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Full Length Research Paper

The ecology of macrozoobenthos in Shallabugh wetland of Kashmir Himalaya, India

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Macrozoobenthos comprise of an important group of aquafauna by way of their contribution to ecosystem stability, besides acting as potential bioindicators of trophic status. Being efficient energy converters, they constitute an important link in the aquatic food web. In view of importance of such an aquatic bioresource, on one hand, and scarcity of information about them, on the other, the present study aimed at working out the species composition, distribution pattern and abundance of macrozoobenthos in relation to several physico-chemical parameters of the Shallabugh wetland of Kashmir Himalaya. The data collected on various physico-chemical parameters showed wide seasonal and site-specific fluctuations. Dissolved oxygen concentration fluctuated between 3 - 12 mg/l, while as free CO_2 ranged from 1 - 19 mg/l showing also high values of bicarbonates of Ca and Mg, nitrogen and total phosphorus. The pH of the wetland remained mostly alkaline but at the emergent macrophytic site it showed a slight acidic trend (6.6) in during late summer. Benthos of the Shallabugh wetland was represented by Arthopoda, Annelida and Mollusca, and was studied in relation to abiotic and biotic factors for one year. Perusal of the results revealed that Arthropoda, Annelida and Mollusca were represented by 10, 7 and 6 species respectively. The abundance of some specific pollution indicator species, especially Annelids such as *Limnodrilus* sp, *Tubifex tubifex* and *Branchiura sowerbyii,* is depictive of transition in trophic status of the wetland from meso- to eutrophy. In view of the eutrophication-induced changing biotic community structure, the present study calls for urgent management and restoration of the Shallabugh wetland ecosystem.

Key words: Shallabugh wetland, organic matter, eutrophication, macrozoobenthos.

INTRODUCTION

The macroinvertebrates of freshwater wetlands provide significant support to the aquatic food web and contribute to ecosystem stability through sustenance of cultivatable fish, aquatic birds and other wild life. Their composition, abundance and distribution pattern acts as an ecosystem index, thereby indicating trophic structure, water quality and eutrophication level of the ecosystem (Mehdi et al., 2005). Now-a-days wetlands and other deep water habitats is globally a subject of great ecological interest due to their socio-economic values and ecosystem services which has necessitated the need for reliable broad based information on their ecological status. The ecological functioning of these ecosystems has been greatly affected by the growing anthropogenic activities. The Kashmir Himalayan valley, sustaining myriad of wetlands such as Hygam, Hokersar, Shallabugh, Malgam, Mirgund etc, has been witnessing rapid eco-degradation, especially since last few decades. Shallabugh wetland, a typical Kashmir Himalayan water body is fed by the Sindh Nalla to the west of the Anchar Lake. The wetland is of great socio-economic importance in view of its being a rich repository of avifaunal, macrophytic and zoobenthic diversity. During the past few years the area of the wetland has considerably decreased due to various human interferences.

Notwithstanding its importance, the wetland has not

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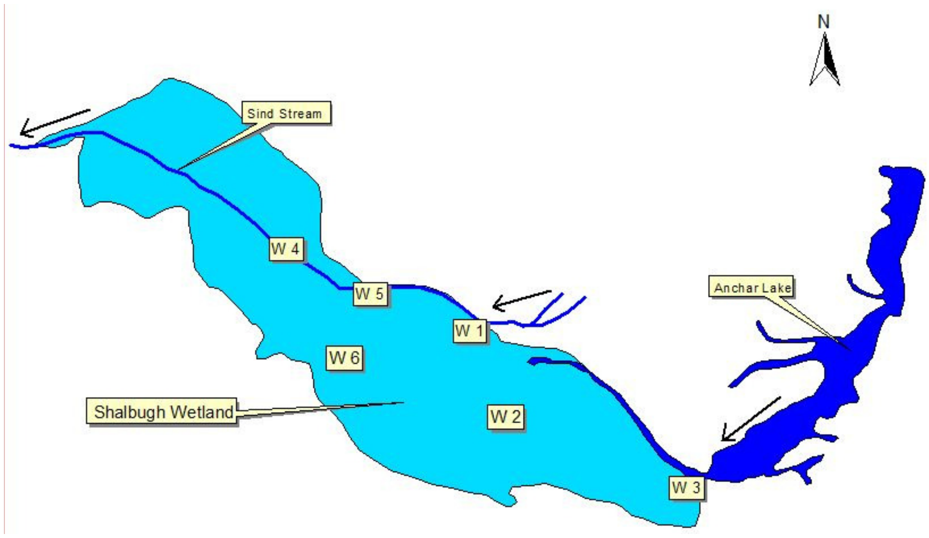

