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Environmental impact Assessment Studies on Dal Lake Kashmir

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Abstract: **Dal Lake Kashmir known as "liquid heart" of summer capital Srinagar, Kashmir is bedevilled by many ecological maladies mainly arising out of human incursions. The present paper summarises the conservation measures taken to retrieve the pristine glory of the lake with an attempt to put forth the environmental impact assessment studies of the various measures viz. catchment treatment, silt n sedimentation Control, wastewater management, weed infestation, improvement in lake hydrology, combatting algal blooms and solid waste management.**

***Index Terms*— Dal Lake, conservation measures, environmental impacts of dredging, deweeding and aeration).**

I. INTRODUCTION

The Dal Lake of Kashmir also known as "Liquid heart" of Srinagar, the capital city of J&K State Is bedeviled by many maladies mainly arising out of human incursions both in periphery as well as within the lake itself. The stupendous environmental problems the lake is facing include massive ingress of untreated domestic sewage, continuous siltation, resulting in obnoxious algal blooms, luxurious weed growth, impaired water quality and loss of biodiversity. In order to restore the Dal Lake ecology number of measures was initiated which include:

a) Catchment management by way of restoration of degraded forests, through plantations contour, hedgerow and in situ moisture conservation, drainage line treatment through properly designed check dams, RCC structures, retards, gabion stone walls, trenching etc. besides forage production through silvi-pasture development and on farm development.

b) Siltation and sedimentation control measures by way of construction of settling basin on the entry of perennial water source (TELBAL NALLAH) into Dal Lake including intake structures, deflecting spurs, backwater bunds and RCC Deck Bridge.

c) Algal bloom control measures were taken by bubbling pure oxygen into polluted waters through floating aerators.

d) Houseboat sanitation through realignment and relocation of houseboats and inter alia connecting to main sewer system.

e) Solid Waste management; The solid waste management in human settlements within the lake (more than 50,000 souls plus 10,000 persons in boats) is one of the contributing factors of the lake environment and thus are managed through garbage bins and the door to door collection including houseboats and the final disposal is being done by Srinagar Municipality.

II. OBSERVATIONS

Whereas 9700 hectares of Dal Lake catchment area have been taken up for engineering measures, more than 1416 hectares have been treated under afforestation with massive plantation up to the tune of 625853 saplings of varied species of trees, with 60% survival rate. The construction of settling basin to arrest the estimated silt load of 80,000 tons annually has been functional now for last more than three decades has given satisfactory results and due to these measures a large reduction of silt and sediment load is recorded. However the failure of periodical de-siltation of the settling basin over a period of time has affected the functioning of settling basin and warrants immediate de-siltation of the basin. The removal of marshy peripheral areas including solid land masses through suction cutter dredgers all along shoreline from Nishat Bagh to Habak has resulted in retrieving of 1.5 Sq.km of the lake body. Kundangar and Adnan(2001) while studying the impact of marginal dredging on the ecology of Dal Lake reported increase in depth, ammonical nitrogen and ortho-phosphate levels in waters but decrease in water transparency, pH, dissolved oxygen, BOD and COD after dredging however did not find any significant change in plankton diversity.

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a) Marginal dredging for improvement of water circulation along shoreline from Nishat Bagh to Habak through suction cutter dredgers with removal of slush and land masses.
b) Improvement of Lake Hydrology and hydraulics by way of construction of gated regulators along Boulevard beset with grit removal chambers. Bio filters of masonry and gated regulators to assist in controlling sediment inflow and nutrient leaching during recession. Removal of Kabutar Khana bund and Ishbar bunds to increase the flow of the lake waters besides cuts in the water supply pipeline bund at Nishat. improvement to Nallah Amir Khan outlet by way of have lock channel and flow control structure to enhance the carrying capacity of Nallaha from 4.25 cumecs to37.26 cumecs. Construction of a water conductor at Fatehkadal in order to connect Brari Nambal lagoon of Dal Lake with River Jehlum with gearing system so as to make it possible to drain adequate quantity of water from Brainambal lagoon to river Jehlum.

c) Sewerage and Sewage treatment which constitutes a major component of the Dal lake conservation plan has been tackled by providing Six no STP's (Sewage Treatment plants) based on FAB (Fluidised Aerobic Bed and Bio filters) technology
d) Deweeding of the infested areas of Dal lake through mechanical harvesters and also by traditional manual methods during their peak seasons of growth.

