International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

Water Quality Assessment of Dal Lake, Kashmir, J&K.

Shabina Masoodi
Associate Professor, SSM College of Engineering and Technology,
Parihaspora, Pattan, Kashmir, J&K.

ABSTRACT

Dal Lake is one of the prized lakes of world; it is part of India's beautiful national heritage and has been the centre of Kashmir's civilization. It has suffered a lot due to the impact of pollution and the present paper is an attempt to assess its water quality. The water quality of the Dal Lake has been seriously altered over a period of time because of human interventions which include agricultural activities within and on the periphery of the lake, urbanization and mushrooming of hotels besides waste discharge into it. The lake thus has turned Eutrophic and is under great stress. Since the lake water is also been harvested for public distribution (potable purposes) this problem has gained significance keeping in view the public health. The zones at the periphery and close to the effluent discharge depict temporal variations. Around fifty percent of the observed maximum specific conductivity, dissolved oxygen, nitrate-nitrogen, ammonical–nitrogen and total phosphorus have been noticed in the spring season. Summer season has twenty five percent of such observations and the remaining twenty five percent are distributed in autumn and winter seasons. This may be possibly due to the start of activities in the catchment, mixing or re-suspension. A comparison of values over a period of time shows that the Dal Lake has passed through several stages of eutrophic evolution. Extensive data establishes far reaching changes in the physico-chemical environment. Dal Lake receives large quantities of nitrogen and phosphorus from incoming sewage drains from non-point sources like seepages and diffused runoff. Of the total phosphorus and inorganic nitrogen inflow from all sources, the quantity contributed by the drains works out to be thirty five percent. Similarly a sizeable quantity of total phosphates and nitrogen are added to the lake from non point sources. Various engineering interventions like catchment management, dredging, de-weeding, sewerage treatment plants etc have been taken but their efficacy is under assessment since the results are not very positive for the health of the Lake.

Keywords: Water quality, Human interventions, Waste discharge, Eutrophication, Engineering intervention.

1. INTRODUCTION:

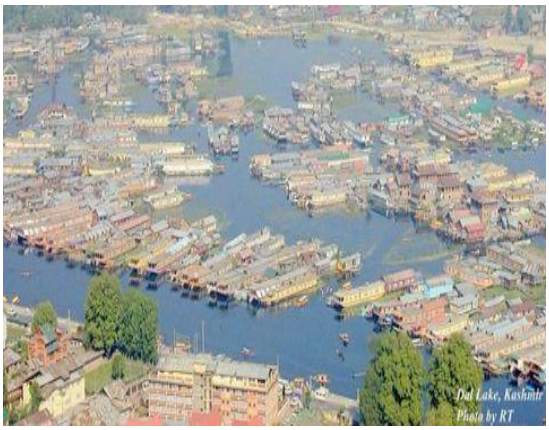
The valley of Kashmir is bordered to the South and West by PirPanjal ranges and to the North and East by the Himalayan foot hills. Numerous freshwater lakes are found within the state of Jammu and Kashmir which covers an altitudinal range of 600m and 500m. These lakes have been originated as a result of earthquakes, damping of glaciers, weathering, denudation, floods and meandering of alluvial deposits. DAL LAKE is one such prized moderate altitude lake located within the geographical coordinates of 34^0 6 N 74^0 45' East of Srinagar spreading over an area of 25 sq Km (1895 AD) and reduced to merely 11.5 Sq Km (2009). It is at an altitude of 1587msl.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

Dal Lake has been the centre of Kashmir civilization and is one of the most beautiful spots of tourist attraction. This shallow-post glacial freshwater body is bounded on Southwest and West by Srinagar city, and its remaining sides are surrounded by gentle terraced slopes at the base of precipitous mountains. Dal Lake is unique because of:

- Floating Gardens with the lake.


- Habitation within the lake.

- Biodiversity.

