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Limnology of lake Surinsar, Jammu, J&K: Part II – Water chemistry

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Abstract: Water quality parameters viz. air temperature (15.21° C -36° C/16.71° C - 39.42° C), water temperature (13° C-32.42° C/15° C-32.8° C), depth (42cm-69.08cm/ 25cm-121.92cm), turbidity (3.88-46.27NTU/3.67-69.39 NTU), salinity (0.10-0.31ppt/ 0.10-0.37ppt). electrical conductivity (0.101-0.172mS/cm/0.114-0.279mS/cm), TDS (49.63-111.78 mg/l/57.64-177.01mg/l), pH (7.92-9.82/7.80-9.09), free CO_2 (0-19.22mg/l/0-15.32mg/l), DO (6.82-9.90mg/l/4.65-9.40mg/l), carbonate (0-18.38mg/l/0-20.63mg/l), bicarbonate (60.99-170.70mg/l/77.62-168.70mg/l, chloride (7.41-12.35mg/l/9.59-19.60mg/l), calcium (6.85-38.50mg/l/11.81-140.49mg/l), magnesium (4.62-7.22mg/l/3.86-39.05mg/l), total hardness (40.29-125.50 mg/l/56.61-511.05mg/l), BOD (3.12-5.79mg/l/1.31-16.21 mg/l), COD (17.74-75.42 mg/l/ 26.57-73.03mg/l), sodium (14.2-22.5mg/l/12.2-30.9mg/l), potassium (1.83-4.17mg/l/2.25-6.21mg/l), phosphate (0.048-0.233mg/l/0.008-0.603mg/l), nitrate (0.13-1.3mg/l/0.11-4.08mg/l), sulphate (1.60-19.19mg/l/1.36-15.70mg/l), silicate (0.14-4.23mg/l/0.27-7.05mg/l), iron (0-0.65/0-0.40mg/l), copper (below detectable limit) and zinc (below detectable limit), of lake Surinsar-the only source of drinking water to the inhabitants of the Surinsar village, have been reported monthly, during the year 2002-03/2003-04. WQI range falls from poor (70.45, December; 73.55, October; 74.4, November and 74.56, September/ 74.52, January and 75.36, September) , very poor(82.54, February; 89.25, May; 80.76, August and 78.86, January/ 80.89, February; 98.25, April; 80.03, June; 82.26, July; 86.55, October and 83.03, November) to unfit (100.44, June; 101.9, July; 103.86, April and 119.5, March/ 103.73, May; 108.28, March; 122.56, August and 103.72, December). Comparison of range of various water quality parameters of Surinsar lake water, with national and international standards has also revealed that most of these parameters are beyond permissible limits. This clearly indicates the unsuitability of raw water, generally consumed by local inhabitants, for human consumption.

Keywords: Lake Surinsar, Physico-chemical parameters,National and international standards, Water quality index

INTRODUCTION

Water is required everywhere, without which neither life nor any development is possible. It contributes about 70% of the fat free mass of the human body and the daily demand of drinking water of man is about 7 percent of his normal body weight. Majority of fruits contain about 3/4th of water. About 90% of jelly fish body weight is water. Water is vital to health, safety and socio-economic development of man. In India, water is unevenly distributed. Urban population, accounting to 25.72% of the total population, is supplied water by various agencies after treatment. Rural areas, with about 74% of total population, depend on raw water from lakes, ponds, wells, tube wells, hand pumps and rivers, for meeting their basic requirements. As such rural population is exposed to a variety of water related diseases. The study of literature reveals that although various abiotic and biotic aspects of this lake in Shiwalik hills have earlier been studied by Jyoti and Sehgal (1979, 1984, 1987), Jyoti *et al.*(1986), Sehgal (1980), Zutshi *et al.* (1980) and Sharma (1994), but no attempt has been made to study the suitability of water for human consumption. Keeping all this in view, the present study was undertaken to monitor water quality of this lake for its potability. To evaluate the suitability of raw water for human consumption and various other uses, water quality index (WQI) has also been calculated.

