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ASSESSMENT OF WATER QUALITY PARAMETERS OF MAN SAGAR LAKE JAIPUR, RAJASTHAN, INDIA

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ABSTRACT

This research paper is based on a study carried out to evaluate the physico-chemical parameters of the Man Sagar Lake water. The Man Sagar Lake is one of the major tourist spots of Jaipur City. Looking to deteriorating condition of the lake, it was included in National Lake Conservation Plan by the Government of India in December 2002. To find out the outcome of steps taken by the Govt. for its conservation and existing status of its water quality, it was decided to perform an analytical study. The samples of water were obtained from four identified spots of the lake for a continuous period of four months during November–December 2019 and January–February 2020. The sampling process was strictly according to the procedure of the Central Pollution Control Board, Govt. of India and the testing protocols followed for analysing samples were as per the Indian and APHA standards. The parameters of of physico-chemical nature found during assessment were compared with the prescribed limits as per the guidelines of National Plan for Conservation of Aquatic Ecosystems (NPCA) enacted by the Ministry of Environment, Forests & Climate Change, Government of India and it was found that the parameters are beyond the standard limits, indicating that the lake is getting polluted. The possible reasons for deteriorating water quality are the negligence in proper implementation and monitoring of planned activities and programmes. Therefore, it is the duty of all concerned stakeholders including govt. authorities, non-govt. organizations and general public to come forward and work together towards conservation of the famous ancient lake.

KEY WORDS : Man Sagar Lake, Jal Mahal, Water Pollution, Physico-chemical Parameters, National Plan for Conservation of Aquatic Ecosystems.

INTRODUCTION

Water is an essential need of life and lakes are one of the best storages of water. The Man Sagar Lake is a type of man-made lake which is situated in the North of World Heritage City Jaipur. The lake is named after the then ruler of Amer Maharaja Man Singh who constructed it in 1610. An architectural monument named "Jal Mahal" was also constructed in the centre of the lake. This lake is known as the only significant water body and one of the major tourist spots of Jaipur city. It is enclosed by Aravalli Hills from three sides and the fourth side consists of plains that are densely inhabited now a days. The water spread area of Man Sagar Lake is nearly 300 acres (121 Hectares). The Man Sagar Lake is a habitat to a variety of migratory birds and also provides sustainable living to species of aquatic ecosystem. In recent times, the lake has increased its water spread area due to deposition of silts on the lake bed, thus decreasing the bed depth of the lake. The lake was getting polluted day by day due to inflow of partly treated and untreated wastewater of Brahmpuri Sewage Treatment Plant and Nagtalai. After which the Government of Rajasthan launched various programs to conserve the lake like restoration works under the National River Conservation Program (NRCP), Jal Mahal Restoration Private Limited (JMRPL) and Jal Tarang Project. [SML, 2019]

The Man Sagar Lake was enlisted in conservation sites under the National Lake Conservation Plan (Now renamed as National Plan for Conservation of Aquatic Ecosystems) in December 2002. [NPCA, 2019] and the Government of India sanctioned Rs. 25 Crore for the conservation and restoration of the lake under this plan [SML, 2019]

In this paper, the assessment of physico-chemical parameters was performed by obtaining samples of lake water in four months during November–December 2019 and January–February 2020. The sampling and testing was carried out as per IS: 3025 [BIS, 2019] and APHA 21st Edition [APHA, 2005]. The pollution in Man Sagar Lake is a serious issue and it is required to conserve the lake to maintain the ecological balance around the Aravalli Hills and to promote the tourism in Jaipur.

In past, many researchers have carried out similar studies on water quality of different lakes including Man Sagar Lake Jaipur (Kavita Sahni *et al.*,2011; Chetna Pradhan *et al.*, 2016; Neera Srivastava *et al.*, 2009; Meenakshi Singh *et al.*, 2010] and other major cities of India like Bhopal (Dixit S. *et al.*, 2008), Hyderabad (Aruna Jyothi Kora *et al.*, 2017), Una–Bilaspur, Himachal Pradesh (Vandana Sharma *et al.*, 2015) and have reported that in almost all of the these cities, the lake were polluted.

METHODOLOY

Study area

The samples were collected from four identified spots of the lake. The coordinates of the sampling locations along with landmark are represented in Table 1. The location of Man Sagar Lake can be seen on map as shown in Fig. 1, whereas the locations of sampling locations (red spots) are shown in Fig. 2.

