



## Assessment of Water Quality and Eutrophication of Lakes

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### *Abstract*

In this study, water quality and eutrophication aspects of Mansar, Surinsar, Tsokar, Tsomoriri and Renuka lakes have been discussed. The water quality parameters were compared with BIS standards for drinking purposes. The values of physico-chemical water quality parameters for Mansar and Surinsar lakes (Jammu Division) were found within the desirable limits except low DO in hypolimnion. Whereas, the values of physico-chemical parameters for Tsomoriri and Tsokar lakes (Ladakh region) were found beyond limits having much higher concentration of pH, total dissolved solids, total hardness, chloride, calcium, magnesium. The water quality of Renuka lake shown higher concentration of magnesium, iron, manganese, lead, total coliform, faecal coliform and low DO in hypolimnion. The eutrophication status assessed on the basis of phosphate concentration show eutrophic condition of Mansar, Surinsar, Tsomoriri and hyper-eutrophic condition of Tsokar and Renuka lake. The results indicate that efforts are required to lower the existing eutrophication levels by adopting conservation measures for the lakes.

**Keywords :** *Carlson's TSI, Eutrophication, Lake, Water Quality, Western Himalayas.*

### 1. INTRODUCTION

The Himalayas are endowed with hundreds of relatively smaller fresh water lakes, which used as natural centers of civilization and to cater the civilian needs. Many lakes are unique ecosystems and valuable from the historical, cultural, biological and socio-economic point of view. They serve variety of purposes like- drinking, irrigation, recreational, aqua-culture, etc. However, with the exponential growth of population in India, the land and water resources are facing a tremendous pressure and Himalayannatural resources are no exception to this fact. Consequently, intensive agricultural practices, encroachments up to the lakeshore, disposal of solid wastes, and discharge of domestic and industrial wastes have posed a serious problem of water quality degradation. The felling of trees for wood/energy

requirements, cultivation on mountainous catchments coupled with indiscriminate use of chemical fertilizers, insecticides and pesticides has also enhanced problem of water quality degradation and eutrophication of water bodies. A large scale fish mortality often observed in most of the Himalayan lakes during winter and posing threat to ecological imbalances in the region.

The Ramsar Convention on wetlands has notified 26 lakes/wetlands as international importance in India. Of them, six are located in the Western Himalayan Region namely, Renuka (H.P.), Mansar-Surinsar, Tsomoriri, Wular and Hokera wetlands in Jammu & Kashmir. In this study, water quality and eutrophication status has been assessed for five Himalayan lakes (Renuka, Mansar, Surinsar, Tsomoriri and Tsokar lakes).

### 2. STUDY AREA

The present study deals with the lakes

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located in the State of Jammu & Kashmir (Mansar, Surinsar, Tsomoriri, Tsokar) and Himachal Pradesh (Renuka) in the Western Himalayas. Tsomoriri and Tsokar lakes fall under Ladakh Region having cold desert type climate with annual rainfall in the order of about 100 mm. The Mansar and Surinsar lakes are situated in the Lower Siwalik (Jammu Region). Mansar lake receives fresh water through rain over the lake basin area and large number of subterranean springs within the base of the lake. The rain water flows into the lake through overland flow. Climatically, the Jammu region falls under the subtropical zone and average annual rainfall is 1500 mm with air temperature variation from 3<sup>0</sup> C (minimum) in winter to 43<sup>0</sup> C (maximum) during peak summer.

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 wetl and is of special importance from biodiversity 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 rests 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 catchment and probably numerous underlying springs. The information of the lakes under this study are given in Table 1.

### 3. REVIEW

A number of studies have been reported in the area lake investigations (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) 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, sedimentation rate and water quality of the Mansar.

However, studies on Renuka lake are reported limited and include mainly morphometry and water quality aspects lake (Singh et. al, 1987;

**Table 1. General information about the lakes under this study**

Details	Lakes				
	Mansar	Surinsar	Tsomoriri	Tsokar	Renuka
District	Udhampur	Jammu	Leh	Leh	Simaur
Latitude	32 <sup>0</sup> 40' 58.25" N	32 <sup>0</sup> 46' 30" N	32 <sup>0</sup> 48' 16" N	33 <sup>0</sup> 4' 14" N	30 <sup>0</sup> 36' N
Longitude	75 <sup>0</sup> 5' 11.5" E	75 <sup>0</sup> 2' 30" E	78 <sup>0</sup> 12' 51" E	79 <sup>0</sup> 5' 32" E	77 <sup>0</sup> 27' E
Altitude (m)	666	604	4527	4225	645
Max. depth (m)	38.25	24.05	30.00	-	13
Area (Sq. Km)	0.59	0.32	141.05	0.55	0.18

Anonymous, 1996, 2004).

