

Water Quality and Eutrophication Status of Some Lakes of Different Regions in Jammu & Kashmir (India)

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ABSTRACT

Lakes are important sources of fresh water in the Himalayan Region. However, during last century, there has been a quantum jump in population without corresponding expansion of civic facilities, which has resulted lakes and reservoirs, especially the urban ones, into sink for contaminants. Consequently, various lakes and reservoirs have suffered from varying degrees of environmental degradation all over the country primarily due to encroachments, eutrophication (from domestic and industrial effluents), and silt.

In this paper, water quality status of selected lakes in Jammu (Mansar, Surinsar), Kashmir (Dal) and Leh & Ladakh regions (Tsokar, Tsomoriri) has been presented. Among these lakes, Dal lake is an urban lake and is under National Lake Conservation Plan, Mansar & Surinsar lakes are fresh water lakes, whereas Tsokar & Tsomoriri lakes belongs to brackish/salt water lakes. Tsomoriri lake is one among the 19 site of Ramsar Convention of international importance in India. The results of physico-chemical parameters have shown that the lakes of Ladakh region have very distinct characteristics of water quality showing very high concentration of pH, EC, TDS, Ca, Mg, Na, K, Cl values. The water quality of these lakes was evaluated for various designated uses.

The eutrophication status in these lakes has been assessed using phosphate data, which showed Mansar, Surinsar and Tsomoriri under eutrophic, Dal and Tsokar lakes under hyper-eutrophic condition. The results of this study indicate that lakes of Himalayan region are no exception for problems of water quality deterioration and increasing level of eutrophication.

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.

A large number of natural fresh water lakes exist in Jammu and Kashmir State. Of them, the important lakes such as Dal, Wular, Manasbal, Nagin are found in Kashmir region; Mansar, Surinsar, Sanasar 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.

Therefore, water quality assessment of these lakes is very essential to have qualitative measurements in addition to quantitative ones, which is required for sustainable development and management of the lake water resource in the regions. Consequently, the need of such studies may also be emphasised in reference to National Water Policy (MOWR, 2002), which states that "both surface water and ground water should be regularly monitored, and a phased program should be undertaken for improvements in water quality".

STUDY AREA

A location map, showing relative positions of the lakes in Jammu (Mansar, Surinsar), Kashmir (Dal) and Ladakh (Tsomoriri, Tsokar) regions of Jammu & Kashmir (J&K) State are shown in Fig. 1. The State of J&K lies between longitude $72^{\circ} 44'$ to $80^{\circ} 34'$ E and latitude $32^{\circ} 07'$ to $37^{\circ} 06'$ N. The total reported area of the J&K State is 2,22,236 Sq. km, which includes the area under occupation of Pakistan and China (Anonymous, 1999). According to the estimates by Ministry of Environment & Forests, the state of Jammu and Kashmir has 29, 107 ha area under the wetlands out of which 7,227 ha is under natural and 21,880 ha is under man-made wetlands (Anonymous, 1998a). Topographically, Jammu & Kashmir State is divisible into different regions: (i) outer Himalayas, also known as Siwalik; (ii) lesser Himalayas, north of Siwalik, also known as Pir Panjal range (Kashmir valley is like a bowl formed of Pir Panjal range and south of Zaskar range); and; (iii) north of Kashmir valley and Zaskar range is Greater Himalayas. The valley between Zaskar range in south and Karakoram in north is called Ladakh valley. The three river systems (Indus, Jhelum and Chenab) of J& K State drain the three divisions of Jammu, Kashmir and Ladakh. Chenab drains most of the Jammu division, Jhelum drains the Kashmir Valley and Poonch district. The Indus itself rises in the Tibet and drains Ladakh north of Zaskar and south of Karakoram.