The Dal Lake lies in the flood plains of river Jhelum whose broad meanders have cut swampy low lands out of the Karewa terraces. The inflow Telbalnallah channel enters the lake from the North bringing water

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

from the high altitude Mansar Lake. During its downward journey the inflow stream collects large quantities of silt from the denuded catchment and deposits it in the lake. Numbers of ephemeral water channels, surface drains enter the lake from the human settlements discharging large quantities of wastes. An estimated load of 12.30 $x10^6 m^3$ of liquid waste with 18.17 tons and 25 tons of phosphorus and inorganic nitrogen is enriching the lake annually. Within Lake Basin itself a number of freshwater springs (mostly choked at present) act as permanent source of water to the lake. Towards the South-west side an outflow channel Tsuant-Kul discharges lake water into Jhelum river at Gawkadal. The outflow is regulated by a sluice gate to prevent the entry of Jhelum water into the lake during the floods. On the Eastern side the Nigeen basin of the lake is connected by nallah or a channel dug by Afghan Governor Amir Khan up to Khushalsar lake, which in turn connects with Anchar lake. This channel also serves an additional outflow channel, particularly during floods. Influx of waste and silt and excessive weed growth in the Lake has affected the quality of its water and the present study it aimed at assessing it.

1. MARGINAL DREDGING AND ITS IMPACT ON WATER QUALITY

The main purpose of dredging is to increase the area of open water to improve water circulation, navigational routes, to create more attractive mosaic and to define margins. As part of the Dal Lake conservation proposals under taken National Lake Conservation Program, NLCP as per the proposals of IRAM consultants, marginal dredging along the shore lines of Dal near Nishat basin and Habak basin was done using suction cutter dredgers. Similar peripheral dredging was also undertaken in the Nigeen basin of the lake. Another consultant AHEC (Roorkee) also had favored marginal dredging but with the remarks that there should be pre-implementation evaluation of lake settings, proper equipment and disposal sites and its effect on lake ecology and long term productivity should be continuously evaluated. AHEC identified 38 channels within the lake which were clogged or reduced in width and proposed to excavate them. Similarly 57 fresh water springs were identified around the lake whose water got polluted during the intervening period they reached the lake. The post dredging changes and a comparative limnology of Dal Lake reported a decrease in Nitrate-nitrogen and total phosphorous content after dredging while increase in Ammonical and ortho-phosphates. The plankton diversity did not show any significant change in dredged and un-dredged sites.

Table1. Comparative changes in Physio-Chemical parameters at dredged and Un-dredged sites in Dal Lake Kashmir.

Parameters	Units	Av. at Dredged sites	Av. At Un-dredged sites
Depth	M	3	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

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

2. DE-WEEDING AND ITS IMPACT ON WATER QUALITY.

Fresh water lakes usually are abound of aquatic vegetation and constitute one of the important components of biodiversity. It is also an established fact that the aquatic plants (Macrophytes) are the bio-indicators of pollution and have an important role in removal of nutrients from the lake sediment and help in pollution abatement. At the same time excessive growth of aquatic weeds impede boat transport hinder irrigation and increase sediment deposition besides effect the lake aesthetics. Thus the most sound and reasonable management approach is to control their growth. In Dal Lake the lake dweller have been doing de-weeding through traditional pole method where in they would whirl the wooden pole in such a skilled way that they would extract the weeds and use them for preparation of vegetation gardens or as bio fertilizers. They would also take out the bottom mud and use it for vegetable garden preparations. But when the weed infestation in the lake basins increased beyond proportion the authorities concerned had to deploy mechanical harvesters which also became an issue of controversy among the lake scientists.

According to the consultants the de-weeding in Dal should be selective. AHEC, Roorkee (2000) states; based on the information available, it is recommended that de-weeding has to be selective and limited to certain areas only especially areas which are useful to repeated harvesting. According to the consultants de-weeding should be limited to backwaters, areas where exotic water ferns, water lilies abound and areas where water skilling or swimming takes place. They further suggest that in areas selected for de-weeding it is very important that only 40% - 50% weed is removed and the rest is left untouched. Efforts should be directed towards harvesting undesirable plant species such as Ceratophyllumdemersum, NymphaeaStellataSalvinianatans and Hydrocharismorusranae.

