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Comparative Studies on Ecology of Hokarsar Wetland, Kashmir : Present and Past

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ABSTRACT

The present investigation carried out during 2002 is an attempt to compare the current data with the earlier ones pertaining to various aspects of wetland ecology of Hokarsar. The perusal of data shows slight changes in water characteristics over a period of more than 30 years. In contrast, species composition has witnessed great variations. Some economically important species, reported earlier, have disappeared from the wetland and at the same time some new species have emerged forming new associations. The frequent floods in 1990's and thereafter the heavy siltation have probably decreased the species number and the stability of environment in the wetland over a period of last few years, resulting in vegetation revival.

Keywords: Macrophytes, water quality, biodiversity, productivity, wetland, Hokarsar

INTRODUCTION

Limnological studies in Kashmir have been carried out from time to time since long but most of them pertain to various allied aspects of lake ecology and only some of the workers have concentrated their studies upon the most valuable pools of biodiversity, the wetlands, covering very large areas in Kashmir. Evidently the wetland ecology is most dynamic and remains ever-changing for its dwindling water depth, providing fluctuating transitional zones for vegetation to develop (Gopal, 1994). In Kashmir only a few ecological studies have been conducted on Hokarsar, the 'Queen wetland' (Kaul and Zutshi, 1967; Handoo, 1978; Pandit, 1980, 91; Pandit and Kaul, 1982; Handoo and Kaul, 1982; Kaul, 1982; Kak, 1990; Pandit and Qadri, 1990; Khan, 2000; Gangoo and Makaya, 2000; Rather, 2001; Rather *et al.*, 2001) and the information available is quite scattered with big gaps.

In the present investigation an attempt is, therefore, made to collate the present data on wetland ecology lying stress over the changes brought about by anthropogenic pressures in terms of water quality and vegetation pattern.

STUDY AREA

Hokarsar wetland is a perennial, protected wildlife reserve, located about 10 km south of Srinagar city at an altitude of 1584m (a.m.s.l.) on Srinagar-Baramulla National Highway (1A), harbouring about two million migratory waterfowl during winter. The wetland is fed by two inlet streams-Doodganga (from east) and Sukhnag Nalla (from west). The water drains out through an outlet channel having a needle gate to regulate the water level during winter. The present area of the wetland is about 7.5 km^2 compared to its original area of 13.5km^2 at the turn of twentieth century, being under the direct impact of human habitation in its catchment.