There is greater variability in climatic conditions of the State. The effect of south-west monsoon is felt in Jammu & Kashmir state inspite of the fact that it lies in tropics. However, the climate of the three divisions is also determined by orography. In Jammu division (mostly south of Peer Panjal range) in Shivalik, the general climate is similar to plains. Kashmir valley has temperate climate i.e. mild summer and snowfall in winter. Leh and Kargil districts, north of Zaskar ranges have extreme Siberian type climate with very little rainfall and prolonged sub zero temperatures in winter. The average annual rainfall in the State varies considerably from about 1500 mm in south western Greater Himalayas to about 100 mm in Ladakh. Western disturbances have a dominating influence in determining the extent of rainfall in winter and spring in the J&K State. In Jammu division, monsoon rainfall ranges about 70% of the annual rainfall. Dominance of the rainfall is observed in Kashmir valley due to western disturbances. Monsoon rainfall is just about 20 to 22%. Most of the spring/winter precipitation in Kashmir and Ladakh regions falls in the form of snow and this forms the biggest reservoir source of perennial water in river systems in Jammu and Kashmir (Kaul, 1990; Goyal & Sreenivasulu, 2001). The salient features of various lakes under this study are given in Table 1.

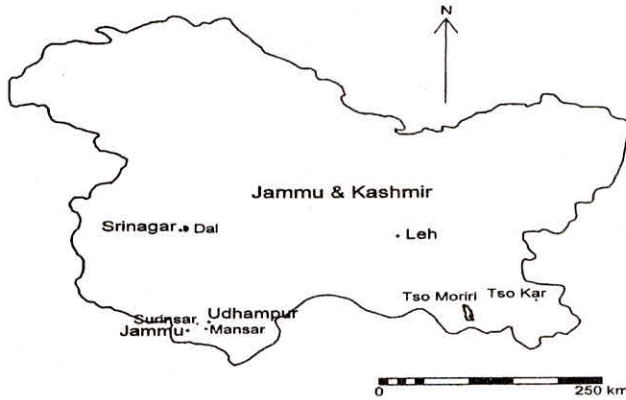


Fig. 1: Location map of the lakes studied in Jammu & Kashmir

Table 1: Salient features of some the lakes in J&K

S. N.	Details	Lakes				
		Mansar	Surinsar	Dal	Tsomoriri	Tsokar
1	District	Udhampur	Jammu	Srinagar	Leh	Leh
2	Type of lake	Rural	Rural	Urban	Rural	Rural
3	River Basin	Chenab	Chenab	Jhelum	Indus	Indus
4	Latitude	32° 40' 58.25"	32° 46' 30"	34° 5'	32° 48' 16"	33° 4' 14"
5	Longitude	75° 5' 11.5"	75° 2' 30"	74° 51'	78° 12' 51"	79° 5' 32"
6	Altitude (m)	666	604	1580	4527	4225
7	Max. depth (m)	38.25	24.05	6.0	30.00	-
8	Area (Sq. Km)	0.59	0.32	11.7	141.05	0.55

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. 1999, Das and Dhiman, 2003; Shewa, 1998). 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. Zutshi and Khan (1977) have carried out comparative study of the morphometric, physico-chemical and biological parameters of the Mansar and Surinsar lake. Rai et al. (2001) performed studies on bathymetry, rate of sedimentation and water quality of Mansar lake during 1998-99.

DATA & METHODOLOGY

In the present study, water quality data of the Mansar, Surinsar (Jammu Region), Tsomoriri and Tsokar lakes (Ladakh Regions), has been used from the various investigations carried out at the WHRC (NIH), Jammu, during different years. The water samples were analysed for various physico-chemical (Temp., pH, EC, TDS, DO, Ca, Mg, Na, K, Alkalinity, HCO₃, Cl, SO₄, NO₃, PO₄, F, Hardness) following standard methods (APHA, 1985; Jain and Bhatia, 1987-88). 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, 1983) and irrigation (USSL Staff, 1954) purposes. The diagrammatic presentation showing pattern of the water quality of these lakes was performed following popular diagrams (Piper, 1953; USSL Staff, 1954). The available 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).

RESULTS AND DISCUSSION

Variation of Water Quality

The variation of water quality parameters along with their average values are given in Table 2, which shows a wide range of variation 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 (BIS, 1983). Various water quality 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. This is mainly 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, which could be prime factor for influencing quality of water in this area.

Eutrophication Status

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, TSI based on phosphate data was evaluated and compared with earlier investigations (Zutshi, 1989; Rai et. al., 2001). The results showing eutrophication status of various lakes are given in Table 3, which indicated eutrophic condition of Mansar, Surinsar and Tsomoriri lakes based on phosphate data collected for the epilimnion zone. Whereas, Dal and Tsokar lakes were found to be under hypertrophic condition.