MATERIALS AND METHODS

Topography of the area: Lake Surinsar (75° 02' 303 E and 32° 46' 303 N), an important subtropical Siwalik lake, about 25 Km to the north-east of Jammu city, is situated at an elevation of 605m above mean sea level. It is oval in contour with a deep notch towards its north-west. The circumference of the lake is 2.496 Km. Main water source to this lake is rain, runoff from catchment and agricultural fields. It is said that some natural springs are also present within the lake, which were not seen during the present study. In this winter monomictic lake, vegetation is highly diversified and migratory birds are also seen in large number. This shiwalik lake is the only source of drinking water to the inhabitants of the area and is supplied by P.H.E. For the present study, based on habitation and degree of pollution, twelve surface water stations were selected along the periphery of the lake (Fig. 1).

Sampling and analysis of water: Monthly water samples, at each experimental station, were collected for two years

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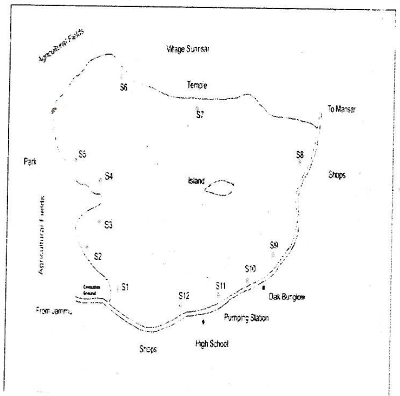

Fig.1. *Map of Surinsar lake showing various sampling stations.*

viz. February, 2002 to January, 2004, in five litre plastic containers and analyzed following standard methods (APHA,1998). Water and air temperature was recorded by using mercury bulb (°C) thermometer and depth by graduated meter rod. Water quality index (WQI) has also been calculated (Kaushik *et al.*, 2002; Fokmare and Musaddiq, 2005 and Samal *et al.*, 2005).

RESULTS AND DISCUSSION

Air temperature varied between 15.21° C (December) to 36° C (June)/16.71° C (December) to 39.42° C (May), during the year 2002-03/2003-04 (Table 1). Surface water temperature, closely following the air temperature, fluctuated between 13° C (January) to 32.42° C (June) / 15° C (December) to 32.8° C (August). Longer day length and increased photoperiod may explain February to July/ February to August rise in temperature. December and January low record of water temperature, during both the years of present study, coincided with reduced solar illumination and comparatively low atmospheric temperature.

Depth, in the littoral zone of lake Surinsar, ranged between 42cm (December) to 69.08cm (July) / 25cm (April) to 121.92cm (September), during the year 2002-03/2003-04. It observed monsoon (July-September/July and August) increase and summer (March to June /April and June) decline and is in agreement with the findings of Dutta and Sharma, 2000; Sharma, 2000 and Sharma, 2002, for various lentic water bodies in the area. Rains and inflow of water from the catchments may explain monsoon rise in water depth. Similarly, effect of winter rains may explain February/ January rise in water depth. Summer trough in water depth is attributed to increased evaporation at higher temperature.

During the year 2002-03, turbidity observed June and December peaks and fluctuated between 3.88 NTU (September and October) to 46.27 NTU (June). In the year 2003-04, it ranged between 3.67 NTU (October) to 69.39 NTU (June) and recorded April, June and December increase. Rise in suspended matter, contributed by decomposing aquatic vegetation and low water level, due to summer increased temperature, may explain April-May/ April rise in turbidity. June highest record of turbidity coincided with inflow of materials from the catchment caused by pre-monsoon showers. Winter lake overturn and presence of large number of migratory birds may accord for December and January/December rise in turbidity. Dilution caused by monsoon may explain September-October/August-October turbidity trough in lake water.

Salinity, during the year 2002-03/2003-04, varied between 0.10 ppt (July and September) to 0.31ppt (January)/ 0.10 ppt (May) to 0.37 ppt (December). Electrical conductivity ranged between 0.101mS/cm (September) to 0.172 mS/ cm (March) / 0.114 mS/cm (August) to 0.279 mS/cm (December). TDS closely followed electrical conductivity fluctuations and varied between 49.63 mg/l (September) to 111.78 mg/l (January) / 57.64 mg/l (July) to 177.01 mg/ l (December). Dissolved solid enrichment during lake overturn may explain December and January rise in salinity, conductivity and TDS (Table 1).