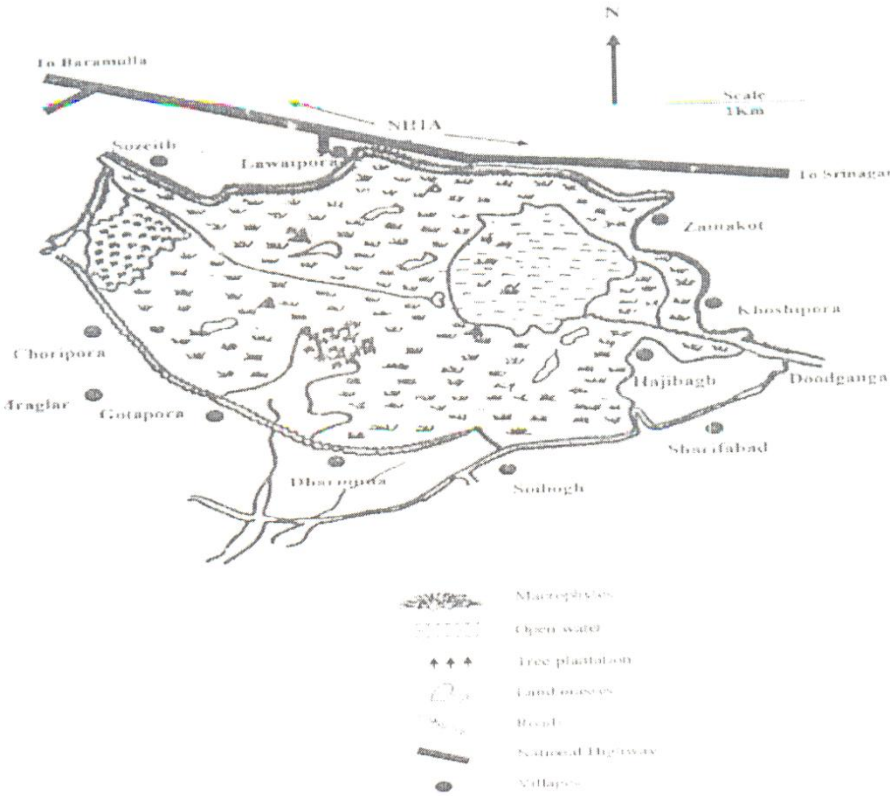

Fig. 1. Location map of Hokarsar wetland

MATERIAL AND METHODS

The water samples were collected from various sampling stations in 1-litre polythene bottles on monthly basis during 2002. The parameters like depth, transparency and water temperature were recorded on spot while rest of the parameters were analysed, within 24 h of sampling, following standard methods of Mackreth (1963), Golterman and Clymo (1969) and APHA (1989).

For the macrophytic composition and production, quadrats of definite size (1 x 1m) were laid randomly (Misra, 1968) at and around the selected sites so as to cover almost whole of the wetland. The macrophytes falling in each quadrat were sorted and identified up to species level wherever possible. Species richness was worked out following Odum *et al.* (1960), Menhinick (1964) and Margalif (1969). The production of various macrophytic species was estimated on fresh weight/ dry weight basis as per Milner and Hughes (1969).

RESULTS AND DISCUSSION

Physico-chemical Characteristics of Water

Table 1 gives the range values of various physico-chemical features of Hokarsar waters from 1978 to 2001. In all the previous studies, the maximum depth reported exceeds 1m except Rather (2001) who reported the maximum depth to be 65 cm only. Water temperature has shown almost a uniform trend, as is the case with pH, calcium and silicates. Higher values of conductivity have been reported by Pandit (1980). While low values of magnesium have been depicted by Handoo (1982). Low alkalinity has been reported by almost all the previous workers except Rather (2001) and the present authors. Handoo (1978), Kaul *et al.* (1978) and Pandit (1980) have reported low ammonical nitrogen. Pandit (1980) and Khan (2000) have given a very narrow range of dissolved oxygen as against the very wide range reported by all other workers.

Estimation of chlorides has not been done prior to Rather *et al* (2001) and the estimation of Iron has only been conducted during the present study. When the present study is compared with the previous studies in terms of physico-chemical characteristics of waters, it clearly reveals that some aspects show a great proximity with the earlier findings and some others depict distinct deviations. Depth of the wetland (0.5 - 1.4m) recorded in the present investigation is much closer to the observations of Khan (2000). Water temperature did not reveal much deviation from

Table 1. Comparison of data on physico-chemical characteristics of Hokarsar waters