Parameters Analysed: The physico-chemical parameters analysed in the lake water samples are pH, temperature, TDS (Total Dissolved Solids), EC (Electrical Conductivity), DO (Dissolved Oxygen), Total Hardness (as $CaCO_3$), Calcium Hardness, Magnesium Hardness, Turbidity, Acidity, Alkalinity, Chloride, Fluoride, Nitrate, BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand).

Fig. 1. Location Map of Man Sagar Lake in Jaipur City.

Fig. 2. Map Showing Sampling Locations at Man Sagar Lake, Jaipur.

Duration of Study: The samples were collected from lake during November 2019 to February 2020. A comprehensive investigation of physico–chemical parameters was planned and performed on the basis of four months sampling and testing.

Protocols Followed: The protocols followed for the sampling and testing of lake water samples are according to the Indian Standards and American Public Health Association (APHA) methods, as shown in Table 2.

Table 1. Detail of Sampling Locations

Location	Coordinates	Landmark
Sampling Spot 1	26.953991, 75.843171	In front of Café Coffee Day
Sampling Spot 2	26.956804, 75.844122	In front of Hotel Trident
Sampling Spot 3	26.958719, 75.846233	In front of Air Force School
Sampling Spot 4	26.960822, 75.848142	Near Parking Toll

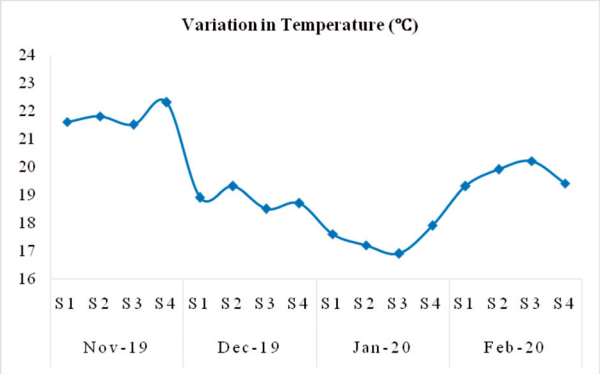
Table 2. Protocols / test methods followed for different parameters

S. No	Test Parameter	Test Method Followed
1.	Temperature	In-house Method
2.	pH	IS 3025 (Part 11): 2017
3.	Total Dissolved Solids	IS 3025 (Part 16): 2017
4.	Dissolved Oxygen	IS 3025 (Part 38): 2019
5.	Total Hardness (as $CaCO_3$)	IS 3025 (Part 21): 2019
6.	Calcium Hardness	IS 3025 (Part 40): 2019
7.	Magnesium Hardness	IS 3025 (Part 46): 2019
8.	Turbidity	IS 3025 (Part 10): 2017
9.	Acidity	APHA (21st Ed.) Method
10.	Alkalinity	IS 3025 (Part 23): 2019
11.	Chloride (as Cl)	IS 3025 (Part 32): 2019
12.	Fluoride (as F)	IS 3025 (Part 60): 2019
13.	Nitrate (as NO_3)	IS 3025 (Part 34): 2019
14.	BOD (3 Day @ 27°C)	IS 3025 (Part 44): 2019
15.	COD	IS 3025 (Part 58): 2017

Standards of NPCA: The Ministry of Environment, Forest and Climate Change, Govt. of India has published standards for lake water based on further use of water under the NPCA (National Plan for Conservation of Aquatic Ecosystems), which are mentioned in Table 3.

RESULTS AND DISCUSSION

The cumulative results of the parameters analysed for the lake water during the study period November–December 2019 and January–February 2020 are represented in Table 4 and 5 respectively. The samples have been abbreviated as S1, S2, S3 and S4.



Graph 1. Variation in Temperature of lake water during study period

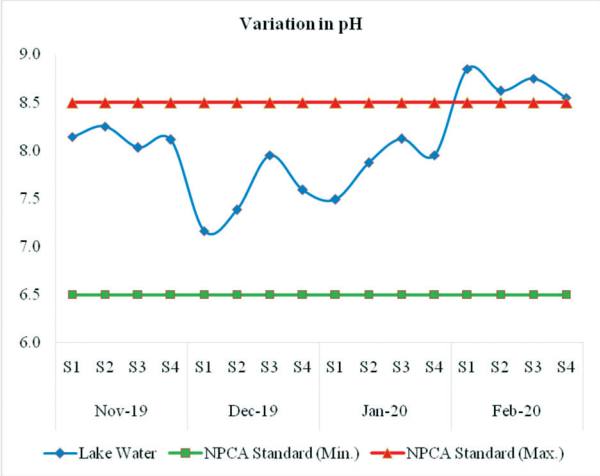
For better understanding and clear representation, the variations in important phyiso-chemical parameters are presented through graphs as shown below:

The Graph 1 shows variation in temperature, which is initially observed high in November, goes on decreasing in December and January and then again rises in February. The variation is according to the atmospheric conditions and no abnormality is noticed during this period.

