

DETERMINATION OF WATER QUALITY INDEX OF SAGAR LAKE, DISTRICT SAGAR, M.P. AND SURROUNDING AREAS

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Abstract: *This paper presents a study on the influence of environmental parameters on water quality of Sagar Lake and surrounding areas. Water samples were collected from different points and their quality was compared on the basis of water quality index, which determines the status of water quality. WQI (water quality index) was determined on the basis of various physical and chemical parameters like pH, EC, TDS, alkalinity, total hardness, calcium, magnesium, chloride, nitrate, sulphate, iron, fluoride and BOD. These parameters were determined for the calculation of water quality index (WQI). A quality of water from four different locations around the lake and one from the lake is been taken. The analysis reveals that Sagar Lake needs treatment as the water in the lake is polluted.*

Key words: Environmental parameters, Water quality index, pH, Alkalinity, Calcium, Nitrate

Introduction

Sagar lake is natural shallow fresh water lake which is been surrounded by the colonies, hospitals, bus stand, vehicle repairing shops, etc. from the three sides and the outlet is from the fourth side. The pollution of water in the lake is increasing steadily due to rapid population growth, urbanization, increasing living standards, human activities and all the discharge from the surrounding through nallas goes into the lake. Time is perhaps not too far when pure and clean water may be unavailable for maintaining the normal human life. There are several ways to assess the quality of water fit for drinking, irrigation and industrial use. A number of parameters affect the usability of water for a particular purpose. Pollution of water has been reported to causes human diseases. Keeping this in view, the present study aims to calculate the water quality index (WQI) in order to assess the suitability of water for the people of Sagar city.

Study Area

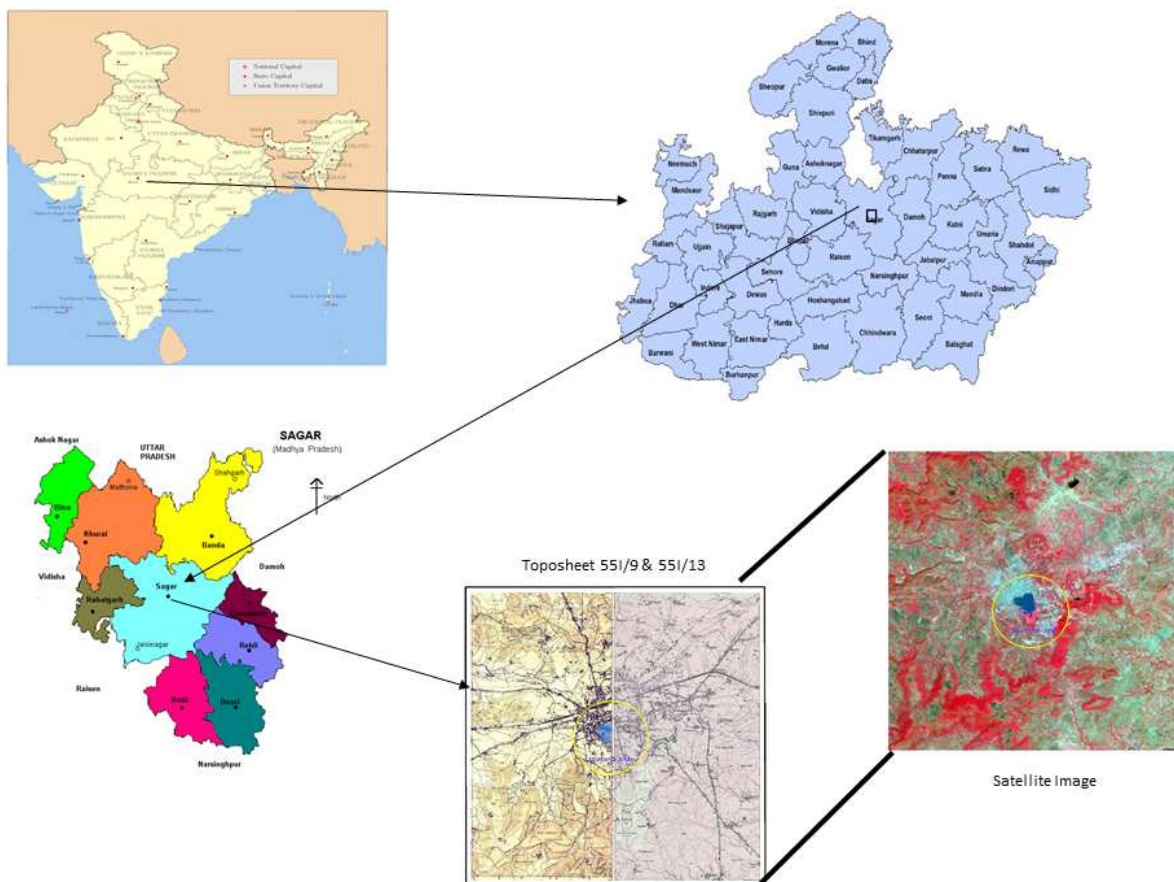
Sagar district is located in the north central part of the state of Madhya Pradesh and occupies as area of 10252 sq. km. The district extends between the latitude of 23⁰10' and 24⁰ 27' north, longitude of 78⁰ 04' and 79⁰ 21' east (fig.1.). Sagar Lake is situated in the heart of Sagar city (23⁰ 50' N: 78⁰ 45' E and 517 MSL) with an area of 82 hectares of which 68 hectare is covered by main lake and the remaining 14 hectare with a small wetland. It falls on the topo sheets no. 55 I/9 and 55 I/13. It is a shallow natural lake which has been polluted due to ill-mannered discharge of pollutant from surrounding areas.