Parameters	Kaul et al. (1978)	Handoo (1978)	Pandit (1980)	Khan (2000)	Rather et al. (2001)	Rather & Pandit (2002)	Present Study (2002)
Depth (m)	-	-	0.66 to 1.12	0.5 to 1.6	0.13 to 0.65	0.15 to 0.63	0.54 to 1.41
Transparency (m)	-	-	-	-	0.11 to 0.55	-	0.54 to 1.22
Water Temp. (°C)	-	-	6.0 to 27.0	6.5 to 28.0	4.6 to 29.2	6.9 to 29.0	3.0 to 27.0
PH	7.2 to 9.0	7.2 to 9.0	7.4 to 8.5	7.2 to 8.5	7.4 to 9.0	7.5 to 8.6	7.32 to 8.10
Conductivity (μScm^{-1})	216 to 348	205 to 429	357 to 722	-	224 to 532	227 to 470	230 to 376
Dissolved Oxygen (mg l^{-1})	3.20 to 12.50	3.20 to 12.50	4.0 to 8.02	4.5 to 8.0	2.6 to 15.20	2.25 to 12.50	1.9 to 11.4
Chlorides (mg l^{-1})	-	-	-	-	8.0 to 70.0	10.0 to 32.0	17.0 to 28.0
Calcium (mg l^{-1})	24.0 to 61.0	23.60 to 61.60	33.0 to 49.0	-	26.45 to 54.30	30.5 to 45.8	27.3 to 39.6
Magnesium (mg l^{-1})	11.0 to 18.0	2.50 to 7.40	11.0 to 17.0	-	7.05 to 16.74	9.0 to 16.2	2.4 to 8.2
Alkalinity (mg l^{-1})	85.0 to 256.0	85.0 to 256.0	98.0 to 268.0	-	50.0 to 415.0	68.0 to 352.0	119.0 to 240.0
Orthophosphate ($\mu g\ l^{-1}$)	112.0 to 306	112.0 to 306.0	22.0 to 54.0	-	40.0 to 255.0	44.0 to 161.0	33.0 to 141.0
Total Phosphorus ($\mu g\ l^{-1}$)	155.0 to 325	155.0 to 306.0	80.0 to 415.0	-	115.0 to 535.0	113.0 to 373.0	116.0 to 307.0
Nitrate Nitrogen ($\mu g\ l^{-1}$)	104.0 to 327.0	154 to 327.0	73.0 to 621.0	-	150 to 520.0	186.0 to 420.0	269.0 to 622.0
Ammonical Nitrogen ($\mu g\ l^{-1}$)	3.0 to 10.0	3.0 to 9.0	16.0 to 69.0	-	65.0 to 425.0	83.0 to 395.0	81.0 to 173.0
Silicates (mg l^{-1})	3.0 to 9.0	3.0 to 9.0	9.0 to 12.0	-	1.40 to 8.42	1.52 to 3.50	1.90 to 5.70
Iron ($\mu g\ l^{-1}$)	-	-	-	-	-	-	262.0 to 476.0

that of previous workers. The pH, falling towards the alkaline side (7.3 - 8.1) did not show any significant variation over the years. However, the recorded observations were much closer to those of Pandit (1980). While the specific conductivity values are much closer to Kaul *et al.* (1978), these are much lower to the findings of Pandit (1980) and Rather *et al.* (2001). The range of chlorides (17.0 - 28.0 mg/l) recorded in the present investigation is not in close agreement with any of the past findings except that of Rather and Pandit (2002). Again the values of calcium recorded in the present study (27.3 - 39.6mg/l) are not in tune with any of the previous records. However, the values lie closer to those reported by Rather and Pandit (2002). The amounts of magnesium recorded by the authors (2.4 - 8.2 mg/l) are almost equal to that of Handoo (1978), while all other authors have registered its higher amounts. The alkalinity values (119.0 - 240.0 mg/l) registered in the present investigation showed a closer proximity with the findings of Kaul *et al.* (1978), Handoo (1978) and Pandit (1980). In contrast, Rather *et al.* (2001) and Rather and Pandit (2002) have depicted much wider ranges. Higher values of silicates, lying closer to the present findings (1.95.7 mg/l), have been reported by all the authors except Rather and Pandit (2002). Almost a similar situation is noticed for total phosphorus wherein the minimum values coincide with those of Rather *et al.* (2001) and the maximum values with those of Handoo (1978). However, Pandit (1980) reported a very wide range of total phosphorus. While there was hardly any agreement with any of the previous authors with regard to the orthophosphates and ammonical nitrogen, the nitrate nitrogen levels recorded in the present study (269.0 - 622.0 µg/l) showed a close proximity with the findings of Pandit (1980) for its maximum values. The present finding was the first ever study conducted for the estimation of iron for Hokarsar waters.

Vegetation

Species Composition

Various workers in the past have dealt with the various biological features of Hokarsar wetland including the classification, species composition, distribution, community structure and production of macrophytic vegetation. Handoo (1978), while classifying the wetlands, placed Hokarsar in deep permanent marsh type as is also well established in the present investigation. A similar view was held by Pandit (1980) and Kaul (1982). They again placed the wetland in deep permanent category along with Mirgund wetland. However, Khan (2000) advocated for its fluvial origin.