Figure 1. Map of Shallbugh wetland showing sampling sites.

received hitherto much attention from limnologists except some sporadic studies (Handoo, 1978; Balkhi and Yousuf, 1992; Siraj et al., 2007). Thus there is considerable dearth of information available on various aspects especially the benthic community structure of this wetland. In view of its changing characteristics, the present study was carried out to assess the effect of physico-chemical parameters on the diversity and distributional pattern of macrozoobenthos.

MATERIALS AND METHODS

Study area and sampling sites

Shallabugh 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 Shallabugh 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 which occasionally dries up during autumn.

Water analysis for zoobenthos

The sampling was carried out on monthly basis for a period of one year (December, 2004 - November, 2005). Water samples were analysed in accordance with Eaton et al. (1995), Mackereth (1973) and CSIR (1974). For collection of macrozoobenthos the mud samples were collected by Ekman's dredge (size 15 cm^2) soon after lifting the grab the samples were immediately transferred to an enamel basin and then passed through a series of sieves with addition of water on the spot. The animals were hand picked with the help of forceps and preserved in 70% alcohol for detailed analysis subsequently. The population density was expressed as individuals per square meter. Different taxa were identified with the help of keys given by Ward and Wipple (1959), Edmondson (1959), Pennak (1978) and Tonapi (1980).

RESULTS AND DISCUSSION

Physico-chemical characteristics of water

Average seasonal data of the physico-chemical characteristics of water recorded at the six sampling sites in the wetland are presented in Table 1. The water temperature during the study period fluctuated from 7 - 31°C showing a distinct seasonal trend of maximum values in summer and minimum in winter. Transparency and depth of the wetland was quite low throughout the lake while the temperature fluctuations are characteristics of temperate wetlands. Low transparency values can be attributed to the increase in suspended matter through silitation, dense plankton population and suspended algal population. During late summer at site W6 pH showed slight acidic value (6.6) which can be attributed to increased rate of decomposition of the organic matter with higher temperatures and also the conversion of released CO_2 into carbonic acid .However, the highest pH value (8.2) recorded at W2 and W4 reflects alkaline nature of waters. The mean of total alkalinity values ranged from 128 mg/l at W3 to 302 mg/l at W1. Conductivity values fluctuated markedly from 300 - 438 µS/cm at W5 Dissolved oxygen (DO) content ranged from 3 - 12 mg/l indicating significant seasonal variability. Depletion in DO with the progression of summer is

Table 1. Variation in the range of physico-chemical characteristics of water at six sampling sites in the Shallabugh Wetland from December 2004 to November 2005.