Methodology

Water samples from five sampling locations namely: - Near Hospitals, Bus stand, Teen Madiya Mandir, Chakra Ghat and Lake, were collected. The sample bottles were washed with nitric acid and after collection; analyses were performed as soon as the samples were carried to the

laboratory. All the samples were stored in an ice chest. The samples were collected during post monsoon season. Standard equipment and AR or GR chemicals were used in chemical analysis following standard methods (APHA 1992).

Figure 1: Location Map



Water Quality Index Calculation

In this study for the calculation of water quality index thirteen important parameters were chosen. The W.Q.I. has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO) and Bureau of Indian Standards (BIS). The weighted arithmetic index method (Brown et. al., 1972) has been used for the calculation of WQI of the lake. Further quality rating or sub index (Qi) was calculated using the following expression.

$$\text{Quality rating, } Q_i = 100 [(V_n - V_i) / (V_s - V_i)]$$

Where, V_n : actual amount of nth parameter

V_i : the ideal value of this parameter

$V_i = 0$, Except for pH $V_i = 7.0$ for pH;

V_s : recommended WHO standard of corresponding parameter

Relative weight (Wi) was calculated by a value inversely proportional to the recommended standard (S_i) of the corresponding parameter:

$$W_i = k / S_n$$

k = Constant of proportionality and it is calculated by using the expression given below

$$k = [1 / (\sum 1/ S_n=1,2,..n)]$$

Generally, WQI are discussed for a specific and intended use of water. In this study the WQI is calculated to know the quality of water and permissible WQI for the drinking water is taken as 100. The overall WQI was calculated by using Equation:

$$\text{Water Quality Index (WQI)} = \sum Q_i W_i / \sum W_i$$

Results and Discussion

Drinking Water Standards recommending Agency and Relative weights in Table 2, the values of various physico-chemical parameters for calculation of WQI are presented in Table 3, quality rating in Table 4, sub index values in Table 5, WQI values in Table 6, and status of water quality based on WQI in Table 1.

