Spatio-temporal dynamics of macrophytes in relation to ecology of a Kashmir Himalayan Wetland

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The present study gives an account of spatio-temporal changes in diversity and distribution of the macrophytic community structure in the Shalbug wetland of Kashmir Himalaya, India during about last three decades (1978-2006). Perusal of the data on changing water chemistry revealed not only a shift in the cationic spectrum but also a significant increase in Total as well as Ortho-P, and Nitrate, Nitrite as well as Ammonical forms of Nitrogen during last three decades. The concentration (mg l^{-1}) of Ca, Mg, Na and K has respectively changed from an average of 24.2, 4.4, 1.9 and 0.9 in 1978 to 109, 41, 16 and 5 in 2006. Moreover, while the average Total P has increased from 227 $\mu\text{g/l}$ in 1978 to 250 $\mu\text{g/l}$ in 2006, the Ortho-P during the same period increased from 32.2 $\mu\text{g/l}$ to 43 $\mu\text{g/l}$. The Nitrate, Nitrite and Ammonical forms of Nitrogen have increased respectively from 128, 6.7 and 6.1 $\mu\text{g/l}$ in 1978 to 374, 16 and 219 $\mu\text{g/l}$ in 2006. In comparison to 20 macrophytic species reported from the wetland in 1978, 27 species were recorded during the present study. The macrophytic communities, dominated by *Typha angustata*, *Phragmites australis*, *Sparganium erectum*, *Trapa natans*, and *Potamogeton natans*, showed a characteristic spatio-temporal distribution pattern from littoral to open waters with maximum number of species in summer than winter. Data on the physico-chemical parameters of water and bottom sediments indicated that the occurrence of macrophytes was greatly influenced by type of bottom substrate, water depth and temperature. Since plant diversity may affect wetland ecosystem processes, the study calls to ensure the conservation and management of the system, which would help maintain both higher diversity and enhance ecosystem functioning.

Key words: Kashmir Himalaya, Macrophytes, Shalbug wetland, Water chemistry, spatio-temporal, substrate.

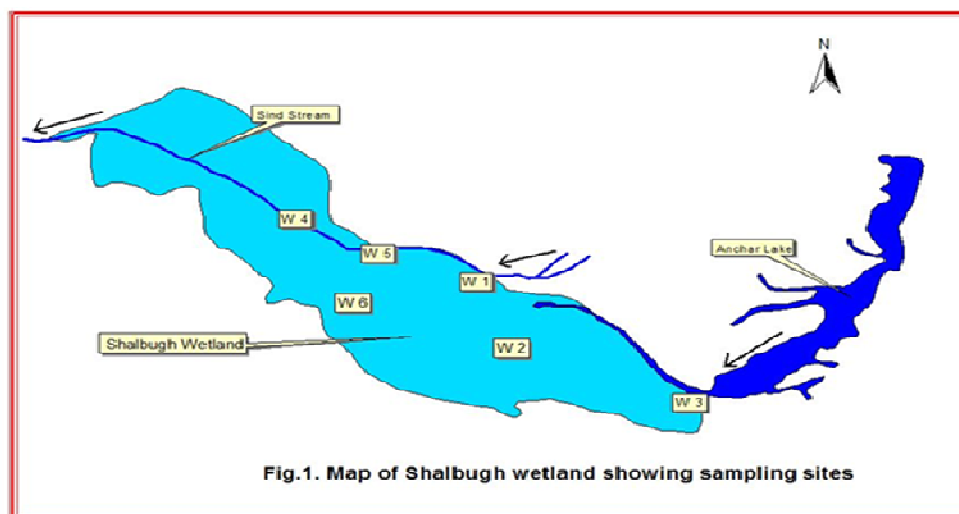
INTRODUCTION

Macrophytes comprise an important component of aquatic biota, especially in nutrient rich wetland ecosystem (Seabloom 2003), contributing significantly towards primary production and influencing various hydro-chemical processes. In addition, macrophytes also serve as a complex habitats which offer support, protection and food to aquatic fauna. (Raspapov et al 2002; Tessier et al, 2004). Aquatic macrophytes are highly important to invertebrates as substrates for periphyton and epiphytic food, refuges from predation, heterogeneous substrates for co-existence, and upon senescence and death as detrital food sources. Besides,

the presence of submerged macrophytes, serves as an important constituent of food for fish community (Yousuf and Firdous, 2001; Crowder et al 1982), for avifauna (Pandit 1982). The pattern of aquatic plant species diversity and distribution has been related to water chemistry by a number of previous studies as well (Spence 1967; Seddon 1972; Kadono 1982; Heegaard et al 2001). Moreover, distribution of species in a plant community in a habitat is also determined by changes in water level and depth (Hudon et al 2004), substrate composition and interactions with other plant or animal communities (Leslie et al. 1983).