Due to the presence/absence of free CO_2 and CO_3^{2-}, pH has shown a wide annual mean variation between 7.92 (January) to 9.82 (April) / 7.80 (January) to 9.09 (April). Inverse relationships of pH with free CO_2 and direct with CO_3^{2-} is already on record (Jhingran, 1991; Horne and Goldman, 1994; Hutchinson, 2004 and Kanungo *et al.*, 2006). During the first year, free CO_2 showed February (1.02 mg/l), August (0.69 mg/l), November (3.54 mg/l), December (11.85 mg/l) and January (19.22 mg/l) presence at one or the other experimental station. In the subsequent year, it made its record in the month of February (9.96 mg/l), March (6.47 mg/l), April (0.51mg/l), July (4.49 mg/ l), November (6.83 mg/l), December (11.15 mg/l) and January (15.32 mg/l) at few stations of lake Surinsar (Table 1). Absence of free CO_2, during the greater part of the study period, coincided with CO_3^{2-} presence in the lake water. The latter varied between 2.98mg/l (November) to 18.38 mg/l (April) with December and January absence, during the first year. In the subsequent year, it ranged between 6.50 mg/l (March) to 20.63 mg/l (April) and showed its absence during February, November, December and January(Table 1). January highest record of free CO_2 and December and January absence of CO_3^{2-} in lake water has its correlation with lake overturn.

Dissolved oxygen, during the year 2002-03/2003-04, observed January, 6.82 mg/l/ January, 4.65 mg/l lowest and October, 9.90 mg/l / August, 9.40 mg/l highest observation. Seasonally, during the first year, it recorded a bimodal viz. February–March and September-October increase. In the subsequent year, DO observed trimodal

Table 1. Mean monthly variations in physico-chemical parameters of lake Surinsar, Jammu (Feb .2002-Jan. 2004).