According Trisal (1977, 1987) TyphaAgustata and Phragmitescommunis were the chief occupants of littoral zone of Dal and Nigeen Lake and extended all along the Eastern part of the Southern side of the Hazratbal basin. In the Nishat basin and Nigeen basin the emergents are scattered towards the shorelines and formed large stands in the arms of the lake basin.

According to the author rooted floating leaf macrophytes (Aquatic plants) occupy 29.2% of total area of the lake free floating aquatic ones were distributed throughout the lake area in sheltered pockets. Submerged aquatic species due to their aggressive capacity cover the maximum area of 57.6% in all the basins of the lake.

Zutshi and Tickoo (1990) while studying the impacts of mechanical de-weeding in Dal Lake recorded the reduction in Seechi transparency of water and attributed it to the suspension of sediments due to impact of harvesters. The authors however noted the increase in dissolved oxygen content by 23 % in the surface waters and by 36% in bottom waters. They further recorded significant temporal change in nitrate nitrogen but little horizontal and vertical difference as a result of de-weeding.

Kundangar (1996) while studying the impact of waste waters on the vegetation pattern of Dal Lake reported surprising changes in the Dal Lake basins and reverted the increase in abundance of some eutrophic species. He attributed the luxuriant entering the lake besides the enrichment of sediments through leaching of fertilizers in the immediate agricultural lands surrounding the lake.

Kundangar (2003) while studying the impact of de-weeding in Dal Lake estimated liquid wastes carrying 18.7 tons of phosphorus and 25 tons of inorganic nitrogen into the lake which results in increase in fertility of lake waters and resulting in accelerated weed growth. They also added that major part of phosphorus and nitrates coupled with other nutrients get locked up in the roots and rhizomes of the aquatic weeds. Thus these aquatic weeds play significant role in keeping the water crustily more or less in stable condition. But these aquatic weeds on decaying during autumn-winter go on enriching the sediment with nutrients and play an active role in re-growth of aquatic weeds in the next spring.

The authors recorded a slight shift in pH of water in Nehru Park and Nigeen basin (Table 2). After de-weeding 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 also recorded that the full scale de-weeding (8-100%) enhance the release of nutrients from the enriched sediment and result in serious and hazardous algal blooms in a Lake ecosystem particularly in Dal Lake. The authors stressed on

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

long term studies to establish a set of standards both for water quality and biodiversity changes as a result de-weeding practices in the Lake ecosystem.

Table 2a: Pre and post de-weeding changes in water quality by Mechanical de-weeding in Dal Lake Kashmir (after Kundangar 2003)

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		

Table 2b: Pre and Post de-weeding changes in water quality by Manual de-weeding in Dal Lake (after Kundangar 2003).

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 II Nishat basin		Site III Hazratbal basin		Site IV Nigeen basin	

3. SEWERAGE AND SEWAGE TREATMENT AND ITS IMPACT ON WATER QUALITY

Sewerage and sewage treatment constitutes a major component of the Dal lake conservation plan for preventing the pollution of the lake. The Dal Lake receives water from fifteen major drains besides inflow from the Telbal and Bota-kadalNallahs. The drains bring in 40 mld of sewage and join the lake at locations identified. Two alternative plans for sewage treatment were envisaged. One proposed conceptualized a centralized sewage treatment where in all the waste will be collected by sewers (gravity mains) and trunk sewers with 15 immediate pumping stations (IPS) and a main pumping station, at Brarinambal. This unit of about 41 mld will treat the sewage through an activated sludge process and release treated waste effluent through Brainambal cut into Jhelum. This system through theoretically very sound has some inherent weakness, such as power dependence (in pumping and treatment) large size trunk sewers and large distance of transport. The power scenario in Srinagar town is dismal and utilizing it for pumping sewage as against

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

domestic requirements seems as far cry. Moreover, failure of system or any component will put the entire machinery out of gear. To obviate these difficulties a decentralized system is preferred and has been proposed, which could do away with a large amount of pumping and trunk sewers. The bulk of the sewage will flow by gravity and pumping will be restored to only when there is no alternative.