CLASSIFICATION OF LAKE WATER

Piper's Classification

In the present study, hydrochemical facies of the water quality parameters pertaining to the Mansar, Surinsar, Dal, Tsomoriri and Tsokar lakes been prepared using Piper's diagram

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Table 2: Variation of water quality parameters in different lakes of J&K

Para-Meters	Limits (Class-A drinkin g water)	Mansar		Dal	Tsomoriri		Tsokar
		Surface	Bottom		Surface	Surface	
Temp. °C		28.6-29.6 (29.3)	14.1-14.7 (14.4)	18.6-21.3 (20)	20-20.5 (20.3)	26-27.1 (26.6)	
pH	6.5-8.5	7.95-8.04(7.99)	7.98-8.12 (8.03)	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)	122-317 (181)	3360-3740 (3550)	62720-64340 (63530)	
TDS	500	118-131 (124)	170-180 (175)	78-202 (116)	2150-2393 (2272)	40141-41178 (40659)	
DO (min)	6	3.3-6.6 (5.5)	0.3-0.6 (0.45)	5.8-10.0 (7.96)	-	-	
BOD (max)	2	1.2-6 (2.08)	1.2-14(7)	-	-	-	
HCO ₃	-	121-129 (125)	173-178 (177)	49-140 (88)	0-2 (1)	2-6 (4)	
TH	300	44-56 (53)	82-94 (88)	42-164 (88)	3161	18292-21195 (19743)	
Cl	250	4-10 (6)	4-8 (7)	6-18 (10)	24 (24)	8850-9206 (9028)	
SO ₄	150	1-4 (2)	1-3 (1.6)	-	32-144 (88)	16-36 (26)	
PO ₄	-	0.01-0.3 (0.1)	0.12-0.18 (0.15)	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)	0-7 (0.7)	-	-	
Ca	75	14-18 (17)	29-32 (30)	14-46 (24)	30-40 (35)	760-1840 (1300)	
Mg	30	2-4 (2.5)	2-4 (2.8)	2-12 (7)	744-750 (747)	3330-4690 (4010)	
Na	-	15-17 (15.6)	14-16 (15)	2-8 (4)	89-1493 (791)	628-1493 (1061)	
K	-	3 (2.8)	3 (2.6)	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)	

(1953). The results (Fig. 2) have shown that Mansar, Surinsar and Dal lakes lied under Ca^{2+} , Mg^{2+} , CO_3^{--} , HCO_3^- hydrochemical facies; Tsomoriri and Tsokar lakes lied mostly under Ca^{2+} , Mg^{2+} , Cl^- , SO_4^{--} except in Tsomoriri, where Na^+ , K^+ , Cl^- , SO_4^{--} was also obtained. Therefore, from this analysis, it could be concluded that the lakes of Jammu and Kashmir regions are dominant of Ca, Mg and HCO_3^- , whereas, lakes of Ladakh region are dominant in Ca, Mg, Cl and SO_4 ions.