#### 4. MATERIAL & METHODS

In the present study, water quality data of the Mansar, Surinsar (Jammu Region), Tsomoriri and Tsokar lakes (Ladakh Regions) of Jammu and Kashmir and Renuka Lake (H.P.) has been used. The data includes mainly: pH, EC, TDS, DO, Ca, Mg, Na, K, Alkalinity, HCO<sub>3</sub>, Cl, SO<sub>4</sub>, NO<sub>3</sub>, PO<sub>4</sub>, F, Hardness. 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 analysis of the water samples was carried out using standard procedures (APHA, 1985/Jain & Bhatia, 1987). The water quality of the lakes was evaluated

as per BIS (IS 10500: 1991) for drinking purposes. 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).

#### 5. RESULTS AND DISCUSSION

##### Water Quality

The variation of water quality parameters of different lakes under this study are given in Table 2. The study has shown pH values greater than 7.0 for all lakes under this study, which indicate alkaline nature of lake water. The average values of pH of Tsomoriri (8.96) and Tsokar (8.82) lakes were found beyond permissible limits for drinking purposes. The values of TDS (2272 mg/l), TH (3161

Table 2. Water quality assessment of Mansar, Surinsar, Tsomoriri and Tsokar lakes

Para-Meters	Class-A drinking water	Mansar		Surinsar	Tsomoriri	Tsokar
		Surface	Bottom	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)	8.9 - 9.02 (8.96)	8.8 - 8.84 (8.82)
TDS	500	118 - 131 (124)	170 - 180 (175)	310 - 380 (350)	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)	-	-
BOD (max)	2	1.2 - 6 (2.08)	1.2 - 14 (7)	0.6 - 1.2 (0.9)	-	-
HCO <sub>3</sub>	-	121-129 (125)	173-178 (177)	120-140 (127)	0-2 (1)	2-6 (4)
TH	300	44-56 (53)	82-94 (88)	100-160 (136)	3161	18292- 21195 (19743)
Cl	250	4-10 (6)	4-8 (7)	7-12 (10)	24 (24)	8850-9206 (9028)
SO <sub>4</sub>	150	1-4 (2)	1-3 (1.6)	8-18 (11)	32-144 (88)	16-36 (26)
NO <sub>3</sub>	45	0.44-2.2 (0.76)	0.5-5 (1.5)	4-6 (5)	-	-
Ca	75	14-18 (17)	29-32 (30)	32-48 (38)	30-40 (35)	760-1840 (1300)
Mg	30	2-4 (2.5)	2-4 (2.8)	5-19 (13)	744-750 (747)	3330-4690 (4010)
F	1.5	0.01-0.32 (0.14)	-	-	0.44-0.50 (0.47)	0.43-0.60 (0.51)

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 extremely higher than the prescribed desirable limits for drinking purposes.

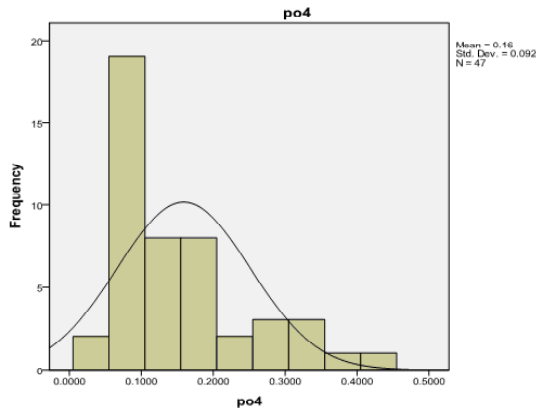
The results indicate wide range of variation of water quality parameters for the lakes of Ladakh Region in comparison to the lakes of Jammu and Kashmir Regions. It may be primarily due to presence of evaporites in lakes of Ladakh division attributed in cold desert type climates GSI (1977) has also reported exceptionally very high values of salt containing constituents in the Ladakh division.

The water quality of the Renuka lake was also assessed as per BIS norms of drinking water quality (BIS-10500: 1991). The results are given in Table 3, which show mean values of some water quality parameters beyond desirable limits viz. magnesium (mean 41 mg/l against limit of 30 mg/l), total coliform (mean 61 MPN/100 ml against limit of 10 MPN/100 ml), faecal coliform (mean 50 MPN/100 ml against limit of zero MPN/100 ml), iron (mean 1.49 mg/l against limit of 0.3 mg/l), lead (mean 0.35 mg/l against limit of 0.05 mg/l), manganese (mean 0.87 mg/l against limit of 0.10 mg/l) and cadmium (mean 0.01 mg/l against limit of 0.01 mg/l), respectively. However, pH, total hardness, TDS, calcium, sulphate, fluoride, alkalinity, DO and BOD were also found to be