The STP's will be provided at least at six sites in Dal Lake and two or three at Nigeen. The treated effluent of three STP's will flow out of the lake and the rest after tertiary treatment will be discharged into the lake (around 40%). The total sewage generated in all three zones worked out to be 36.7 mld in the year 2017. A total of nine IPS, one in zone one, six (under construction) in zone 2 and two (existing) in zone 3 are proposed. The decentralization has resulted in a significant reduction in the cost of sewers and of operation and maintenance.

Sewerage treatment.

There are numerous options available to treat the waste water. These include dispersed and attached growth aerobic systems. (Activated Sludge process, Aerated Lagoon, Oxidation ditch, Trickling filter and Rotating Biological Discs), suspended and attached growth anaerobic systems (up flow anaerobic Sludge Blanket, expanded bed, fluidized bed) and pond processes. In recent past the artificial wetland compartment technology has also gained momentum in the developed countries where in aquatic plant species are exploited for waste water treatment. According to the AHEC consultancy the FAB (Fluidized Aerobic Bed and Bio-filters) technology was considered and recommended for Dal Lake.

FAB technology consists of screening, grit removal, biological treatment (bioreactors), tertiary treatment of clarifloculator (with alum), centrifuge and chlorination. The six units were proposed of which five have been made operational.

STP 1 (a)	Habak	3.2mld
STP 1 (b)	REC	7.5mld
STP 1 (c)	Nallah Amir Khan	5.4mld
STP 2	BrariNambal	9.5mld
STP 3 (a)	Hotel Heemal	6.6mld
STP 3 (b)	Laam	4.5mld
Total		36.7mld

The treated effluent of STP 1 (c) and 3 (a) is discharged in channels leaving Dal Lake via Amir Khan. Dalgate exit and Brari-Nambal cut). Thus only 40% of the total of 36.7 mld finds its way into the Dal Lake.

Controversy regarding FAB Technology:

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.

In their studies during April 2008 (Table 3a) regarding the functioning of FAB based STP reported 44% increase in nitrate-nitrogen content of the treated sewage indicating the malfunctioning of the STP's installed.

Table 3(a) Efficiency of nutrient removal through FAB – STP (April 2008) (after Adnan and Kundangar 2008)

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 5
May 2017

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

CONCLUSION-WATER QUALITY ASSESSMENT

Water quality of the Dal Lake has been seriously altered over a period of time because of human interventions which include agricultural activities within and on the periphery of the lake, urbanization and mushrooming of hotels besides waste discharge. The lake thus has turned Eutrophic and is under great stress. Since the lake water at Nishat and Nigeen is also harvested for public distribution (Potable purposes), the quality of water has therefore assumed a great significance keeping in view the public health.

The zones at the periphery and close to the effluent discharge depict temporal variations. Around 50% of the observed maximum specific conductivity, dissolved oxygen, nitrate-nitrogen, ammonical–nitrogen, PO4 and total phosphorus have been noticed in the spring season. Summer season has 25% of such observations and the remaining 25% are distribution in autumn and winter seasons. This may possibly be due to the start of activities in the catchment, mixing or re-suspension (LAWDA, 2000 report).

A comparison of values over a period of time (Table 4) shows that the Dal Lake has passed through several stages of trophic evolution. Extensive data establishes far reaching changes in the physico-chemical environment. Dal Lake receives large quantities of nitrogen and phosphorus from incoming sewage drains, TelbalNallah and that of BhotaKadal as well as from non-point sources like seepages and diffused runoff.

The lake being peculiar in having human habitations within the lake either in hamlets (Islands), boats, house boats etc of the total phosphorus inflow 156.62 tons from all sources, the quantity contributed by the drains works out to be 56.36 tons. In the case of inorganic nitrogen (NO3 and NH3-N) these figures are 241.18 tons and 77.60 tons with a flow of 11.70 million cum/yr. Similarly 4.5 tons of total phosphates and 18.14 tons of nitrogen are added to the lake from non point sources.