Table 01: Water Quality Classification Based ON WQI Value

WQI	Quality of water
0-24	Excellent
25-49	Good
50-74	Poor
75-100	Very Poor
>100	Unfit For Drinking

Table 02: Drinking Water Standards recommending Agency and Relative weights

Parameter	Unit	Standard permissible value (Si)	Relative weight (Wi)
Conductivity at 25°	-	1000	0.000212
ph	(mS/cm)	8.5	0.025
Total Alkalinity	(mg/L)	200	0.001063
TDS	(mg/L)	500	0.000425
Chloride at Cl	(mg/L)	250	0.00085
Nitrate as NO ₃	(mg/L)	45	0.004722
Total Hardness as CaCO ₃	(mg/L)	300	0.000708
Calcium as Ca ⁺⁺	(mg/L)	75	0.002833
Magnesium as Mg ⁺⁺	(mg/L)	30	0.007083
Iron as Fe	(mg/L)	0.3	0.708333
Sulphate as SO ₄	(mg/L)	200	0.001063
Fluoride as F	(mg/L)	1	0.2125
BOD	(mg/L)	6	0.035417

Table 03: Observed Water Quality Parameters of Sagar Lake and Surrounding areas

Parameter	Unit	Near Hospitals	Bus stand	Teen Madiya Mandir	Chakra Ghat	Lake
Conductivity	-	2050	750	770	890	525
pH	(mS/cm)	7.5	7.4	7.2	7.3	7.6
Total Alkalinity	(mg/L)	750	280	235	330	220
TDS	(mg/L)	1150	470	410	550	320
Chloride	(mg/L)	277.5	80	75.5	150.5	190
Nitrate	(mg/L)	32.5	35	34.5	31.5	32
Total Hardness	(mg/L)	520	225	210	190	230
Calcium	(mg/L)	90.5	52	60.5	47.5	76.5
Magnesium	(mg/L)	50.5	23.44	15.5	21.46	25.24
Iron	(mg/L)	0.5	2	0.6	0.8	1.2
Sulphate	(mg/L)	25.6	20.4	18	20.8	20.5
Fluoride	(mg/L)	0.5	0.5	0.5	0.5	0.6
Bod	(mg/L)	70.5	45.5	40.5	60	43.5

Table 04: Water Quality Rating (Qi) of Sagar Lake and Surrounding areas

Parameter	Unit	Near Hospitals	Bus stand	Teen Madiya Mandir	Chakra Ghat	Lake
pH	-	205	75	77	89	52.5
Conductivity	(mS/cm)	33.33333	26.66667	13.33333	20	40
Alkalinity	(mg/L)	375	140	117.5	165	110
Chloride	(mg/L)	230	94	82	110	64
Nitrate	(mg/L)	111	32	30.2	60.2	76
Total Hardness	(mg/L)	72.22222	77.77778	76.66667	70	71.11111
Calcium	(mg/L)	173.3333	75	70	63.33333	76.66667
Magnesium	(mg/L)	120.6667	69.33333	80.66667	63.33333	102
TDS	(mg/L)	168.3333	78.13333	51.66667	71.53333	84.13333
Iron	(mg/L)	166.6667	666.6667	200	266.6667	400
Sulphate	(mg/L)	12.8	10.2	9	10.4	10.25
Fluoride	(mg/L)	50	50	50	50	60
BOD	(mg/L)	1175	758.3333	675	1000	725

Table 05: Calculated sub index (QiWi) values of different parameters of Sagar Lake and Surrounding areas

Parameter	Unit	Near Hospitals	Bus stand	Teen Madiya Mandir	Chakra Ghat	Lake
pH	-	0.043553	0.015934	0.016359	0.018909	0.011154
Conductivity	(mS/cm)	0.833333	0.666667	0.333333	0.5	1
Alkalinity	(mg/L)	0.398438	0.14875	0.124844	0.175313	0.116875
Chloride	(mg/L)	0.09775	0.03995	0.03485	0.04675	0.0272
Nitrate	(mg/L)	0.09435	0.0272	0.02567	0.05117	0.0646
Total Hardness	(mg/L)	0.341049	0.367284	0.362037	0.330556	0.335802
Calcium	(mg/L)	0.122778	0.053125	0.049583	0.044861	0.054306
Magnesium	(mg/L)	0.341889	0.196444	0.228556	0.179444	0.289
TDS	(mg/L)	1.192361	0.553444	0.365972	0.506694	0.595944
Iron	(mg/L)	118.0556	472.2222	141.6667	188.8889	283.3333
Sulphate	(mg/L)	0.0136	0.010838	0.009563	0.01105	0.010891
Fluoride	(mg/L)	10.625	10.625	10.625	10.625	12.75
BOD	(mg/L)	41.61458	26.85764	23.90625	35.41667	25.67708

Table 06: Water quality index (WQI) of Sagar Lake and Surrounding Areas

Near Hospitals	Bus stand	Teen Madiya Mandir	Chakra Ghat	Lake
173.74	511.68	177.71	236.75	324.2

pH Values: The pH values of the water ranges from 7.2 to 7.6.