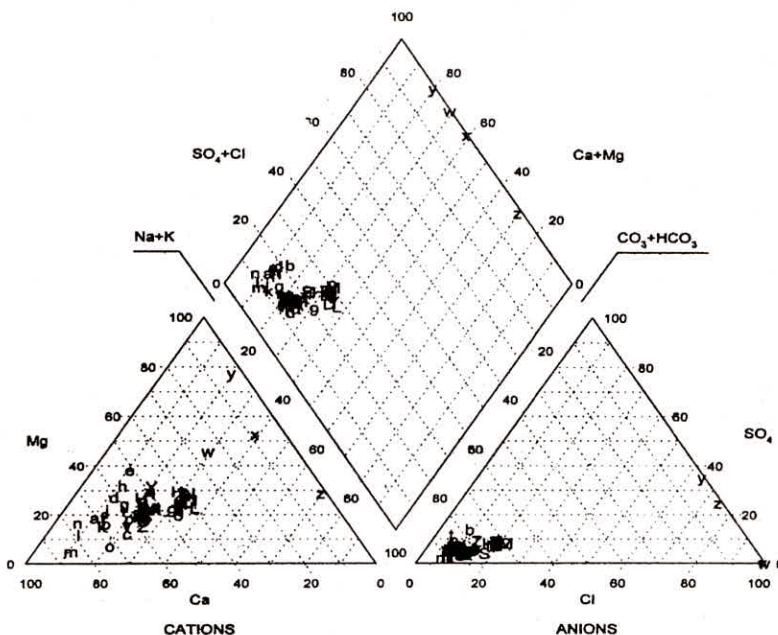


Fig. 2: Piper diagram showing hydrochemical facies of lakes studied in J&K

Table 3: Eutrophication status of the lakes

Lakes	Phosphate, $\mu\text{g/l}$	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

U.S. Salinity Classification of Irrigation Water:

The U.S. Salinity classification (based on SAR in combination with EC) (Fig. 3) indicates that the water samples of Mansar, Surinsar and Dal lake lied under low to medium salinity- low SAR category. Water of these lakes can be used for irrigation in the most of crops and soils.

Since, irrigation water quality parameters (particularly EC, Cl, SO₄ values) were extremely high (EC >5000 μS) for the lakes of Ladakh region (Tsomoriri and Tsokar) in comparison to other lakes, these could not be recorded on U.S. Salinity diagram, which suggest very poor quality of irrigation water from salinity point of view and should be restricted for use. However, if unavoidable to use such high salinity water for irrigation, irrigators should adopt an appropriate ways to control soil salinity with suitable soil & water management options alongwith selection of salt tolerant crops in this area.

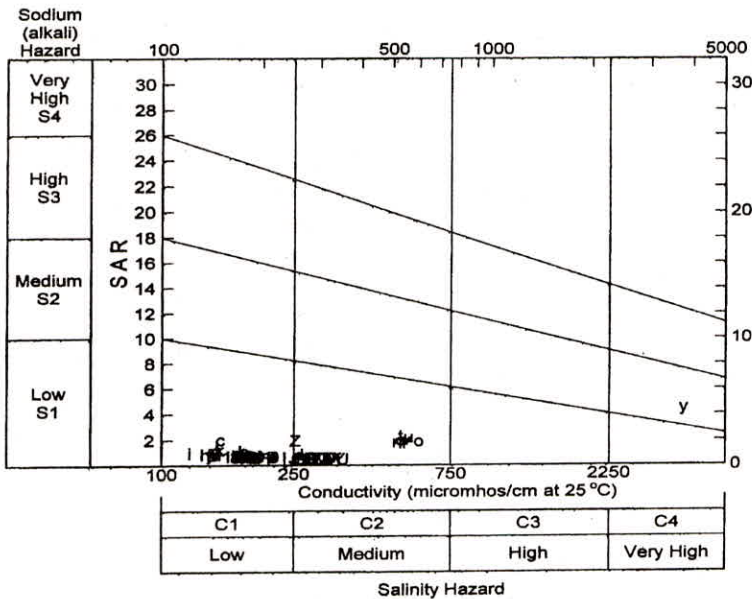


Fig. 3: U.S. Salinity diagram showing irrigation water quality of the lakes studied in J&K

CONCLUSIONS

In the present study, water quality of the selected lakes in Jammu (Mansar, Surinsar), Kashmir (Dal) and Ladakh (Tsomoriri and Tsokar) regions has been evaluated. The study has shown alkaline (pH > 7.00) nature of water in all lakes. 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. The Piper's diagram has shown water quality of the Mansar, Surinsar, Dal lakes under Ca^{2+} , Mg^{2+} , CO_3^{2-} , HCO_3^- hydro-chemical facies; the Tsomoriri and Tsokar lakes mostly under Ca^{2+} , Mg^{2+} , Cl^- , SO_4^{2-} hydro-chemical facies with presence of higher concentration of Na and K ions in few samples.

The eutrophication status was studied based on the phosphate data, which has shown Dal, Tsokar and Mansar lakes (in hypolimnion zone) under hypertrophic condition. Therefore, it could be concluded that eutrophication levels are increasing in these lakes of J&K, which required an integrated approach (involving local bodies, NGO's and Government) to maintain healthy condition of the lakes.

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