Parameters		W1	W2	W3	W4	W5	W6
Air temperature (^0C)	Winter	7	7	10	8	8	10
	Spring	16	15	16	15	17	18
	Summer	30	31	31	30	30	31
	Autumn	22	22	22	22	22	22
Water temperature (^0C)	Winter	5	5	6	7	7	7
	Spring	13	12	12	12	10	12
	Summer	24	25	27	25	27	26
	Autumn	18	19	20	19	19	D
Depth (m)	Winter	0.8	0.5	0.3	0.3	0.3	0.1
	Spring	1.3	1.1	0.3	0.6	0.6	0.4
	Summer	1.4	1.1	0.4	0.5	0.6	0.3
	Autumn	1.1	0.6	0.3	0.3	0.4	D
Transparency (m)	Winter	0.4	0.4	0.3	0.1	0.3	0.1
	Spring	0.3	0.2	0.1	0.2	0.3	0.2
	Summer	0.4	0.1	0.1	0.1	0.2	0.1
	Autumn	0.4	0.3	0.1	0.1	0.3	D
pH	Winter	7.7	7.5	7.4	7.7	7.5	7.6
	Spring	7.8	7.9	8.0	8.0	7.8	7.5
	Summer	7.9	8.2	7.8	8.2	8.1	7.2
	Autumn	7.4	7.3	7.4	7.4	7.6	D
Total alkalinity (mg/l)	Winter	270	252	255	257	250	250
	Spring	159	125	144	130	135	143
	Summer	136	131	128	144	142	140
	Autumn	302	230	215	264	247	D
Conductivity (µS/cm)	Winter	390	392	370	412	400	423
	Spring	401	346	376	309	376	433
	Summer	338	371	346	313	300	393
	Autumn	329	417	430	431	438	D
Dissolved oxygen (mg/l)	Winter	12	9	9	9	8	8
	Spring	12	9	7	8	5	4
	Summer	4	4	4	3	3	3
	Autumn	7	6	7	7	6	D
Carbon dioxide (mg/l)	Winter	9	8	11	10	9	9
	Spring	5	4	4	3	4	6
	Summer	1	1	3	3	3	4
	Autumn	9	12	11	14	12	D
Total hardness (mg/l)	Winter	257	309	294	228	266	244
	Spring	266	302	281	243	281	281
	Summer	267	239	251	275	264	262
	Autumn	290	299	388	289	222	D
Ca (mg/l)	Winter	103	127	115	95	117	102
	Spring	106	121	123	102	119	107
	Summer	107	95	103	105	106	102
	Autumn	123	122	162	125	90	D

Table 1. Contd.

Magnesium (mg/l)	Winter	38	44	43	32	36	34
	Spring	39	44	38	34	39	42
	Summer	39	35	36	41	38	39
	Autumn	41	43	54	40	32	D
Sodium (mg/l)	Winter	12	15	15	14	17	18
	Spring	12	13	14	12	17	12
	Summer	12	9	9	13	9	11
	Autumn	14	24	21	13	23	D
Potassium (mg/l)	Winter	6	6	5	6	7	5
	Spring	6	5	6	5	3	5
	Summer	6	7	6	2	7	3
	Autumn	4	6	7	3	4	D
Bicarbonate (mg/l)	Winter	270	252	255	257	250	250
	Spring	157	123	142	129	134	142
	Summer	135	130	127	143	141	139
	Autumn	302	230	215	264	267	D
Carbonates(mg/l)	Winter	Ab	Ab	Ab	Ab	Ab	Ab
	Spring	2	2	2	1	1	1
	Summer	1	1	1	1	1	1
	Autumn	Ab	Ab	Ab	Ab	Ab	D
Chloride(mg/l)	Winter	30	30	36	33	29	28
	Spring	24	24	44	27	30	21
	Summer	27	31	33	26	18	16
	Autumn	32	45	44	37	33	D
Sulphate(mg/l)	Winter	12	13	12	12	12	11
	Spring	13	9	9	10	6	5
	Summer	12	6	6	Tr	Tr	Tr
	Autumn	11	10	11	11	10	D
Silicate(mg/l)	Winter	4	4	4	5	4	4
	Spring	4	2	2	3	3	3
	Summer	3	2	2	2	2	2
	Autumn	4	4	5	5	6	D
Nitrate(µg/l)	Winter	213	267	332	264	427	339
	Spring	284	333	256	293	394	466
	Summer	257	159	177	272	170	187
	Autumn	321	314	376	417	321	D
Ammonical nitrogen (µg/l)	Winter	286	288	323	287	278	299
	Spring	205	228	305	197	210	218
	Summer	174	181	274	111	179	201
	Autumn	277	275	354	330	265	D
Nitrite (µg/l)	Winter	25	26	27	25	27	24
	Spring	16	13	15	19	16	13
	Summer	7	11	5	5	5	6
	Autumn	15	20	26	22	16	D

