



Impact of anthropogenic activities on Dal Lake (Ecosystem/conservation strategies and problems)

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Abstract

Dal Lake (located at 34° 07' N, 74° 52' E, 1584 m above MSL, in Srinagar, Jammu & Kashmir, India) has been a great tourist attraction in the past. However, once beautiful water body has been the worst victim of the anthropogenic pressures during the second half of the 20th Century and has undergone tremendous ecological changes. In spite of innumerable conservation measures taken by the management authorities over the past two three decades, the ecological condition of the lake has deteriorated and it is getting enriched with plant nutrients and other pollutants, becoming more and more infested with macrophytes, getting slowly shallower and shallower and shrinking gradually in size. An ecological study of the water body was conducted during March-April 2013 so as to gain insight into the flaws of the conservation endeavors. It was revealed that ecologically unsound management practices are the major cause for the plight of the lake. In response to the inshore dredging, skimming of free floating macrophytes and unplanned mechanical dewatering undertaken during the past several years, some previously sparsely distributed aquatic plants in the lake have reached nuisance levels, while hitherto unknown invasive *Azolla pinnata* has got widely distributed throughout the water body. A thorough study encompassing all environmental aspects, including socioeconomics, needs to be undertaken so as to frame an ecologically well balanced conservation strategy for this important aquatic ecosystem of the region.

Keywords: nutrients, macrophytes, dredging, skimming, dewatering, socio-economics, management, *Azolla pinnata*

1. Introduction

The Dal lake of Kashmir situated in the north-east of Srinagar at mean latitude of 34°7' N latitude and longitude of 74° 52' E at an altitude of 1584 m.a.s.l., is probably of fluvial origin having been formed from the ox-bows of the river Jhelum. The lake is multi-basined with (i) Hazratbal (ii) Bod dal (ii) Gagribal and (iv) Nagin as its four basins. The lake covers an area of about 11.4Km² with a maximum depth of 5.4m. In spite of being the center of Kashmir civilization, the lake has suffered numerous insults in the hands of man and as a result the lake is moving towards its definite end. Due to the ecological stress from human activities, the lake system is not only shrinking in surface area but its water quality has also deteriorated and the aquatic life is also badly affected. Large quantities of untreated sewage and garbage are received by the lake from the human settlements as well as business establishments. Some recently introduced macrophytic species have colonized vast expanses of the lake. Conservation practices in operation have not succeeded in restoring the lake. In order to gain an insight into the possible reasons responsible for failure of conservation measures the present study was undertaken.

2. Literature Survey

A survey was conducted to various sites of Dal lake where the multiple colonies have been developed illegally during the past years. A questionnaire was conducted about their health and other problems people facing living in such slums are listed below

2.1 Health

Ishrat (1985) ^[17] attributed the poor health of the Donga population to poor sanitation and intake of deficient daily diet. A thorough survey regarding the health of the population living in the Dal interiors revealed the incidence

of diseases like Blepharitis, conjunctivitis (bacterial), and Dermatophytic infections (fungal). The incidence of Blepharitis and conjunctivitis was more common in children who frequently bathed in the lake waters and the incidence of Dermatophytosis was more in dwellers belonging to low income group living in unhygienic conditions. As per the information collected from the inhabitants during the survey it was found that the majority of the Donga population had worms and complained of fever and shivering. Gastroenteritis was found to be common among the Donga population. Gastroenteritis worms in the intestine carried through water could be due to polluted lake water used by the Donga population probably for washing of eatables and utensils. Air borne disease asthma was more prevalent in the Dalgate area which may be attributed to the heavy traffic load in the area.

2.2 Socio-Economics

As per the information given in the Detailed Project Report prepared by the Alternate Hydro Energy Centre, University of Roorkee for J & K lakes and Water Ways Authority in Oct. 2000, about 90 percent of the Dal dwellers have a very poor socio-economic base and eke out their modest living from agricultural activities, mat shikaras and dewatering of weeds.

A major proportion of the population was found to be engaged in vegetable and Nadru (*Nelumbo nucifera*) cultivation. As per the information furnished by the Dal Dwellers' Zamindar Union, vegetables worth 35 crores are cultivated and supplied from the lake every year. The area of land available for the vegetable cultivation is 450ha. A small proportion of population is involved in weaving of Typha mats and also carpet weaving. As per the survey conducted by Ishrat (1985) ^[17], 28 percent of the population possessed domestic animals including poultry, ducks and

geese, while the present study revealed that only 5 - 6 percent of the population possessed domestic animals due to a shift in the occupation and the standard of living

2.3 Conservation practices

In spite of spending approximately Rs 250 crores, on the conservation of the lake and allied programmes thus far there is no visible improvement in the condition of the Dal lake. A lack of proper management and restoration plan and the incidence of engineered but ecologically unsound management practices have led to a failure in the conservation efforts.