Parameters	AT(^{0}C)	WT(^{0}C)	Depth(cm)	Turbidity(NTU	Salinity(ppt)	EC(mS/cm)	TDS(ppm)	pH	FCO$_2$(mg/l)	DO(mg/l)	CO_3^{2-}(mg/l)	HCO_3^-(mg/l)	Cl^-(mg/l)	Ca^{2+}(mg/l)	Mg^{2+}(mg/l)	TH(mg/l)	BOD(mg/l)	COD(mg/l)	Na^+(mg/l)	K^+(mg/l)	PO_4^{3-}(mg/l)	NO_3^-(mg/l)	SO_4^{2-}(mg/l)
Feb.2002	21.5	18.5	61.6	15.0	0.2	0.157	101.3	8.53	1.02	9.57	7.86	157.25	8.59	31.42	6.99	107.58	3.38	66.95	17.6	3.5	0.096	0.33	4.05
March	27.0	22.2	43.9	19.8	0.2	0.172	83.4	8.80	0.00	9.49	11.83	137.91	8.88	25.55	7.15	93.14	3.12	66.98	18.7	3.6	0.144	1.04	13.04
April	35.8	24.0	53.5	33.2	0.2	0.127	82.0	9.82	0.00	8.23	18.38	80.98	10.02	9.82	5.89	51.22	3.49	75.42	20.1	3.1	0.048	1.30	2.06
May	35.5	24.0	52.9	35.4	0.2	0.131	81.5	9.36	0.00	8.37	12.25	60.99	7.41	10.25	7.22	55.27	3.38	55.91	16.4	2.6	0.062	0.50	1.60
June	36.0	32.4	49.8	46.3	0.2	0.127	55.4	9.01	0.00	7.99	18.10	64.90	10.66	6.85	5.64	40.29	5.45	69.40	15.3	2.7	0.070	0.13	19.19
July	34.8	32.1	69.1	34.7	0.1	0.125	53.6	9.42	0.00	7.88	18.22	70.36	9.30	8.20	5.67	43.91	5.79	43.97	18.7	3.9	0.233	0.44	5.73
Aug.	33.6	30.8	63.8	8.0	0.1	0.121	51.7	9.02	0.69	7.87	9.81	87.06	10.75	7.41	7.00	47.28	3.53	31.02	14.2	4.2	0.082	0.73	10.53
Sep.	30.6	29.2	63.9	3.9	0.1	0.101	49.6	8.49	0.00	9.22	9.39	83.31	12.12	10.48	6.03	50.93	3.73	35.71	22.5	3.1	0.064	0.69	7.48
Oct.	26.6	24.7	50.8	3.9	0.2	0.125	58.0	8.93	0.00	9.90	8.34	93.69	10.40	15.49	4.62	57.65	3.54	34.54	14.5	2.4	0.065	0.45	6.46
Nov.	21.2	18.8	46.0	13.0	0.2	0.126	81.5	8.74	3.54	8.72	2.98	84.98	12.02	17.98	6.04	69.70	4.39	17.74	20.0	1.8	0.223	0.44	5.97
Dec.	15.2	14.7	42.0	24.6	0.2	0.133	79.4	7.99	11.85	7.72	0.00	142.12	8.72	24.47	6.38	87.27	4.67	18.01	16.9	2.5	0.214	0.73	4.53
Jan.	17.9	13.0	44.0	20.5	0.3	0.157	111.8	7.92	19.22	6.82	0.00	170.70	12.35	38.50	7.17	125.50	4.69	32.66	17.9	3.7	0.170	0.49	4.30
Feb.2003	21.5	16.0	36.0	10.4	0.3	0.221	101.7	7.80	9.96	8.88	0.00	168.70	13.96	33.81	6.59	111.43	6.33	36.76	20.8	3.1	0.101	0.28	4.89
March	29.5	23.5	41.4	9.0	0.2	0.209	85.6	8.61	6.47	9.35	6.50	167.05	15.21	44.03	6.15	135.10	10.27	41.56	30.9	4.0	0.060	0.20	6.23
April	31.1	25.8	25.0	21.5	0.2	0.125	61.2	9.09	0.51	9.02	20.63	77.62	11.89	15.16	6.97	66.48	6.83	33.56	23.3	4.2	0.008	0.11	5.65
May	39.4	26.4	39.3	11.0	0.1	0.124	61.6	8.78	0.00	8.08	8.74	91.60	11.55	17.15	6.75	70.54	6.33	51.89	26.5	5.4	0.090	0.18	7.95
June	35.5	31.8	34.1	69.4	0.2	0.119	59.9	8.73	0.00	5.81	7.96	85.25	10.00	11.81	6.60	56.61	1.31	49.32	18.8	4.8	0.090	0.52	5.24
July	31.0	31.0	29.9	26.2	0.1	0.132	57.6	8.60	4.49	7.61	15.69	107.21	12.23	32.36	16.53	148.73	2.42	51.73	16.9	6.2	0.046	1.50	15.70
Aug.	34.5	32.1	113.7	6.0	0.2	0.114	59.7	8.51	0.00	9.40	7.81	103.38	10.81	17.79	5.50	58.15	16.21	73.03	14.3	4.5	0.085	0.44	2.60
Sep.	30.5	28.6	121.9	3.8	0.2	0.115	58.4	8.47	0.00	7.60	9.66	101.02	9.59	30.42	4.62	94.88	5.54	61.40	12.2	2.3	0.603	0.15	4.48
Oct.	29.0	26.0	77.8	3.7	0.2	0.129	60.5	8.51	0.00	9.00	14.38	128.26	10.48	23.47	6.25	84.25	4.43	68.80	15.3	3.1	0.019	4.08	2.63
Nov.	21.6	19.0	48.2	7.7	0.2	0.139	78.2	8.00	6.83	8.89	0.00	159.16	12.15	26.58	10.49	109.47	6.97	35.63	22.6	5.0	0.081	0.29	1.36
Dec.	16.7	15.0	43.8	18.4	0.4	0.279	177.0	7.87	11.15	6.30	0.00	168.22	19.60	140.49	39.05	511.05	3.10	26.57	19.3	3.7	0.078	0.16	2.60
Jan.2004	17.0	16.0	48.3	4.4	0.3	0.181	116.2	7.86	15.32	4.65	0.00	166.00	13.15	40.34	3.86	116.46	3.06	30.45	16.1	4.0	0.021	0.18	3.86

* Below detectable limit

viz. March, August and October peaks (Table 1).Turbulence and agitation caused by heavy rains may explain monsoon (September/ August) high record of dissolved oxygen. March /March to April DO enrichment in lake water is caused by summer increased photoperiod and macrophytic abundance. Free CO_2 absence/low record may also account for DO enrichment during this period and is in conformity with the findings of Hutchinson (2004). Summer highest water temperature may explain June fall in DO and is in agreement with the findings of Sehgal, 1980 and Sharma, 1994 for this lake. Winter lake overturn and shorter day length may explain January lowest observation of DO and is contrary to the earlier observations of Cole (1975), Reid and Wood (1976), Wetzel (2000) and Hutchinson (2004) for rise of DO at low temperature. It was during this period that mass mortality of *Puntius* was seen in this lake as has also been reported earlier by Sehgal (1980). During the year 2002-03/2003-04, chloride fluctuated between 7.41mg/l (May) to 12.35 mg/l (January) / 9.59 mg/l (September) to 19.60 mg/l (December).