Table 1. contd

Orthophosphorus (µg/l)	Winter	73	89	87	83	79	71
	Spring	56	58	53	57	56	47
	Summer	27	30	36	34	26	30
	Autumn	45	39	41	36	42	D
Total phosphorus (µg/l)	Winter	320	289	327	335	328	341
	Spring	206	199	229	234	204	153
	Summer	173	182	187	190	163	188
	Autumn	297	298	303	303	296	D
BOD (mg/l)	Winter	6	5	4	5	4	3
	Spring	8	12	13	14	11	17
	Summer	18	24	31	34	23	26
	Autumn	6	5	6	9	7	D
COD (mg/l)	Winter	23	29	31	27	29	35
	Spring	48	39	40	36	36	57
	Summer	51	61	45	56	56	79
	Autumn	41	43	33	40	40	D

Note; D = Dry period; Ab = absent; Tr = traces.

attributed to higher temperatures, though faster rate of organic matter decomposition also contributes to consumption of DO under warmer conditions (Goldman and Horne, 1983). Decomposition of organic matter substrate especially in summer contributes not only to higher value of free CO_2 but also to depletion in O_2 content subsequently leads to built up of free CO_2 by the process of an aerobic digestion of organic wastes. Free CO_2 ranged from 1 - 19 mg/l.

The cationic composition of the whole wetland waters was dominated by calcium (Ca^{++}) following the order $Ca^{++} > Mg^{++} > Na^{+} > K^{+}$. This indicates marl character of the wetland, typical of geologically distinct Kashmir Himalayan water bodies. The mean values of calcium content, however, varied from 90 mg/l at W5 to 162 mg/l at W3. Ca- hardness was nearly four times more as compared to that of Mg-hardness throughout the study period. Magnesium ranged from 32 mg/l at W4 to 54 mg/l at W3 and almost paralleled to Ca- hardness in its pattern and periodicity. The continuous increase in Ca-Mg hardness of the wetland towards spring and autumn may be attributed to the addition of Ca-Mg salts from the catchment areas and due to evaporation of the surface water and decomposition process (Khan et al. 2004). Overall total hardness varied from 228 mg/l at W4 to 388 mg/l at W3. Na^{+} ranged from 9 mg/l at various sites to 24 mg/l at W2 while K from 2 mg/l at W4 to 7 mg/l at various sites. The anionic spectrum $HCO_3^{-} > Cl^{-} >$ sulphate > silicate shows bicarbonate dominance. Bicarbonates ranged from 123 mg/l at W2 to 302 mg/l at W1. Chloride showed a range of 21 mg/l at W1 to 61 mg/l at W2. Carbonate ions fluctuated in the narrow range of undectable mg/l to 2 mg/l making their presence only during warmer months. Sulphate varied from traces at various sites to 13 mg/l at W1, W2 and W5. Silicate ranged from 2 - 6 mg/l. Over all the spectrum of ionic pattern is generally in agreement with observations in other Kashmir lakes and wetland (Khan et al., 2004).

Of the three forms of nitrogen - the seasonal values of nitrate ranged from 159 µg/l at W2 to 446 µg/l at W6; ammonia ranged from 111 µg/l at W4 to 354 µg/l at W3; nitrite ranging from traces at various sites to 27 µg/l at W5, all recording low values in wetland. This low value may be attributed to the role of rich population of macrophytes and also sediments which act as major sinks of nutrients. Increase in nitrate from mid spring to early summer can be attributed to the runoff from the Sindh Nallah. Chapman et al. (1981) proposed that surface run off from the catchment forms the major input of nutrients in water. The orthophosphorus concentration in the wetland water varied from 26 µg/l at W5 to 89 µg/l at W2 and Total Phosphorus also show considerable site - specific variation and the peak values were obtained during winter - autumn period (153 µg/l at W6 to 335 µg/l at W4) which is apparently related to the decomposition process. Levels of BOD and COD, important water pollution indicators, differed widely during the study period showing a range value of 3 mg/l at W6 to 34 mg/l at W4 and from 23 mg/l at W1 to 79 mg/l at W6 respectively. Over all lowest value of BOD and COD were recorded in winter and highest in summer which may be due to the attribution of organic pollution into the water

Table 2. Composition of macrozoobenthos recorded in the Shallabugh wetland during the study period.