Regarding species number and composition, many workers have reported varied number of macrophyte species from the wetlands at different times. Thus, while Kaul and Zutshi (1967) reported 67 species from this closed type wetland (as the authors called it), Pandit (1980) in his extensive study reported only 24 species of macrophytes from Hokarsar. Handoo and Kaul (1982) held water fluctuations responsible for the species decline and further reported only 18 macrophytic species. In contrast, Kak (1990) in his taxonomic survey reported 58 species out of which 44 were rare to the wetland. In the later studies, Khan (2000) while studying on the biodiversity in Kashmir wetlands, reported a total of 25 macrophytic species, encompassing 14 emergents in Hokarsar and Gangoo and Makaya (2000) registered 24 species from the same, the later holding anthropogenic pressures to be responsible for vegetational changes (Table 2).

A perusal of data in Table 2 depicts significant temporal variations in the species composition. Thus, according to earlier reports of Kaul and Zutshi (1967), Hokarsar sustained 85 species of macrophytes in 1963 and thereafter a decreasing trend was registered. Pandit (1980) held that decrease in the number of species from 85 in 1963 to 24 in 1980 was due to increasing frequency of floods and increasing population around causing greater anthropogenic pressures on the wetland biotope. Pandit and Qadri (1990) further studied the impact of floods on the vegetation pattern of Hokarsar and held silt deposition responsible for luxuriant growth of *Sparganium ramosum* replacing *Phragmites australis*. Pandit (1989), while discussing conservational strategies of wetlands, again held floods and siltation responsible for disappearance of species like *Nelumbium nucifera, Euryale ferox* and *Acorus calamus* reported earlier by Lawrence (1967), Kaul and Zutshi (1967) etc. Contrary to the present study, Khan (2000) did not enlist the species like *Ceratophyllum demersum, Myriophyllum spicatum, Utricularia* sp., *Nymphaea alba, Sium latijugum, Menyanthese trifoliata, Hippuris vulgaris, Bidens cernua, Hydrocharis dubia* etc. which have been recorded abundantly during the present investigation except *Menynanthese trifoliata* which was found to be a rare species.

As regards the number of emergents, the studies of Kak (1990) and Kaul and Zutshi (1967) show close proximity with the present study. However, for other types of macrophytes, all the previous reports coincide with the present study. The increase in species number from 24 (Pandit, 1980) to the present 46, with 30 emergents, 7 rooted floating-leaf type, 2 free floating and 7 submergeds (classification after Arber, 1920 and Sculthorpe, 1967), can be attributed to the possible reason of improvement in flood situation following dry weather conditions leading mostly to summer draw-down during the recent years and restricted human interferences.

Table 2. Number of macrophytic species recorded over a period of 40 years by different workers from Hokarsar wetland

S. No.	Name of the Author	Year	Number of Macrophytes
1	Kaul and Zutshi	1963 (cf. 1967)	85
2	Kaul and Zutshi	1967	67
3	Pandit	1980	24
4	Handoo	1982	19
5	Handoo and Kaul	1982	18
6	Kak	1990	58
7	Pandit	1991	24
8	Khan	2000	25
9	Gangoo and Makaya	2000	24
10	Present study	2002	46