Table. 1 Impact of Dredging on the lake waters of Dal Lake.

Parameters	**Units**	**Av. at Dredged sites**	**Av. At Un-dredged sites**
Depth	M	3.0	0.6
Transparency	M	0.7	0.4
Ph	-	7.9	8.3
D. oxygen	mg1-1	6.5	8.6
Calcium	//	44	42
Magnesium	//	6.5	8.3
Nitrate –N	µg1-1	387.5	572.2
NH4 – N	//	1377	781
O – phosphate	//	29.4	22.7
T – phosphate	//	179.7	188
BOD	mg1-1	19.6	28.5
COD	//	19.6	28.5

The Sewage treatment plants which are presently dealing with about 36 .7 mld of raw sewage entering Dal lake have become controversial from the initiation as the technology adopted(FAB) has been criticized for their mal functioning. Kundangar (2003) while maintaining the FAB based Sewage Treatment Plant of one of the hotels in the immediate vicinity of Dal Lake recorded reversed trend i.e. Instead of expected decrease in nutrients, a significant increase was observed in the treated sewage. According to the author 90-98% increase was recorded in ortho-phosphate and total phosphorus respectively while 32% increase was recorded in nitrate-nitrogen during winter months. LWDA (Lakes and Water Ways Development Authority) in 2006 reported that the concentration of some of the nutrients increased at the outflow stage vis-a-vis inflow stage despite receiving treatment at STP. According the report the percentage efficiency of the two STPs ranged between 63.39 and (-) 36.3. The report further added that the STPs did not match the prescribed norms particularly with regard to inorganic nutrients such as nitrogen and phosphorus .According to the CAG report and audit scrutiny the Union Urban Development Ministry Government of India have had expressed doubts over the effectiveness of STPs during cold weather conditions and sustainability of huge maintenance costs. In similar studies Adnan and Kundangar (2008),(2009) and Shabeena Masoodi et al (2014) regarding the FAB based STP reported 44% increase in nitrate-nitrogen content of the treated sewage indicating malfunctioning of the STPs installed.

Table. 2 Efficiency of nutrient removal through FAB-STP.

Parameters	Raw Sewage	Treated sewage	% Removal
COD mgl-1	190	108	43.1
Po_4 µgl-1	620	390	37
TP µgl-1	1320	805	39
NH_4 - N µgl-1	2810	1392	50
NO_3-N µgl-1	680	1232	44
(after Adnan and Kundangar 2008)			

Since it is an established fact that the aquatic plants (macrophytes) are the bio indicators of pollution and have an important role in nutrient removal from the lake sediment and help in pollution abatement. At the same time the excessive growth of these very aquatic plants impede boat transport, hinder recreational activities, movement of fish, deposition of sediment and over all lake aesthetics. Thus the most sound

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and reasonable management approach is to control their growth.As a result of ingress of liquid wastes an estimated quantity of 18.7 tons of Phosphorus and 25 tons of inorganic Nitrogen are received by the lake which increases the lake fertility and results in accelerated growth of aquatic weeds to a nuisance level (Kundangar et.al 2003).According to LWDA Authorities about 25000 Cum are extracted manually while 100,000 Cum through mechanical harvesters. Kundangar et.al. (2003) while studying the impact of deweeding on Dal Lake recorded a slight shift in pH of water after deweeding in Nehru Park Basin of Dal Lake. The authors concluded that with overall 55% of manual aquatic weed removal in various basins of Dal Lake there was decrease in specific conductivity, iron, and phosphorus. The authors further recorded that the full scale deweeding (80-100%) enhance the release of nutrients from the enriched lake sediment and result in serious and hazardous algal blooms in the lake ecosystem.

Table 3 Impact of deweeding on water quality of Dal Lake.

