Sengupta, M. and Dalwani, R. (Editors). 2008.
Proceedings of Taal2007: The 12th World Lake Conference: 286-291

Water Quality and Eutrophication Status of Some Lakes of the Western Himalayan Region (India)

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ABSTRACT

The water bodies are facing a severe threat of pollution all over the world. To ensure fresh water availability from the local water sources has become a big challenge. The main objectives of this paper are to assess water quality and eutrophication status of various lakes situated in the Western Himalayan part of India. Lakes situated in J&K (Mansar, Surinsar, Dal, Tsokar, Tsomoriri lakes) and Himachal Pradesh (Renuka Lake) have been studied.

The study has shown most of physico-chemical parameters lied within range for drinking and irrigation purposes in the Mansar, Surinsar, and Dal lakes. However, water quality for the lakes of Ladakh region ((Tsomoriri and Tsokar) was found to show very distinct characteristics due to prevailing cold desert type climate having a very low rainfall in the order of 100 mm. As such, unusually a very high concentration of certain water quality parameters viz. pH, Total Dissolved Solids, Total Hardness, Chloride, calcium, magnesium were obtained in Tsomoriri and Tsokar lakes of Ladakh region, which may be treated as brackish water. Fe, Mn and Pb were found to be exceed the limits for drinking water as per BIS (1991) in Renuka lake (H.P.). The data of DO indicated that hypolimnion layer of the Himalayan lakes remain mostly under anxious condition. The lakes also remain stratified during summer and become overturn during winter months. The eutrophication status in all lakes has been assessed using phosphate data, which showed Mansar, Surinsar and Tsomoriri under eutrophic, Dal, Tsokar and Renuka lakes under hyper-eutrophic condition.

Key words: Western Himalayas, Water Quality, Carlson's TSI, Eutrophication, Lake

INTRODUCTION

Lakes are important source of fresh water in the Himalayan Region. Generally, the lakes represent additional storage capacity of hydrologic systems. Natural or artificial changes in storage either in quality or quantity of water may alter not only the stream flow regime but also the water balance of the region, affecting ecological balance in the region. The hydrologic status of water of a lake in terms of quantity, quality and regimen is results of complex processes of physical, chemical and biological inputs. The physical features include wind, terrain relief, water current, temperature, light level etc. The chemical environment consists of water, gases like oxygen, minerals, trace metals and other complex chemicals.

The relationship between healthy humans and clean drinking water goes back more than 200,000 years when modern humans first emerged. As hunter gatherers we were directly dependent on the availability of resources in our immediate environment-foremost of which was reliable and clean source of drinking water. Later, when we developed agriculture and industry, the increasing rate of human exploitation and modification of the environment adversely affected the health of wetlands, some of which are now no longer able to provide the clean drinking water upon which we are dependent. Sources of drinking (and irrigation) water now often contain toxic pollutants that poison plants, fish and people, and microbial pathogens that kill almost two million children annually worldwide.

Despite the capacity of fresh water wetlands to purify water, they do have their limits. They can only deal with so much agricultural runoff, so much inflow from domestic and industrial wastes. And of course the human species is capable of adding much more toxic chemicals, antibiotics from animal husbandry, untreated human sewage, pesticides that acts as 'endocrine disrupters' and more. We can, and do, readily move beyond the purifying powers of wetlands so that these sources of fresh water, and the food they supply, are rendered unfit for consumption and pose a danger to human health (Ramsar, 2008).

The water quality problems and concerns for eutrophications are not only restricted to the urban lakes, but these threats have expanded to the rural lakes as well. The lakes of Himalayan regions are no exception. Therefore, the present study was undertaken to study the water quality and eutrophication status for the Himalayan lakes.

Study Area

The present study deals with the lakes located in the State of Jammu & Kashmir (Mansar, Surinsar, Dal, Tsomoriri, Tsokar) and Himachal Pradesh (Renuka

Lake), in the Western Himalayas. A map showing location of these lakes in Western Himalayan Region have been shown in Fig. 1. The Dal lake is located in Kashmir region; Mansar, Surinsar in Jammu region and Tsomoriri and Tsokar lakes in Ladakh Region. Dal lake is an urban lake which is under National Lake Conservation Plan and remaining are non urban lakes representing fresh water lakes (Mansar, Surinsar) and brackish/salt water lakes (Tsokar, Tsomoriri). Tsomoriri lake is one among the 19 site of Ramsar Convention of international importance in India. These lakes are of great socio-economic importance and are famous for their picturesque view and most of them are being used for drinking and irrigation purposes.