ARTHOPODA	ANNELIDA	MOLLUSCA
Ephemeroptera	**Hirudinea**	**Gastropoda**
Caenis sp.	*Glossiphonia* sp.	*Lymnaea auricular*
Baetis sp.	*Erpobdella* sp.	*L. columella*
		L. stagnalis
Diptera	**Oligochaeta**	
Athrix sp.	*Tubifex tubifex*	**Pelecypoda**
Chironomus sp.	*Branchiura sowerbyi*	*Promentus* sp
Chaoborus sp.	*Limnodrilus* sp.	*Corbicula* sp.
	Aelosoma sp.	*Planorbula* sp.
Coleoptera	*Nais* sp.	
Hydrophilus sp.		
Hemiptera		
Gerris sp.		
Odonata		
Lestes sp.		
Amphipoda		
Gammarus pulex		
Arachnida		
Acari		

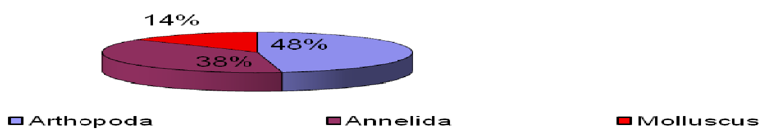

Figure 2. Population density of different groups of macrozoobenthos present in the Shallabugh wetland.

body. Considering the BOD profile of the wetland it is revealed that BOD level rises abruptly upto 34 mg/l during summer season which is indicative of an augmented organic load besides rapid growth of microorganisms at high temperature as also stated earlier by Joshi and Bisht (1993). In the spring season the BOD rises mildly due to heavy entry of water from the Sindh stream and from Anchar lake carrying organic wastes from the catchment area while its fall during a prolonged autumn–winter juncture, is indicative at low temperature.

Biological characteristics

The benthic organisms collected from the wetland ecosystem belonged to three major groups, Annelida (47%), Arthopoda (38%) and Mollusca (14%) each represented by 7, 10 and 6 taxa respectively (Table 2 and Figure 2). The macrozoobenthic communities of six study sites belonged to more or less similar taxonomic groups, although the number of individuals within each group varied considerably. The presence or absence of few organisms accounted for the differences in the total number of benthic organisms. The maximum number of taxa (21) was recorded at site W2 and minimum 12 at site W5. The mean population density ranged from 1 individual/l at site I to 128 individuals/l at site W2. Total density of macrozoobenthos showed significant spatial variation as depicted in Figure 3. Relatively high species density and species composition of macrozoobenthos at Site W2 seems to be correlated with macrophytic species richness because they spent much of their life cycle on host plants (Shah and Pandit, 2001). This particular site was rich in submerged macrophytes surrounded by some emergents. Tessier et al. (2004) reported that submerged macrophytes harboured greater number and greater taxonomic diversity of benthic species. Site W2 was followed by Site W5 (18%) in population density which seems to be related with the fluctuations in water level and changes in flow pattern by which the free floating species such as *Lemna* and *Salvinia* are drifted to the semiclosed outlet where they accumulated and upon decomposition enhance nutrient levels for the macro-zoobenthos. Such dominance pattern of gastropods and oligochaetes in respect of density has been earlier reported by Gupta (1976) and Singh et al. (1994). In

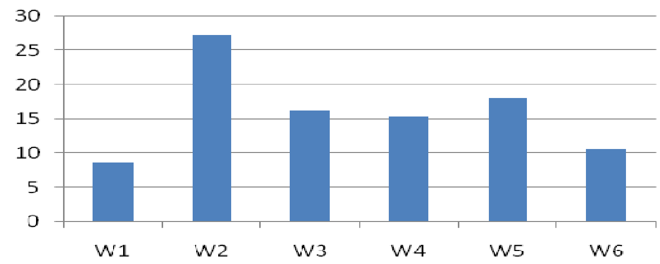

Figure 3. Spatial variation in population density (%) of macrozoobenthos at study sites.