In the year 2002-03, bicarbonate, calcium, magnesium and total hardness showed an annual mean variation of 60.99 mg/l (May) to 170.70 mg/l (January), 6.85 mg/l (June) to 38.50 mg/l (January), 4.62 mg/l (October) to 7.22 mg/l (May) and 40.29 mg/l (June) to 125.50 mg/l (January), respectively. In the subsequent year, these fluctuated between 77.62 mg/l (April) to 168.70 mg/l (February), 11.81 mg/l (June) to 140.49 mg/l (December), 3.86 mg/l (January) to 39.05 mg/l (December) and 56.61 mg/l (June) to 511.05 (December), respectively (Table 1). Lake overturn, conversion of sedimented marls, brought to the surface by water, into soluble form by large amount of free CO_2 $\{CO_2+H_2O \leftrightarrow H_2CO_3\ \ CaCO_3+H_2CO_3 \leftrightarrow Ca(HCO_3)_2\}$, high solubility of these ions at low temperature and low metabolic activities of aquatic flora, utilizing these nutrients (Wetzel, 2000), may explain winter (December and January) rise in bicarbonate, calcium ,magnesium and total hardness, during both the years of study. Increased photosynthesis due to longer photoperiod may explain summer trough in one or the other nutrient under discussion.

BOD, during the year 2002-03/2003-04, varied between 3.12 mg/l (March) to 5.79 mg/l (July)/1.31mg/l (June) to 16.21 mg/l (August). COD recorded an annual mean variation of 17.74 mg/l (November) to 75.42 mg/l (April) / 26.57 mg/l (December) to 73.03 mg/l (August). COD followed fluctuating pattern of BOD and recorded bimodal viz. April and June peaks, with slight increase during September, October and January, during the first year. In the subsequent year, BOD observed trimodal viz. March, August and November peaks, while COD recorded a continuous increase from May to August with a trough during September and further decline from October to December (Table 1).

Sodium, during the year 2002-03, recorded irregular fluctuations with April, July, September, November and January peaks and varied between 14.17 mg/l (August) to 22.46 mg/l (September). In the subsequent year, it ranged between 12.21mg/l (September) to 30.92 mg/l (March) and observed trimodal viz. March, May and November increase (Table 1). Potassium showed annual mean variation of 1.83 mg/l (November) to 4.17 mg/l (August) with peaks during March, August and January, during the first year. In the second year, it fluctuated between 2.25 mg/l (September) to 6.21 mg/l (July) and showed irregular pulse with March, May, July, November and January increase. Summer (April and March; and April/ May and March to May) rise in sodium and potassium coincided with increased evaporation and is in accordance with the findings of Pandit *et al.* (2006). Lake overturn and addition of guano by wintering migratory birds may account for winter (January and February; and December and January /February and December; and January), enrichment of sodium and potassium. This may also explain phosphate enrichment during this period which varied between 0.048mg/l (April) to 0.233mg/l (July)/ 0.008 mg/l (April) to 0.603 mg/l (September), during the year 2002-03/2003-04. Summer (April) phosphate trough may be attributed to increased diversity and density of algae and macrophytes in lake water.

During the year 2002-03, nitrate, sulphate and silicate fluctuated between 0.13 mg/l(June) to 1.3 mg/l (April), 1.60mg/l (May) to 19.19 mg/l (June) and 0.14 mg/l (October) to 4.23 mg/l (January), respectively (Table 1). In the subsequent year viz. 2003-04, these showed annual mean variation between 0.11mg/l (April) to 4.08 mg/l(October), 1.36mg/l (November) to 15.70 mg/l (July) and 0.27 mg/l (January) to 7.05 (July), respectively (Table 1). Runoff from the catchment may explain monsoon increase in one or the other nutrient and is in agreement to the findings of Aher *et al.* (2007) and Rajashekhar *et al.* (2007). Sulphate winter (December and January/November to December) decline may be accorded to mixing of sulphate deficient bottom water with surface water, during lake overturn (Table 1).