2.4 Dredging and Dewatering (Mechanical)

Suction cutter dredger is being employed by the managing authorities to dredge out the nutrient rich sediments but the dredging operation has its own ecological constraints associated with it as it disturbs the overall nutrient state of the water. Mechanical de- weeding, instead of uprooting the macrophytes, results in their trimming, which promotes their quick and luxuriant growth. In case of free floating *Azolla pinnata* skimming results in its fragmentation, which promotes its profuse growth through vegetative propagation.

2.5 Rehabilitation

As per the detailed project report prepared by the Alternate hydro-energy centre University of Roorkee for J & K lakes and Water Ways Authority in October 2000, there were 6250 households in the lake located in 105 hamlets. Out of these households only 1221 families living in 441 houses/structures had been resettled but not fully rehabilitated. A comprehensive, result-oriented method for the resettlement and rehabilitation is lacking as the land is being acquired in a piecemeal manner compelling the dwellers to stay inside the lake and not move permanently. The land in the Dal lake had been notified for public purposes firstly in 1971 and thereafter notifications for acquisition of land have been repeatedly published but not acted upon promptly as a result of which the population inside the Dal lake increases year after year in spite of a blanket ban imposed upon all kinds of constructions within and around Dal lake up to the outward limit of 200 m from the fringe of the lake.

2.6 Removal of willow plantation

It was observed during the present study that the removal of the willow plantations led to more profuse growth and expansion of the free floating *Azolla pinnata*. The profuse growth of *Azolla pinnata* in these areas can be attributed to the direct exposure of *Azolla* to temperature stress which leads to the fragmentation of the fronds leading to its vegetative propagation

2.7 Plant species

A total of 31 species were recorded from Dal Lake during the present study (Table 2). Among the emergents, *Typha angustata* and *Phragmites australis* covered vast expanses of the lake, while among the rooted floating leaf type, *Nelumbo nucifera*, *Nymphaea mexicana*, *Nymphaoides peltatum* and *Trapa natans* dominated the lake. The open water zone was colonized by submerged species, mainly

3. Material and Methods

For studying the water quality conditions a total of fifteen

sites were selected in the Dal Lake with 5 sites in Hazratbal basin, 4 in Lokut Dal basin, 3 in Gagribal basin and 3 in Nageen basin (Figure 1). Water samples were collected from all the sites during 2009-2013 on bimonthly basis in 2L polyethylene bottles. The samples were analyzed in the laboratory within 24 hours for different parameters adopting standard methods of Mackereth (1963) [15], CSIR (1974) [8], and APHA (1998) [1].

The macrophytes were collected from different areas of the four basins by quadrat method. These were sorted and identified up to genus/species level with the help of standard works (Sculthorpe, 1967; Kaul and Zutshi, 1967; Kak, 1989, Gopal, 1990 and Cook, 1996) [11, 9, 10, 6] For assessing the health and socio-economic status of the Dal lake dwellers, surveys were conducted on periodic basis and the information was collected through direct interaction with the inhabitants. reports published by the J&K Lakes and Waterways Development Authority (Anonymous, 1998, 99, 2000) 15 major drains find their way into the lake waters which are charged with nutrients and carry about 18.17 tons of phosphorus and 25 tons of inorganic nitrogen, enriching the lake water and lake sediments.



Fig 1: Satellite image of Dal Lake showing study sites (Courtesy: Google Earth)

4. Results and Discussion

Remarkable changes have taken place in the water chemistry over the last few decades which are revealed by comparing the present water quality with that of the past (Table 1).