(A) De-weeding by mechanical means

Parameters	Units	Site I		Site II	
		Pre	Post	Pre	Post
pH	-	9.8	9.1	7.9	8.2
Sp. Conductivity	/µs	224	152	251	289
D. oxygen	Mgl-1	8.4	10.6	9.5	11.5
Iron	Mgl-1	674	232	199	170
Nitrate-N	Mgl-1	801	69	561	90
Total-P	Mgl-1	1262	386	1379	831
Site I Nehru Park basin			Site II Nigeen Basin		

(B) De-weeding by manual means

Parameters	Units	Site I		Site II		Site III		Site IV	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Ph	-	8.8	8.4	8.4	8.2	8.4	8.0	8.4	8.2
Sp. Conductivity	Ms	317	248	291	132	357	258	326	247
D. Oxygen	Mgl-1	8.7	7.4	8.6	8.2	6.5	6.7	7.6	7.4
Iron	Mgl-1	318	122	125	104	157	86	184	157
Nitrate-N	Mgl-1	640	590	721	873	487	768	385	715
Total-P	Mgl-1	627	585	429	388	415	380	389	357
		Site I Nehru Park basin		Site I Nishat basin		Site I Hazratbal basin		Site I Nigeen basin	

It was observed and established that the frequent algal blooms were caused by water stagnation and also due to full scale deweeding practices which would release the nutrients from the lake sediment and trigger the blooms particularly during warm temperatures. The algal blooms viz. red euglenoid bloom, microcystis bloom, volvocale bloom, cynobacterial bloom and Chlorophycian blooms in various stagnant zones of Dal Lake are being controlled by aeration of stagnant waters by deploying floating type of aerators. The aeration of polluted waters resulted in significant increase in oxygen levels of the water with significant decrease of free CO2, nitrates and phosphates.

Table 4 Impact of aeration on the polluted zones of Dal Lake.

Parameters	Units	Before aeration						After 4 weeks of aeration					
		Site I		Site II		Site II		Site I		Site II		Site II	
		S	B	S	B	S	B	S	B	S	B	S	B
pH	-	9.0	9.5	9.3	9.3	8.7	8.4	8.5	8.5	9	8.7	9.6	8.7
D.oxygen	Mgl-1	6.5	5.5	6.7	6.0	10.8	9.4	8.4	6.7	8.0	8.1	10.2	6.4
Free CO_2	Mgl-1	0.25	0.07	0.12	012	0.40	0.92	0.98	0.74	0.48	0.06	0.39	0.58
Iron	µgl-1	2837	512	34	11009	69	232	69	139	313	556	440	614
NO_3	µgl-1	159	132	136	211	232	223	181	100	167	185	204	157
Total P	µgl-1	909	251	348	909	956	828	56	60	128	321	378	424

The houseboats are the most attractive living on Dal Lake waters with every visitor and particularly craze for foreign tourists. However over a period of time the houseboat sanitation has become a serious issue viz a viz health of the lake and that of tourists too. Since all the wastes from toilets of are discharged directly into the lake the same has resulted in deterioration of water quality around the houseboat areas with high bacterial population posing serious threat of waterborne diseases. Adnan and Kundangar (2005) while studying the bacterial dynamics of Dal Lake reported high density of coliforms and faecal coliforms around houseboat areas.

Table 5 Impact of houseboat sanitation on water quality of Dal Lake.

Parameters	Unit	SiteA	SiteB	SiteC
pH		8.1	7.6	7.8
D-Oxygen	Mg-1	7.3	5.7	7.7
Nitrate-M	Ugl-1	793	529	323
Amm-M	Ugl-1	819	716	270
Po4-P	Ugl-1	83.6	240	83.3
Total Colifirm	CUF/100ml	19283	729	400
Faecal Coliform	CUF/100ml	700	38	400

Since the Solid Waste Management in human settlements within the lake and on the periphery is one of the contributory factors for the deterioration of the lake

environment. Solid waste management practices are being followed through door to door collections including the houseboats. The solid waste generated in Dal Lake is calculated as 0.024Kg per person per day with 0.135 polythene bags per person per day. The estimated load of solid waste is 1200 Kg per day besides a high percentage of vegetable wastes. In order to overcome Dal lake area has been declared as "No polythene" zone by the authorities and as such use of polythene bags is totally banned in this area. Other methods adopted include composting and sanitary land fillings.

III. CONCLUSIONS

Although the conservation measures to retrieve the Dal lake are going on for last more than three decades yet there is no appreciable change in the ecological status of the lake, the lake continues under ecological stresses and the water quality does not show any significant improvement. The half-hearted approach and faulty Proposal by the consultants have overshadowed the earlier achievements. The malfunctioning of STPs have made them point source pollutants and the incomplete sewerage system around Nigeen basin of Dal Lake has further aggravated the problems for the management practices. The houseboat sanitation has still remained an unaccomplished job which may cause catastrophe to the tourist industry of the state in near future.

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