Among heavy metals, zinc and copper were below the detectable limits (Table 1). Iron, during the year 2002-03/ 2003-04, showed an annual mean variation between nil (March) to 0.65 mg/l (July)/ nil (October) to 0.40 mg/ l(August). A look at the Table 1, reveals winter (December/ January) rise in iron and may be attributed to the upwelling caused due to lake overturn and rise in free CO_2 (Schwoerbel, 1991 and Wetzel, 2000). Summer (May to June/May) rise in Fe^{2+} is in agreement with the findings of Horne and Goldman (1994) and Subhashini and Saradhamani (2005) and is accorded to accelerated decomposition of organic matter at high temperature.

Table 2. Showing comparative study of maximum and minimum range of various physico-chemical parameters as reported by Sehgal (1980) and the present study.

S.No	Parameter	Sehgal(1980)	Present Study (2002-03)	Present Study (2003-04)
1.	Air Temp (^{0}C)	8.08(January)-33.72(May)	15.21(December)-36(June)	16.71(December)-39.42(May)
2.	Water Temp (^{0}C)	12.64(January)-32.42(July)	13(January)-32.42(June)	15(December)-32.8(August)
3.	pH	7.3(January)-8.9(August)	7.92(January)-9.82(April)	7.80(January)-9.09(April)
4.	Free CO_2(mg/l)	nil(March-October)-7.66(January)	nil -19.22(January)	nil -15.32(January)
5.	DO (mg/l)	4.14(December)-11.19(October)	6.82(January)-9.90(October)	4.65(January)-9.40(August)
6.	Carbonate(mg/l)	nil(November- February)-12.26(March)	nil-18.38(April)	nil-20.63(April)
7.	Bicarbonate(mg/l)	96.5(July)-216(February)	60.99(May)-170.70(January)	77.62(April)-168.70(February)
8.	Chloride(mg/l)	2.10(May)-7.82(August)	7.41(May)-12.35(January)	9.59(September)-19.60(December)
9.	Calcium(mg/l)	12.40(May)-44.54(August)	6.85(June)-38.50(January)	11.81(June)-140.49(December)
10.	Magnesium(mg/l)	1.58(January)-7.62(April)	4.62(October)-7.22(May)	3.86(January)-39.05(December)
11.	TH (mg/l)	38.04(May)-138.96(August)	40.29(June)-125.50(January)	56.61(June)-511.05(December)
12.	Phosphate(mg/l)	BDL(April, May ,June)-0.27(December)	0.048(April)-0.233(July)	0.008(April)-0.603(September)
13.	Nitrate(mg/l)	BDL(April, May , June)-0.45(December)	0.13(June)-1.30(April)	0.11(April)-4.08(October)
14.	Sulphate(mg/l)	0.76(October)-15.89(June)	1.60(May)-19.19(June)	1.36(November)-15.70(July)
15.	Iron(mg/l)	BDL(March and April)-2.05(January)	BDL(March)-0.65(July)	BDL(October)-0.40(August)

***BDL**- Below detectable limit

Table 3. Comparison of water quality of Surinsar lake with various national and international standards.