Some information has been generated over the years on ecology, species composition and production of macrophytes in various waterbodies of the Kashmir valley (Rather et al., 2007; Wani et al., 2007; Mahdi et al.,

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2007). However, with regard to Shalbug wetland just a few studies have been undertaken (Handoo, 1978; Dar and Dar, 2009). In view of the growing anthropogenic pressures, the wetland has evolved from oligotrophic to an almost eutrophic system. With reference to the previous studies by Hundoo (1978), the objective of the present study was to assess the changes in the macrophytic species composition in relation to water chemistry of the wetland over last about three decades.

MATERIAL AND METHODS

Study area and sampling sites

Shalbug wetland (Figure 1), situated in the deltaic region of the Sindh Nallah, about 18 km from Srinagar to the west of the Anchar Lake is an important aquatic ecosystem of Kashmir Himalaya. It harbours rich diversity of resident and migratory avifaunal species as well as macrophytes of high socio-economic importance. The water body is under myriad anthropogenic perturbations that threaten its survival and the problem is exacerbated by heavy silt load brought into it through various feeding channels from the Sindh Nallah. Six sampling sites were selected in the wetland. Site W1 was chosen from the Shalbug Nallah, Site W2 from the open water area of the wetland having rich population density of submerged macrophytes, Site W3 near the inlet from the Anchar Lake, Site W4 was located in rooted floating leaf type vegetation zone, Site W5 was located at the outlet connected with the Sindh stream and Site W6 was located in emergent vegetation zone.

Macrophytic studies

The macrophytic composition of the wetland in 1978 was sampled by Hundoo (1978) taking into consideration a number of factors. Macrophytes were sampled using a quadrat size of

25 X 25 cm² in case of the low growing emergent and ground layer species and 1 X 1 m² in case of the tall growing emergent species. However, the rooted-floating leaf types and submerged macrophytic species were collected using Ekman dredge (Welch, 1948). The same protocol was followed for sampling the macrophytes during the present study. The species composition at present in the wetland was worked out during March 2005 to February 2006. Every month 10 quadrats of 25 × 25 cm were laid randomly in each of the well differentiated vegetational zones of the wetland. The macrophytes occurring in each quadrat were collected and identified to determine their species wise list. The individuals of each species were counted to work out their abundance.

Water Analysis

The sampling was carried out on monthly basis for a period of one year (Dec 2004- Nov 2005). Water samples were analyzed in accordance with APHA (1998), Mackereth (1973) and Council of Scientific and Industrial Research (CSIR) (1974).

RESULTS AND DISCUSSION

Perusal of the data on changing water chemistry in the Shalbug wetland revealed a significant increase in the parameters such as Ca, Mg, Na, K, Total as well as Ortho-P, and Nitrite as well as Nitrate Nitrogen. The cationic spectrum of Ca, Mg, Na and K has respectively changed from an average concentration (mg l⁻¹) of 24.2, 4.4, 1.9 and 0.9 in 1978 to 109, 41, 16 and 5 mg l⁻¹ in 2006. Moreover, while the average Total P has increased from 227 µg/l in 1978 to 250 µg/l in 2006, the Ortho-P during the same period increased from 32.2 µg/l to 43 µg/l. The Nitrate, Nitrite and Ammonical forms of Nitrogen have increased respectively from 128, 6.7 and 6.1 µg/l in 1978 to 374, 16 and 219 µg/l in 2006.

Table 1. Changing physico-chemical characteristics of water in the Shalbug wetland from 1978 to 2006.

PARAMETER	Handoo (1978)		Present study	
	RANGE	AVERAGE	RANGE	AVERAGE
Depth (cm)	* 12.0-24.0	59	30.0-90.0	60
Water temperature (°C)	24.0	*	5.0-27	16
Conductivity (µS)	229-374	294	322-485	397
pH	7.3-8.5	7.8	7.0-9.0	8
DO (mg/l)	2.7-9.5	6.6	3.0-12.0	7
Total alkalinity(mg/l)	76-137	104	111-303	203
Ca (mg/l)	20.6-29.3	24.2	95-140	109
Mg(mg/l)	3.0-7.3	4.4	32-103	41
Na (mg/l)	0.8-3.6	1.9	8.0-25.0	16
K (mg/l)	0.3-3.0	0.9	2.0-7.0	5
Total phosphorus (µg/l)	211-270	227	121-374	250
Orthophosphorus(µg/l)	16-66	32.2	25-83	43
Nitrate(µg/l)	78-222	128	198-635	374
Nitrite (µg/l)	2.0-11.0	6.7	3.0-29.0	16
Ammonia (µg/l)	3.0-11.0	6.1	133-325	219
Silicate mg/l)	3.0-7.3	4.9	2.0-5.0	4