**Table 3. Water quality assessment of the Renuka lake for drinking purposes**

Sl. No.	Substance or Characteristic	Requirement (Desirable Limit)	Permissible Limit	WQ of the Renuka lake
1	pH Value	6.5 to 8.5	No Relaxation	5.8-9.1 (7.13)
2	Total Hardness (as CaCO <sub>3</sub> ) mg/l, Max	300	600	224-430 (287)
3	Iron (as Fe) mg/l, Max	0.3	1.0	0.0-7.84 (1.49)
4	Chlorides (as Cl) mg/l, Max	250	1000	0.0-9.0 (1.8)
5	Dissolved solids mg/l, Max	500	2000	324-570 (364)
6	Calcium (as Ca) mg/l, Max	75	200	32-104 (49)
7	Magnesium mg/l, Max	30	75	33-49 (41)
8	Copper (as Cu) mg/l, Max	0.05	1.5	0-0.16
9	Manganese (as Mn) mg/l, Max	0.10	0.3	0.0-7.17 (0.87)
10	Sulfate (as SO <sub>4</sub> ) mg/l, Max	200	400	61-215 (113)
11	Nitrate (as NO <sub>3</sub> ) mg/l, Max	45	-	0.0-42 (4.3)
12	Fluoride (as F) mg/l, Max	1.0	1.5	0-1.6 (0.71)
13	Cadmium (as Cd) mg/l, Max	0.01	No relaxation	0-0.03 (0.01)
14	Lead (as Pb) mg/l, Max	0.05	No relaxation	0.17-0.66 (0.35)
15	Zinc (as Zn) mg/l, Max	5	15	0.0-1.64 (0.15)
16	Alkalinity mg/l, Max	200	600	125-260 (165)
17	Faecal coliform. MPN, Max	Nil	Nil	0-1100 (50)
18	Total coliform MPN, Max	Nil	10	0-1100 (61)
19	Dissolved Oxygen, mg/l, Min	6.0	-	0-10.4 (6.7)

exceeding the desirable limits in few water samples of the Renuka lake under this study. Therefore, the Renuka lake water requires appropriate water treatment measures before use for drinking purpose.



**Fig. 1: Frequency plot of phosphate concentration in Renuka lake (2006 to 2008)**

**Eutrophication Status**

The eutrophication 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 eutrophication of Renuka lake was assessed on the basis of phosphate data collected during 2006-2008 (Fig. 2). The results are given in Tables 4, which indicated eutrophic condition of Mansar, Surinsar and Tsomoriri lakes. Whereas, Tsokar and Renuka lake were found under hypertrophic condition. The results indicate that there is a need for taking appropriate actions for conservation and restoration of the lakes.

**6. CONCLUSION**

The study has shown a majority of physico-chemical parameters fall within range for drinking and irrigation purposes in the Mansar and Surinsar. Whereas, water quality for the lakes of Ladakh region (Tsomoriri and Tsokar) shows extremely higher concentration of salts attributed due to prevailing cold desert type climate having low annual rainfall in the order of about 100 mm. Accordingly, the water quality being debar from dilution showing unusually very high concentrations of some water quality parameters viz. pH, Total Dissolved Solids, Total Hardness, Chloride, calcium, magnesium in Tsomoriri and Tsokar lakes of Ladakh region. The observed water quality of the Renuka lake was compared with the BIS norms of drinking water quality, which show mean values of few water quality parameters beyond desirable limits for magnesium,

**Table 4. Eutrophication status of the lakes**

Lakes	Phosphate, µg/l	TSI (TP)	Trophic Status	Year
Mansar	14	42.20	Mesotrophic	Zutshi, 1989
	80	67.00	Eutrophic	June, 1999 (Rai et. al., 2001)
	100	70.00	Eutrophic	2004
Surinsar	50	61.00	Eutrophic	1995
Tsomoriri	30	53.00	Eutrophic	2000
Tsokar	300	86.00	Hypertrophic	2000
Renuka	160	77.00	Hypertrophic	2006, 2007, 2008

total coliform, faecal coliform, iron, lead, manganese and cadmium, respectively. The data of DO indicated that hypolimnion of the Himalayan lakes remain mostly under anoxic condition. The lakes also remain stratified during summer and mixed during winter months. The eutrophication status reveals Mansar, Surinsar and Tsomoriri lakes under eutrophic, Tsokar and Renuka lakes under hyper-eutrophic condition. The results indicate that there is a need for taking appropriate actions for conservation and restoration of the lakes for improving water quality and lowering the level of eutrophication.

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