The Renuka lake is one of the natural wetlands located in the Sirmour district of the Himachal Pradesh. The Renuka lake is a very important tourist & religious place of the HP. Being situated in the main range of lesser Himalayas, this wetland is of special importance from bio-diversity point of view. The National Wetland Management Committee of the Ministry of Environment & Forests (Govt. of India) has recognized the Renuka lake as one of important wetlands of the country, which requires conservation and management on priority basis (State Council for Science, Technology & Environment, Govt. of HP). This lake also finds placed in the priority list of lakes, which required immediate attention for restoration under the title "Management of Lakes in India"(Reddy & Char, 2004). The lake is located in a long valley and the surrounding slopes are covered with a variety of vegetation and thick woods. The supply of the lake is through nallahs draining the catchement and probably numerous underlying springs. The basic information of the lakes under this study are given in Table 1.

Review

Various investigators have reported their studies on various aspects of the Himalayan region lakes (Zutshi, 1989; Omkar & Sharma, 1994-95; Jain et al., 1999, Kumar et al. 1999a, Kumar et al. 1999b; Das and Dhiman, 2003; Shewa, 1998, Rai et al; 2006, 2007). Physico-chemical and biological characteristics of Mansar lake have been studied by Zutshi (1985, 1989), Chandra Mohan (1992) and Gupta (1992). Zutshi et al. (1980) have reported that lakes of Jammu and Kashmir are different in their morphology and thermal behaviour and vary from sub-tropical monomictic to dimictic type. Rai et al. (2001) performed studies on bathymetry, rate of sedimentation and water quality of Mansar lake during 1998-99. Few studies have also been reported for the Renuka lake, which include mainly morphometry, general water quality and catchment related aspects of the Renuka Lake (Singh et. al, 1987; Anonymous, 1996, 2004).

Data & Methodology

In the present study, water quality data of the Mansar, Surinsar (Jammu Region), Dal lake (Kashmir Region), Tsomoriri and Tsokar lakes (Ladakh Regions) of Jammu and Kashmir and Renuka Lake (H.P.) has been used. The data includes mainly: Temperature, pH, EC, TDS, DO, Ca, Mg, Na, K, Alkalinity, HCO_3, Cl, SO_4, NO_3, PO_4, F, Hardness. In few lakes, water quality deterioration due to the bacterial contamination of lakes has also been reported. In-situ measurements of temperature, pH and EC were also made using portable instruments. Standard Water Sampler was used for depth wise sampling in the Mansar Lake.

The water quality of the Dal lake has been described based on the published data (Handa et al., 1991). Water quality of the lakes was evaluated for drinking (BIS, 1991). The data of phosphate obtained in different years was used to study eutrophication status of these lakes on the basis of Trophic State Index (Carlson, 1977).

Table 1. Basic Information of the Lakes

S. No.	Details	Lakes					
		Mansar	Surinsar	Dal	Tsomoriri	Tsokar	Renuka
1	District	Udhampur	Jammu	Srinagar	Leh	Leh	Sirmaur
2	Type of lake	Rural	Rural	Urban	Rural	Rural	Rural
3	Latitude	32^0 40' 58.25" N	32^0 46' 30" N	34^0 5' N	32^0 48' 16" N	33^0 4' 14" N	30^0 36' N
4	Longitude	75^0 5' 11.5" E	75^0 2' 30" E	74^0 51' E	78^0 12' 51" E	79^0 5' 32" E	77^0 27' E
5	Altitude (m)	666	604	1580	4527	4225	645
6	Max. depth (m)	38.25	24.05	6.0	30.00	-	13
7	Area (Sq. Km)	0.59	0.32	11.7	141.05	0.55	0.18

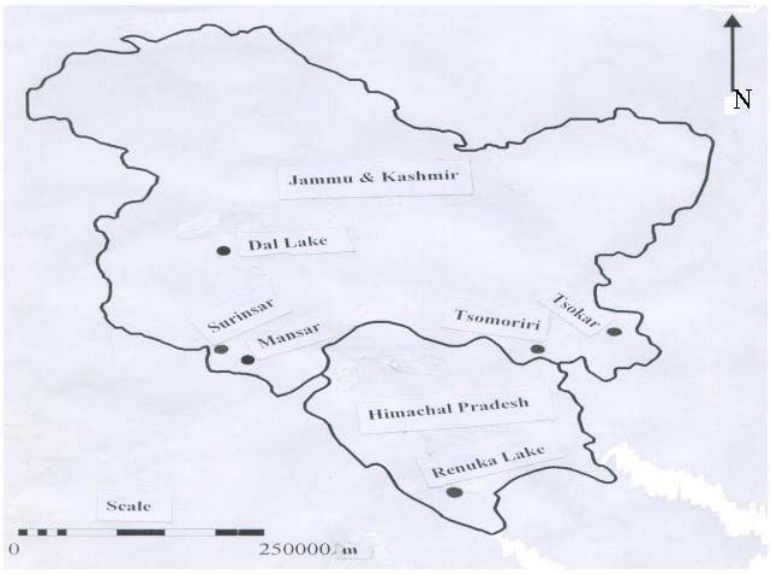

Figure 1. Map showing location of lakes studied in J&K and HP falling under the Western Himalayan Region