Production

Macrophytic production of the wetland has been studied by Handoo (1978), Kaul *et al.* (1978), Handoo and Kaul (1982), Kaul (1982) and Pandit (1991). Kaul *et al.* (1978) recorded the productivity (on dry weight basis in g $m^{-2}d^{-1}$) for *Phragmites australis* (16.93), *Sagittaria sagittifolia* (20.0), *Nymphaea alba* (1.38), *Trapa natans* (3.69), *Nymphoides peltatum* (0.98), *Nymphaea* sp. (1.78) and *Ceratophyllum demersum* (23.0). The authors provided data on the percentage biomass contribution of different life-form classes of macrophytes in the wetland to be: tall growing emergents (40%), low growing emergents (0.02%), ground layer emergents (0.03%), rooted floating-leaf type (59.9%) and submergeds (0.04%). However, their production studies were restricted to the single peak month of growth, august for the species like *Phragmites austradis Nymphoides peltatum, Trapa* sp. and *Nymphaea* sp., June for *Sagittaria* sp. and September for *Ceratophyllum demersum*. In another study, Kaul (1982) estimated primary productivity in terms of above ground biomass (AGB), below ground biomass (BGB) and annual net primary productivity (ANP) and reported AGB for *Trapa* sp. to be 435.20 g m^{-2}, while for others it came to be 3.60 g m^{-2}. The author further worked out the ANP for *Trapa* sp. to be 432 g m^{-2} and the overall productivity values of 0.55-6.22 g $m^{-2}d^{-1}$ with a turnover rate of 0.815 for the said plant.

The present investigation purely pertains to the production of some macrophytes in terms of increments of dry weight biomass calculated over a period of eight months and the species for which the dry weight and productivity were determined included three emergents (*Sparganium ramosum, Myriophyllum verticillatum* and *Sagittaria sagittifolia*), two rooted floating-leaf types (*Trapa natans* and *Nymphoides peltatum*), two free floating forms (*Salvinia natans* and *Lemna* sp.) and one submerged (*Ceratophyllum demersum*). Further, excepting *Sparganium ramosum*, the whole plants were taken into account for production estimates for all other species. The great variations in the production values in the present study compared to the values reported earlier were due to varying methodical approaches. Thus, while in the earlier studies of Kaul (1982) the highest values of productivity were obtained for *Trapa* sp., it was estimated to be maximum for *Sparganium ramosum* growing luxuriantly in the wetland during the recent years the most significant feature of the wetland ecology.

Table 3. Macrophytic production of Hokarsar wetland

S.No.	Name of the species	Part taken	Period	g/m²/day	g/plant/ day
1	*Sparganium ramosum*	Above ground	April-October 2002	1.981	0.1679
2	*Myriophyllum verticillatum*	Whole plant	-do-	0.236	0.0501
3	*Sagittaria sagittifolia*	-do-	-do-	0.103	0.0383
4	*Trapa natans*	-do-	-do-	0.483	0.1283
5	*Nymphoides peltatum*	Leaf lamina	-do-	0.087	0.0018
6	*Salvinia natans*	Whole plant	-do-	0.047	0.0035
7	*Lemna* spp.	Whole plant	May-August 2002	0.005	0.00008
8	*Ceratophyllum demersum*	-do-	April-October 2002	0.318	0.0149

Species Richness

Being one of the most important features of biodiversity, species richness is often used in bio-monitoring studies. Handoo and Kaul (1982) reported a species richness of 1.33 in Hokarsar on the basis of number of species m^{-2} and that too in the peak month of growth. However, during the present investigation it was calculated on monthly basis throughout the growing period, the data being depicted in Fig. 2.

hertifolium and *Scirpus lacustris.* The marshes represented the species like *Myosotis sylvatica, Veronica anagalis, Roripa indica, Sium latijugum, Juncus glaucus* and *Menyanthese trifoliata.* The above authors further classified macrophytes into 8 taxonomic classes after Arber (1920) and Welch (1948). Latter, Kaul (1982) also advocated that the wetland is colonized mostly by *Trapa-Nymphoides* associations.