Table 4a: Water Quality changes in Hazratbal Basin of Dal Lake over a period of time

Parameters	Units	Year 1977*	Year 2000**	Year 2013***
pH	-	7.7-9.5	7.1-8.6	7-9.5
Conductivity	µs	290-485	226-670	240-712
Dissolved oxygen	µgl	2.2-12	3.6-9.4	1.5-8.8
Nitrate –nitrogen	µgl-1	80-650	120-1377	110-1400
Amm. Nitrogen	µgl-1	20-30	98-1519	90-1600
Total phosphorus	µgl-1	62-623	400-700	450-980

Table 4b: Water Quality changes in Nishat Basin of Dal Lake over a period of time

Parameters	**Units**	**Year 1977***	**Year 2000****	**Year 2013*****
pH	-	7.4-9.5	7.3-8.8	7.5-10.8
Conductivity	µs	279-431	170-485	150-380
Dissolved oxygen	µg1	5.5-11.5	5.2-9.8	2.5-9.5
Nitrate –nitrogen	µgl-1	95-691	105-899	150-1990
Amm. Nitrogen	µgl-1	5-28	98-729	90-750
Total phosphorus	µgl-1	65-620	415-712	460-850

Table 4c: Water Quality changes in Nehru Park basin of Dal Lake over a period of time

Parameters	**Units**	**Year 1977***	**Year 2000****	**Year 2013*****
pH	-	7.5-9.5	7.6-9.2	7.5-9.2
Conductivity	µs	302-543	221-631	220-650
Dissolved oxygen	µg1	4.5-10.5	2.0-9.2	1.5-9.8
Nitrate –nitrogen	µgl-1	80-603	126-2350	130-2412
Amm. Nitrogen	µgl-1	9-26	105-352	130-350
Total phosphorus	µgl-1	70-506	403-815	480-992

Table 4d: Water Quality changes in Nigeen Lake over a period of time

Parameters	**Units**	**Year 1977***	**Year 2000****	**Year 2013*****
pH	-	7.7-9.5	7.2-9.0	7.5-805
Conductivity	µs	305-490	282-1072	220-980
Dissolved oxygen	µg1	0.8-10	3.2-10	0.5-9.5
Nitrate –nitrogen	µgl-1	90-632	105-3337	120-3210
Amm. Nitrogen	µgl-1	5.25	93-1244	90-1268
Total phosphorus	µgl-1	90-873	330-891	230-1020

REFERENCES:

- 1978, Pollution of Dal Lake, Enex.
- 1990. Impact of mechanical de-weeding on Dal lake eco system, Zutshi&Tickoo.
- 1993. Effects of weed cutting on species, composition and abundance of plankton population, Zutshi&Tickoo.
- 1996, Impact of waste water on the vegetational pattern of Dal Lake, Kundangar.
- 1996. Aeration of Dal lake (an interim report) HRL.
- 1997, Dal Lake conservation & rehabilitation. (J&K LAWDA).
- 1998, Technical report on Dal Lake (J&K LAWDA).
- 1999, Technical report on Dal Lake (J&K LAWDA).
- 2000, Technical report on Dal Lake (J&K LAWDA).
- 2000. DPR conservation and management plan for Dal –Nigeen lake-AHEC Roorkee.
- 2001, Post dredging changes & comparative limnology of Dal Lake, Kundangar.
- 2003, De-weeding practices in Dal Lake & impact assessment.Kundangar.
- 2004, Thirty years of Ecological Research on Dal Lake, Kundangar.
- 2004, Groundwater quality of downtown Srinagar, Adnan, Neelofer, Nuzhat and Kundangar. 2005.
- 2004, Bacterial Dynamics of Dal Lake, a Himalayan temperate fresh water lake, Adnan &Kundangar.
- 2005. Ecology of peripheral springs of Dal lake, Kashmir Adnan &Kundangar.

- 2009, Monitoring of Dal-Nigeen Lakes & other water bodies (J&K PCB).
- 2009. Three decades of Dal Lake, Adnan &Kundangar.
- 2010, Sanative role of macrophytes in Aquatic Ecosystems, Adnan.
- 2011, Water quality changes in Nigeen Lake, Shariqa Maryam.
- 2011. Ecological studies & uses of valued aquatic plants in Kashmir wet lands, Adnan, Afsha&Kundangar.
- 2012, Impact of mechanical de-weeding on Macrozoobenthic community in Dal Lake, Basharat, Rajini, AR Yousuf&Ashwani.