Table 2. Water quality status for different lakes of J&K

Para-Meters	Class-A drinking water	Mansar		Surinsar	Dal	Tsomoriri	Tsokar
		Surface	Bottom	Surface	Surface	Surface	Surface
pH	6.5-8.5	7.95-8.04 (7.99)	7.98-8.12 (8.03)	8.2-8.86 (8.43)	7.16-9.36 (8.65)	8.9-9.02 (8.96)	8.8-8.84 (8.82)
EC	-	184-204 (194)	265-281 (273)	510-600 (545)	122-317 (181)	3360-3740 (3550)	62720-64340 (63530)
TDS	500	118-131 (124)	170-180 (175)	310-380 (350)	78-202 (116)	2150-2393 (2272)	40141-41178 (40659)
DO (min)	6	3.3-6.6 (5.5)	0.3-0.6 (0.45)	7.2-8.6 (7.8)	5.8-10.0 (7.96)	-	-
BOD (max)	2	1.2-6 (2.08)	1.2-14 (7)	0.6-1.2 (0.9)	-	-	-
HCO_3	-	121-129 (125)	173-178 (177)	120-140 (127)	49-140 (88)	0-2 (1)	2-6 (4)
TH	300	44-56 (53)	82-94 (88)	100-160 (136)	42-164 (88)	3161	18292-21195 (19743)
Cl	250	4-10 (6)	4-8 (7)	7-12 (10)	6-18 (10)	24 (24)	8850-9206 (9028)
SO_4	150	1-4 (2)	1-3 (1.6)	8-18 (11)	-	32-144 (88)	16-36 (26)
PO_4	-	0.01-0.3 (0.1)	0.12-0.18 (0.15)	0.03-0.11 (0.05)	0.0-0.56 (0.09)	0.03-0.04 (0.03)	0.16-0.43 (0.3)
NO_3	45	0.44-2.2 (0.76)	0.5-5 (1.5)	4-6 (5)	0-7 (0.7)	-	-
Ca	75	14-18 (17)	29-32 (30)	32-48 (38)	14-46 (24)	30-40 (35)	760-1840 (1300)
Mg	30	2-4 (2.5)	2-4 (2.8)	5-19 (13)	2-12 (7)	744-750 (747)	3330-4690 (4010)
Na	-	15-17 (15.6)	14-16 (15)	10-11 (10)	2-8 (4)	89-1493 (791)	628-1493 (1061)
K	-	3 (2.8)	3 (2.6)	4-6 (4)	0.2-4 (0.9)	98-319 (209)	1470-1960 (1715)
F	1.5	0.01-0.32 (0.14)	-	-	-	0.44-0.50 (0.47)	0.42-0.60 (0.51)

RESULTS AND DISCUSSION

Water Quality Status of Lakes in J&K

The variation of water quality parameters of various studied lakes along with their average values are given in Table 2. The Table shows a wide range of variation of water quality parameters for the lakes of Ladakh Region in comparison to the lakes of Jammu and Kashmir Regions. The study has shown pH values greater than 7.0 for all lakes under this study, which indicate alkaline nature of lake water with varying scale of alkalinity. The average values of pH in Dal (8.65), Tsomoriri (8.96) and Tsokar (8.82) lakes were found beyond permissible limits for drinking purposes. Parameters, namely: TDS (2272 mg/l), TH (3161 mg/l), Mg (747 mg/l) in Tsomoriri lake and TDS (40659 mg/l), TH (19743 mg/l), Cl (9028 mg/l), calcium (1300 mg/l), magnesium (4010 mg/l) in Tsokar lake were obtained many fold higher than their prescribed limits for drinking purposes. It could be primarily due to presence of evaporites in lakes of Ladakh division attributed in cold desert type climates. GSI (1977) has also reported exceptionally very high values of salt containing constituents in the Ladakh division.

Water Quality Status of Renuka Lake (H.P.)

The water quality of the Renuka lake has been evaluated for drinking purpose based on physico-chemical and bacteriological parameters of water quality (Tables-3 & 4). In the present study, the dissolved oxygen has been observed in the order of 1ppm in the bottom of the lake, which shows anoxius condition in the hypolimnion zone of the lake. The study has shown that lake water belongs to hard water category, which is caused primarily due to dominance of magnesium and calcium in the lake water. The bacteriological analysis has shown that surface water was well within the limits for drinking purposes. However, the bacterial contamination in hypolimnion zone of the lake was observed from 0 to 150 MPN/100 ml of total coliforms, which is beyond the permissible limits for drinking purposes. The trace element analysis has shown that Fe, Mn and Pb were found to exceed the limits for drinking water as per BIS (1991).