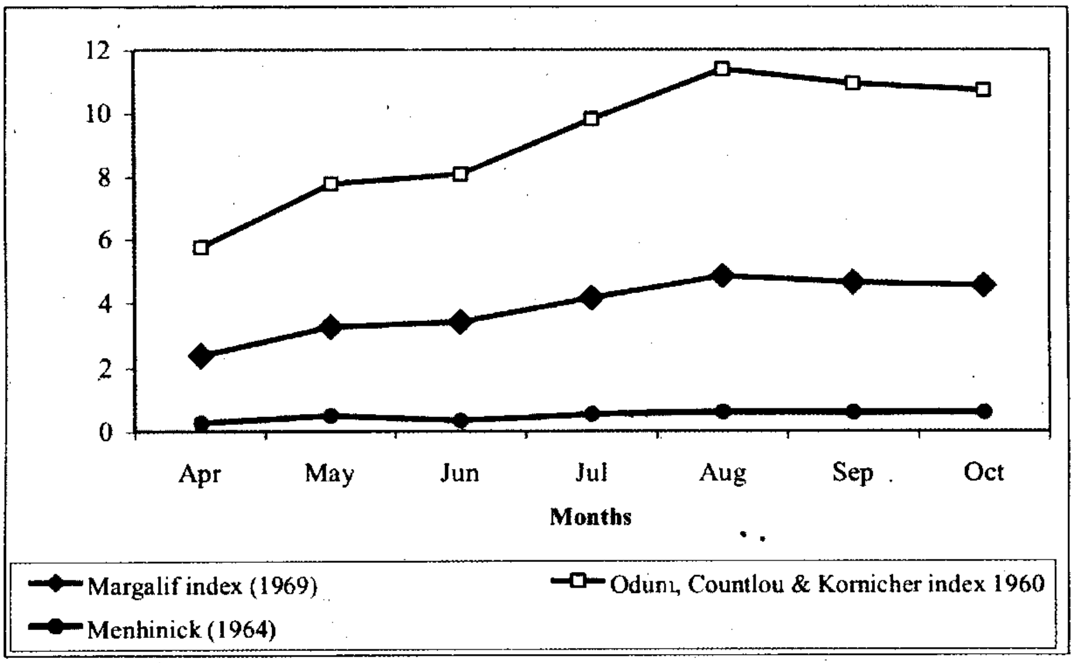

Fig. 2. Graph showing species richness indices in the present study

An overview of macrophytic studies reveal that there has not been any significant work in the past regarding the distribution of macrophytes in terms of different associations and frequencies of recorded species. However, Kaul and Zutshi (1967) have reported that the bulk of vegetation in the Hokarsar wetland was represented by *Trapa* spp. and *Nymphaea stellata* (both rooted floating-leaf types). The authors further reported that the land masses within the open waters sustained thick stands of *Phragmites communis, Typha* spp., *Barbera vulgaris, Menyanthese trifoliata, Gallium*

Pandit (1998) in a later study again reported that the floating-leaf type species are dominating in the wetland and opined that the comparative greater depth (than other wetland sites) has favoured the floating leafy vegetation in Hokarsar. The author, while studying the distribution of *Trapa* sp. reported 55.2 and 91.7% relative frequencies for *Trapa bispinosa* and *T. natans* respectively.

Thus, a perusal of data reveals that the open waters are colonized by rooted floating-leaf type and submerged vegetation as has been reported by most of the workers. The rooted floating-leaf type was dominated by *Nymphoides peltatum, Trapa natans* and *Hydrocharis dubia* while *Potamogeton natans* and *Nymphaea* spp. were the sub-dominants. The submerged vegetation was dominated by *Ceratophyllum demersum,* followed by *Potamogeton pucillus, Utricularia aurea, Hydrilla verticillata, P. lucens, P. crispus* and *Myriophyllum spicatum* in order of their decreasing dominance. As against the open water assemblages, the land masses within open waters were colonized mostly by emergents like *Sparganium ramosum,* followed by *Phragmites australis, Myriophyllum verticillatum, Hippuris vulgaris, Menyanthes trifoliata, Sagittaria sagitifolia, Polygonum amphibium* etc. It was further observed that the thick stands of *Phragmites australis,* as reported earlier by Kaul and Zutshi (1967), Handoo and Kaul (1978) and Pandit (1980), are being replaced by *Sparganium ramosum* as noticed during the present investigation. This gains further support from the earlier findings of Pandit (1991).

The species like *Barbera vulgaris, Juncus glaucus, Euryale ferox, Acorus calamus, Nelumbo nucifera* etc. as reported by some previous workers were not recorded at all during the present study - a noteworthy feature. It is quite possible that these species might have disappeared from the wetland for the possible reasons of greater anthropogenic pressures on the wetland in the recent past.

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