Total dissolved solids: TDS values ranged from 320 to 1150 mg/L. Higher concentration of dissolved solids may produce distress in cattle livestock and a saltiness to water.

Total hardness: Hardness values were recorded between 190 and 520 mg/L. Values of hardness in the sample shows that the water is moderately hard to hard. The scale of hardness from the consumer's point of view may be taken as below:

0-50 mg/L	-	Soft
50-100 mg/L	-	Moderately soft
100-150 mg/L	-	Slightly hard
150-250 mg/L	-	Moderately hard
Over 250 mg/L	-	Hard

Calcium: Calcium occurs in water mainly due to the presence of limestone, gypsum, dolomite and gypsiferrous minerals. The determination of calcium is usually required for potable water. The values varied in the range of 47.5 to 90.5mg/L. High calcium contents in water are undesirable for washing, bathing and laundering. It tends to create scales on utensils. The permissible limit of calcium is 75 mg/L (ISI).

Magnesium: The values varied within range of 15.5 to 50.5 mg/L in the waters. The permissible limit of magnesium is 30 mg/L (ISI). Magnesium is an essential element for man. However, at higher levels, magnesium salts have a laxative effect.

Chloride: Concentrations of chloride were found to vary within 75.5 to 277.5 mg/L. Though chloride concentration is below permissible limit, except at near hospital, the concentration is high.

Sulphate: The values of sulphate ranged within 18 to 25.6 mg/L. Sulphate may have laxative effect if magnesium is present at an equivalent concentration (Chatterjee & Raziuddin 2002). In the present study sulphate in waters is below permissible limit.

Nitrate: Nitrates are the end products of decomposition of organic matter present in fully oxidized waters and harmful above 45 mg/L. In the present study nitrate in waters is below permissible limit and ranges from 31.5 to 35 mg/L.

Iron: WHO International standards of iron recommended a permissible limit of 0.3 mg/L and excessive limit of 0.1 mg/L in drinking water. The values ranged within 0.5 to 2 mg/L.

Conductivity: Conductivity is used to measure the concentration of dissolved solids which have been ionized in a polar solution such as water. The unit of measurement commonly used is one millionth of a Siemen per centimeter (micro- Siemens per centimeter or $\mu\text{S}/\text{cm}$). The values obtained are in the range 525 and 2050 mhos.

Alkalinity: Alkalinity is a measure of the capacity of water to neutralize acids. The predominant chemical system present in natural waters is one where carbonates, bicarbonates and hydroxides are present. The bicarbonate ion is usually prevalent. In the present investigation the total alkalinity of the water samples is found in the Range 220 to 750 mg/L.

Fluoride: Fluoride is the simplest anion of fluorine. Its salts and minerals are important chemical reagent. In terms of charge and size, the fluoride ion resembles the hydroxide ion. Fluoride ions occur on earth in several minerals, particularly fluorite, but are only present in trace quantities in water. Fluoride contributes a distinctive bitter taste. It contributes no color to fluoride salts. In present study it varies in the range from 0.5 to 0.6 mg/L.

Biochemical Oxygen Demand: Biochemical oxygen demand (BOD) is the amount of dissolved oxygen needed (i.e., demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period. This parameter values obtained in the present study are 40.5 to 70.5 mg/l.

Conclusion

From present observations, it may be concluded that water quality index (WQI) values of Sagar Lake and surrounding areas are above 100, indicating that the source, i. e, lake water is unsuitable for drinking purposes. This pollution is due to the disposal of domestic sewage from the colonies surrounding the lake and also from the vehicle repairing shops near the lake, cattle grazing and washing of cloths. Therefore, the lake water is polluted and it is recommended that water should not be used for domestic purposes without treatment.

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