Eutrophication Status of Lakes in J&K and H.P.

The process of eutrophication is defined as the loading of inorganic and organic dissolved and particulate matter to lakes at rates sufficient to increase the potential for high biological production that leads to a decrease in the capacity of the lake. It is usually measured using one of several trophic state index (TSI) of algal weight (biomass): water transparency (Secchi Depth, TSI-SD), algal chlorophyll (TSI-Chl), and total phosphorus (TSI-TP) (Carlson, 1977).

In the present study, eutrophication status of lakes has been studied based on Carlson's Trophic State Index (Carlson, 1977) using phosphate data. The results are given in Tables 5 & 6, which indicated eutrophic condition of Mansar, Surinsar and Tsomoriri lakes for the epilimnion zone. Dal and Tsokar lakes were found to be under hypertrophic condition. The Carlson's Trophic State Index has shown that Renuka lake has entered under hypertrophic condition for the past several years.

Table 3. Water quality (in mg/l) status of the Renuka Lake (H.P.)

Parameters	BIS, 1991 (Class-A)	1996 (PCB, Shimla)		Oct. 2006	
		Surface	Bottom	Surface	Bottom
pH	6.5-8.5	8.2	8.5	7.4	7.34
TDS	500	147	380	329	343
DO	6 (min)	7	-	6.7	1.01
BOD	2 (max)	3.2	3.4	1.74	2.18
TH	300	282	475	302	322
Cl	250	17	3.8	1.5	2
SO_4	150	94	56	70	68
NO_3	45	0.01	0.25	1.7	18
Ca	75	180	-	51	58
Mg	30	102	-	42	43
F	1.5	-	-	0.98	0.92

Table-4. Bacterial Contamination in the Renuka lake (2006)

Statistical Measure	Surface		Bottom		BIS, 1991 Limits
	Total Coliforms	Faecal Coliforms	Total Coliforms	Faecal Coliforms	
Min.	0	0	0	0	(50 MPN/100ml)
Max.	9	4	150	28	
Mean	1.63	0.5	41.8	10	
Std. Dev.	3.29	1.41	36.57	7.42	

Table 5. Eutophication status of the lakes in J&K

Lakes	Phosphate, µg/l	TSI (TP)	Trophic Status	Year
Mansar	14 (Epilimnion)	42.20	Mesotrophic	Zutshi, 1989
	80 (Epilimnion)	67.00	Eutrophic	June, 1999 (Rai et. al., 2001)
	100 (Epilimnion)	70.00	Eutrophic	May, 2004
	150 (Hypolimnion)	76.00	Hypertrophic	May, 2004
Surinsar	50	61.00	Eutrophic	1995
Dal	115	72.00	Hypertrophic	1985
Tsomoriri	30	53.00	Eutrophic	2000
Tsokar	300	86.00	Hypertrophic	2000

Table 6. Eutrophication status of the Renuka (H.P.)

Year	Phosphate (mg/l)		TSI (Phosphate)		Av. TSI	Trophic Status
	A	B	A	B		
1983 (Pangtey & Joshi, 1987)	0.222	0.37	82.05	89.23	85.6	Hyper-eutrophic
2004 (PCB, Shimla)	0.23	0.25	82.57	83.77	83.2	Hyper-eutrophic
2006	0.2	0.23	80.55	82.57	81.6	Hyper-eutrophic

CONCLUSIONS

The study has shown most of physico-chemical parameters lie within range for drinking and irrigation purposes in the Mansar, Surinsar, and Dal lakes. However, water quality for the lakes of Ladakh region ((Tsomoriri and Tsokar) was found to show very distinct characteristics due to prevailing cold desert type climate having a very low rainfall in the order of 100 mm. As such, unusually a very high concentration of certain water quality parameters viz. pH, Total Dissolved Solids, Total Hardness, Chloride, calcium, magnesium were obtained in Tsomoriri and Tsokar lakes of Ladakh region, which may be treated as brackish water. Fe, Mn and Pb were found to exceed the limits for drinking water as per BIS (1991) in Renuka lake (H.P.). The data of DO indicated that hypolimnion of the Himalayan lakes remain mostly under anuxious condition. The lakes also remain stratified during summer and become overturn during winter months. The eutrophication status in all lakes has been assessed using phosphate data, which showed Mansar, Surinsar and Tsomoriri under eutrophic, Dal, Tsokar and Renuka lakes under hyper-eutrophic condition.

ACKNOWLEDGEMENT

The authors are grateful to Dr. K.D. Sharma, Director, National Institute of Hydrology, Roorkee, for kind permission to submit this paper for the present seminar. Authors are also thankful to all concerned officers and research staff of WHRC, Jammu/EHD for their contribution in the field investigations for lake studies.

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