Parameter	(2002-03)		(2003-04)		UPSH*	WHO		BIS	European Standards	ICMR		ISI Limit		
												Dr. W.		Do. W.
						Ac.	Al.			Ac.	Al.	Ac.	Mp.	
Turbidity	3.9	46.3	3.7	69.4	-	6	25	5	-	-	-	-	-	-
Salinity (ppt)	0.1	0.3	0.1	0.4	-	-	-	-	-	-	-	-	-	-
EC	0.101	0.172	0.114	0.279	300	-	300	-	400	-	300	-	300	300
TDS (ppm)	49.6	111.8	57.6	177.0	500	-	500	-	500	500	1500	500		500
pH	7.92	9.82	7.80	9.09	6.0-8.5	7.0-8.5	6.5-9.2	6.5-8.5	6.5-8.5	7.0-8.5	6.5-9.2	6.0-8.5	6.5-9.2	6.5-9.0
FCo_2 (mg/l)	0.00	19.22	0.00	15.32	-	-	-	-	-	-	-	6	-	-
DO (mg/l)	6.82	9.90	4.65	9.40	-	5	-	5	-	-	-	4	6	-
HCO_3 (mg/l)	60.99	170.70	77.62	168.70	-	30	150	-	-	-	120	150	300	-
Cl (mg/l)	7.41	12.35	9.59	19.60	250	200	1000	250	250	250	1000	250	600	1000
Ca^{2} (mg/l)	6.85	38.50	11.81	140.49	100	75	200	75	100	75	200	75	200	75
Mg^{2} (mg/l)	4.62	7.22	3.86	39.05	30	50	150	30	-	50	200	30	100	50
TH (mg/l)	40.29	125.50	56.61	511.05	500	300	600	300	-	300	600	300	600	-
BOD (mg/l)	3.12	5.79	1.31	16.21	5	3	6	3	-	-	-	-	-	3
COD (mg/l)	17.34	75.42	26.57	73.03	4	10	20	-	5	-	-	-	-	-
Na (mg/l)	14.2	22.5	12.2	30.9	-	175	200	-	-	-	-	-	-	-
K (mg/l)	1.8	4.2	2.3	6.2	-	-	12	-	-	-	-	-	-	-
PO_4^{3-} (mg/l)	0.048	0.233	0.008	0.603	-	0.1	1	-	-	-	-	-	0.1	-
NO_3^- (mg/l)	0.13	1.30	0.11	4.08	-	45	100	45	-	45	100	45	100	100
SO_4^{2-} (mg/l)	1.60	19.19	1.36	15.70	250	200	400	150	-	200	400	200	400	1000
SiO_2 (mg/l)	0.14	4.23	0.27	7.05	-	-	-	-	-	-	-	-	20	-
Fe (mg/l)	0.00	0.65	0.00	0.40	-	0.3	1	0.3	-	0.3	1	0.3	1	-
Zn (mg/l)	*	*	*	*	-	5	15			5	15	5	10	-
Cu (mg/l)	*	*	*	*	-	1	1.5	-	-	1	3	0.05	1.5	-

Table 4. Showing water quality rating based on water quality index (WQI) value(Kaushik *et al.*, 2002; Fokmare and Musaddiq, 2005 and Samal *et al.*, 2005).

W.Q.I. Values	Water Quality Rating
0-25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
Above 100	Unfit for drinking

Table 5. Comparison of monthly water quality index (WQI) of Surinsar lake with water quality rating based on above table.

Months	2002-03	Category	2003-04	Category
Feb.	82.54	Very Poor	80.89	Very Poor
Mar.	119.5	Unfit for drinking	108.28	Unfit for drinking
Apr.	103.86	Unfit for drinking	98.25	Very Poor
May	89.25	Very Poor	103.73	Unfit for drinking
June	100.44	Unfit for drinking	80.03	Very Poor
July	101.9	Unfit for drinking	82.26	Very Poor
Aug.	80.76	Very Poor	122.56	Unfit for drinking
Sep.	74.56	Poor	75.36	Poor
Oct.	73.55	Poor	86.55	Very Poor
Nov.	74.4	Poor	83.03	Very Poor
Dec.	70.45	Poor	103.72	Unfit for drinking
Jan.	78.86	Very Poor	74.52	Poor

Erosion and agricultural runoff from the catchment during rains, may explain July/August rise in Fe^{2+} (Gupta *et al.*, 2000). High DO record may explain March/April iron trough in the lake water (Schwoerbel, 1991).

Comparison of various physico-chemical characteristics with the observations made by Sehgal, 1980 (Table 2) indicates variations in various water quality parameters particularly rise in chloride, phosphate, nitrate, and sulphate. This is attributed to increased biotic interference caused by increased urbanization, influx of tourists and winter settlement of large number of nomadic tribes and their animals.

Comparison of various water quality parameters with national and international standards reveals that some of the parameters are above their permissible limits (Table 3).

Water quality index (WQI) : Water quality index (WQI) value ranged between 70.45 (December) to 119.50 (March) / 74.52 (January) to 122.56 (August). Comparison of monthly WQI value with the water quality index rating(Table 4 and 5) for drinking water, it falls under the category of poor (70.45, December; 73.55, October; 74.4, November and 74.56, September/ 74.52, January and 75.36, September) , very poor(82.54, February; 89.25, May; 80.76,August and 78.86, January/80.89, February; 98.25, April; 80.03, June; 82.26, July; 86.55, October and 83.03, November) and unfit for drinking (100.44, June; 101.9, July; 103.86, April and 119.5, March/ 103.73, May; 108.28, March; 122.56, August and 103.72, December).

Annual range of some of the water quality parameters above permissible limits and WQI in the range of poor to unfit for drinking clearly indicates the unsuitability of raw water for human consumption.

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