As is revealed from Table 1 noticeable changes have taken place in the nitrate and total phosphorus content of all the basins, however, no significant shift is observed in the pH and the waters continue to be alkaline. The increasing trend in nitrate and total phosphorus can be attributed to the untreated sewage received by the Dal Lake water. As per the technical *Ceratophyllum demersum*. The most striking feature revealed by the present study was the absence of species like *Euryale ferox* and *Chara sp* earlier reported by Mukerjee (1921) [16] in Dal Lake. Instead, some new species have found their way into the lake. Kundangar *et al.* (2003) [14] reported *Azolla pinnata* and *Eichornia crassipes* as new records to the Dal Lake. *Azolla pinnata*, which was a rare species in the lake till recently, has become within a very short period widespread in the water body and is posing a threat to the other life forms, especially the free floating plant species. *Eichornia crassipes*, though at the moment

restricted only to the water channels in the lake at the moment, does signal an imminent threat to the lake ecosystem in near future if the lake condition does not improve. *Ceratophyllum demersum*, *Myriophyllum spicatum*, *Hydrilla verticillata*, *Salvinia natans*, and *Azolla pinnata* were found to be forming monospecific stands

widely in the lake, which has been attributed by Kundangar and Zutshi (1987) [3] to anthropogenic pressure. This is substantiated by the data on the plants nutrients like N and P, which are contributed by the inflow channels and sewage drains.

Table 1: Changes in water chemistry of Dal lake, Kashmir, over the last few decades After Trisal (2009) [9] **After Kundangar and Abubakar (2013) [14] P.S. =Present Study

Parameters	Hazratbal Basin			Lokut Dal Basin			Gagribal Basin			Nageen Basin		
	2009	2013	P.S	2009	2013	P.S	2009	2013	P.S	2009	2013**	P.S
Ph	77-95	7.1-8.6	69-9.5	7.4-9.5	7.3-8.8	7.9-9.2	7.5-9.5	7.6-9.2	7.3-9.4	7.7-9.5	7.2-9.0	7.2-9.0
Total (mg/l-1)	70-120	39-161	44-120	22-210	36-160	29-125	70-135	40-126	20-134	80-204	65-221	22-164
Nitrate-Itrogen (mg/l-1)	80-650	120-1377	100-3680	95-691	105-899	150-2800	80-603	126-2350	80-3360	90-632	105-3337	90-3700
Total phosphorus (mg/l-1)	62-623	400-700	76-820	65-620	415-712	48-750	70-506	403-815	100-840	90-973	330-891	96-582

Table 2: List of the macrophytic species recorded from the Dal Lake during 2009-2013

S. No	Life form	Status
	Emergent	
1.	<i>Alisma plantago-aquatica</i>	P.
2.	<i>Carex sp.</i>	P.
3.	<i>Cyperus defformis</i>	P.
4.	<i>Lycopus europus</i>	P.
5.	<i>Myriophyllum verticillatum</i>	P.
6.	<i>Nasturtium officinale</i>	P.
7.	<i>Phragmites australis</i>	D.
8.	<i>Polygonum hydropiper</i>	P.
9.	<i>Polygonum amphibium</i>	P.
10.	<i>Saggitaria saggitifolia</i>	P.
11.	<i>Scirpus triqueteter</i>	R.
12.	<i>Sium latijugum</i>	R.
13.	<i>Sparganium ramosum</i>	P.
14.	<i>Typha angustata</i>	D.
Rooted floating leaf type		
15.	<i>Hydrocharis dubia</i>	P.
16.	<i>Nelumbo nucifera</i>	D.
17.	<i>Nymphaea alba</i>	R.
18.	<i>Nymphaea mexicana</i>	D.
19.	<i>Nymphoides peltatum</i>	D.
20.	<i>Potamogeton natans</i>	P.
21.	<i>Trapa natans</i>	D.
22.	<i>Eichhornia crassipes</i>	P.
Submerged		
23.	<i>Ceratophyllum demersum</i>	D.
24.	<i>Hydrilla verticillata</i>	D.
25.	<i>Myriophyllum spicatum</i>	D.
26.	<i>Potamogeton crispus</i>	P.
27.	<i>Potamogeton lucens</i>	P.
28.	<i>Potamogeton natans</i>	P.
Free Floating		
29.	<i>Azolla pinnata</i>	D.
30.	<i>Lemna spp.</i>	D.
31.	<i>Salvinia natans</i>	D.

Conclusion

As is evident from the present study, Dal Lake is moving towards its definite end. The conservation efforts, being ecologically inefficient and unsound, have proved to be a total failure. Official apathy and non-seriousness of the managing authorities have deteriorated the overall condition of the lake. There is a need to formulate proper ecologically sound management plan for the lake encompassing all the environmental components of the lake ecosystem and thus help to conserve the lake in a real ecological sense.

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