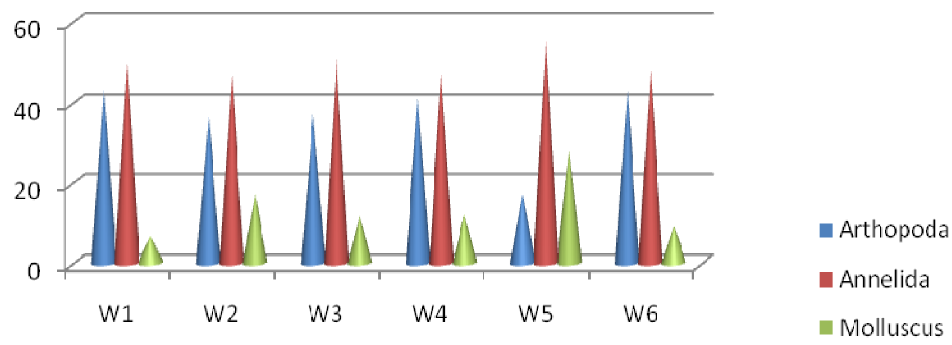

Figure 4. Spatial variation in population density (%) of three groups of macrozoobenthos at study sites.

general among three groups, annelida depicted the highest relative abundance at all the study sites (Figure 4). Molluscs were least abundant group with the highest relative abundance of 28% at W5 followed by W2 (17%), W3 (13%), W4 (12%), W6 (9%) and W1 (7%).

Sharma and Belsare (1997) related the richness of benthic organisms in lake littorals with the primary production of phytoplankton and macrophytes, food supply, O_2, ionic composition, pH and other factors. In general summer season showed peak population density, probably due to low water depth, which tend to warm up quickly during summer and enhance the rate of production. Highest population density of macrozoobenthos seems to be due to provision of suitable breeding, hiding and sheltering and egg laying, anchorage and rich oxygen supply sites by profused growth of varied types of macrophytes (Soszka, 1975) and buffered nature of the water.

Among annelids, oligochaetes were dominant and represented by taxa including *Tubifex, Branchiura*, *Limnodrilus, Nias, Aelosoma*. Among these 5 taxa first three taxa were present at all study sites showing a contribution of 48.7, 29.7 and 10.9% to the total annelida population. Other taxa contributed 4.9 and 1.1% respectively. All these species are true representatives of eutrophic conditions (Howmiller and Beeton, 1971) and were typical constituent of sediment with abundant organic matter and pollution (Adholia et al., 1990, Millbrink, 1994). Bais et al. (1992) further emphasized that oligochaetes occur in large number when the bottom water at mud water interface contain low in DO content. Hirudinea was represented by two taxa only that is *Glossiphonia* and *Erpobdella* contributing only 4.2 and 0.6% to total annelida population density. *Erphobdella* was reported from Site W2 and Site W4 only while Glossiphonia was present at all sites except Site W1. Some of the *Glossiphonia* sp were seen parasitizing on the tadpoles during spring and summer season near plantation areas. Higher temperature, low DO during summer months appeared to have a direct influence on the population density and species composition of oligochaetes in the wetland.

Among arthopoda *Chironomus* and *Gammarus pulex* were dominant one contributing 50 and 34.4% to the total arthopoda population density and were also recorded almost at all sites. Other taxa showed a little contribution ranging from 0.04 - 6.6% only. *Lestes* sp and *Caenis* larvae were recorded only once at site W2. Presence of *Chironomus* sp and *G. pulex* to the whole wetland seems because of the fact that these organisms prefer substrate rich in microbe -organic detritus complex. Chironmids are known to be pollution tolerant (Milbrink, 1980) with low oxygen content and high organic nutrients (Kaushik et al., 1991, Pandit, 1992).

Among Mollusca, *Lymnaea* was the dominant genus (73.1%) represented by three species (*L. auricula*, *L. stagnalis* and *L .collumella*). *Corbicula* was present at site W1 only with relatively lower population density (0.75%). This species apparently prefers silty sand texture.

Overall the highest population density of *Tubifex* (23.75), C*hironomus (*18.1%), *Branchiura* (14.5%) and *Gammarus pulex* (12.4%) contributed significantly to the total macro invertebrate population in the wetland especially from mid summer to late autumn as during this period wetland water show high conductivity, low depth, low velocity of water and variable amount of organic matter (Sang, 1987) dense macrophytic population (Soszka, 1975).

The altered physico-chemical characteristics of waters together with growing occurrence of the pollution indicator macrozoobenthic species, allows us to conclude that the Shallabugh wetland has evolved over the years as a eutrophic ecosystem and merits urgent attention for eco-restoration and sustainable management.

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