(*) not available

The changing water chemistry of the wetland over the years (Table 1) has brought a shift in macrophytic species composition and distribution pattern (Table 2). The submerged macrophytic species not reported from the wetland during early 1970s but are quite frequently found at present include *Hydrilla verticillata*, *Potamogeton crispus*, *P. pucilus* and *Utricularia flexouosa*. Amongst the free-floating types, while *Salvinia natans* has been persisting in wetland during last three decades, *Azolla* and *Lemna* species have currently taken over most of the wetland open waters and side channels. The rooted floating leaf-type macrophyte were almost common now and then except for *Hydrocharis dubia* which occurs presently. There were only 8 species of emergent macrophytes reported from the wetland in 1978, we found 11 species growing there at present of which 6 species are different from the previous ones. The occurrence of aquatic plant species in aquatic ecosystems has been related to water chemistry by a number of previous studies as well (Spence 1967; Seddon 1972; Kadono, 1982; Heegaard *et al* 2001). The distribution of a plant community in a habitat is also determined by changes in water level and depth (Hudon *et al* 2004), substrate composition and interactions with other plant or animal communities (Leslie *et al.* 1983).

During 2006 twenty seven species of macrophytes were recorded in the wetland (Table1) out of which 11 species were emergents, followed by submerged types with eight species, rooted floating types with five species and three species were free floating types. Spatial

differences were observed in the quality and quantity of macrophytes. Emergent macrophytes *Typha angustata*, *Phragmites australis*, *Sparganium erectum* were the dominant ones and were widely distributed over the entire littoral zone of the wetland. *Myriophyllum verticillatum*, *Ranunculus lingua*, *Butomus umbellatus*, *Scirpus lacustris* were also scattered all over the emergent zone. The dense population of emergent vegetation in the littoral zone seems to be mainly due to the shallowing of the wetland by siltation carried by the Sindh Nallah and from the catchment area. Zutshi and Vass (1982) have estimated 0.5m as the maximum depth of colonization by emergent forms; floating leaf forms are reported to be distributed over depth ranges between 0.25-1.97m, while maximum amplitude of 0.4-3.0m is recorded for the submerged communities. In the present study the maximum depth in the emergent vegetation zone was 0.4m and minimum was 0.1 m. In the rooted floating vegetation zone the dominant forms of macrophytes were *Trapa natans*, *Potamogeton natans*, *Hydrocharis* sp. At some places of this zone monospecific colonies of *Trapa* sp and *Salvinia* sp. were also recorded. This is somewhat deeper water area with depth fluctuating from 0.1-0.6 m. In the submerged vegetation zone the dominant macrophytes were *Ceratophyllum demersum* followed by *Myriophyllum spicatum* and *P. crispus* in order of their decreasing dominance. Only a small portion of open water area of the wetland was characterized by dense population of submerged macrophytes. The depth here ranged

Table 2. Change of macrophytic species in the Shalabugh wetland from 1978-2006.

Species present in 1978	Species present in 2006
Submerged type <i>Ceratophyllum demersum</i> <i>Myriophyllum spicatum</i> <i>Potamogeton lucens</i> <i>P. pectinatus</i> <i>Ranunculus aquatilis</i>	Submerged <i>Ceratophyllum demersum</i> <i>Hydrilla verticillata</i> <i>Myriophyllum spicatum</i> <i>Potamogeton crispus</i> <i>P. pucilus</i> <i>P. lucens</i> <i>Ranunculus aquatilis</i> <i>Utricularia flexouosa</i>
Free floating type <i>Salvinia natans</i>	Free floating type <i>Azolla</i> sp <i>Salvinia natans</i> <i>Lemna</i> sp
Floating leaf type <i>Nymphoides paltatum</i> <i>Nymphaea stellata</i> <i>N.alba</i> <i>Trapa natans</i> <i>Potamogeton natans</i>	Rooted floating leaf type <i>Nymphoides peltatum</i> <i>Nymphaea alba</i> <i>Hydrocharis dubia</i> <i>Trapa natans</i> <i>Potomage-ton natans</i>
Emergents <i>Typha angustata</i> <i>Phalaris arundinacea</i> <i>Phragmites communis</i> <i>Scirpus lacustris</i> <i>Sparganum erectum</i> <i>Sagittaria sagittifolia</i> <i>Ranunculus lingua</i> <i>Polygonum amphibium</i>	Emergents <i>Phragmites australis</i> <i>Polygonum amphibium</i> <i>Myriophyllum verticillatum</i> <i>Sparganium ramosum</i> <i>Typha angustata</i> <i>Sagittaria sagittifolia</i> <i>Carex</i> sp <i>Sparganium erectum</i> <i>Scirpus lacustris</i> <i>Ranunculus lingua</i> <i>Butomus umbellatus</i>

between 0.5m to 1.1m. In addition to all this thick patches of *Lemna* sp, *Azolla* sp and *Salvinia* sp. were found sporadically in patches and dispersing from place to place by water currents, wind and by boating.

To conclude, significant changes in the water quality of the Shalbug wetland have induced evident shift in macrophytic community structure and species composition of the wetland. The changes in water chemistry *per se* reflect growing anthropogenic pressures and changing land-use practices in the catchment of the

wetland. The study calls for urgent ecological restoration, conservation and management of the wetland.

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