Table 3. Water Quality Criteria as per NPCA Standards [NPCA, 2019]

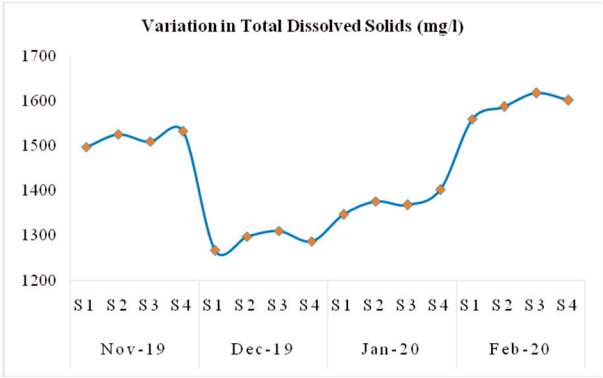
Designated Best Use	Class of Criteria	Criteria
Drinking Water Source without conventional water treatment but after disinfection	A	1. Total Coliforms MPN/100 mL ≤ 50 2. pH: 6.5 to 8.5 3. Dissolved Oxygen ≥ 6 mg/L 4. BOD ≤ 2 mg/L
Outdoor bathing (organized)	B	1. Faecal Coliforms MPN/100 mL d" 2500 (max.) or 1000 (desirable) 2. pH : 6.5 to 8.5 3. Dissolved Oxygen ≥ 5 mg/L 4. BOD ≤ 3 mg/L
Drinking water source after conventional water treatment and disinfection	C	1. Faecal Coliforms MPN/100 mL ≤ 5000 2. pH : 6 to 9 3. Dissolved Oxygen ≥ 4 mg/L 4. BOD ≤ 3 mg/L
Propagation of wildlife & fisheries	D	1. pH : 6.5 to 8.5 2. Dissolved Oxygen ≥ 4 mg/L 3. Free Ammonia (as N) ≤ 1.2 mg/L
Irrigation, Industrial Cooling, Controlled waste disposal	E	1. pH: 6.0 to 8.5 2. Electrical Conductivity at 25 °C ≤ 2250 µ mhos/cm 3. SAR ≤ 26 4. Boron ≤ 2 mg/L

The Graph 2 shows variations in pH values of lake water as well as the range of standard values of pH for different purposes. It can be seen that except the month of February, pH values are within the permissible limits. In February, the pH exceeds the upper limit of 8.5 and the possible reason may be introduction of alkaline (basic) water or wastewater into the lake by nearby residents or some industrial effluents. The Graph 3 represents variation in total dissolved solids which shows an undulating trend of values, which may be again due to varying nature of input of wastewater into the lake.



Graph 2. Variation in pH of lake water during study period

Graph 4 shows the variation in one of the important parameters, i.e. the dissolved oxygen. It can be seen that during initial three months of the study, the level of DO is within the permissible limits, but in the last month of February, it is less than the required minimum value of 4.0 mg/L. Lower levels of DO can prove to be very harmful for the aquatic life in the lake water.



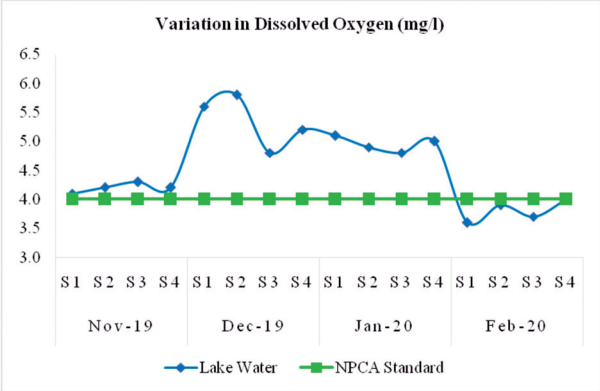
Graph 3. Variation in Total Dissolved Solids of lake water during study period

The variation in other parameters like hardness, turbidity, acidity, alkalinity, chloride, fluoride and nitrate are shown in Graph 5 to 11 below. In each of these parameters, we can notice undulating trend of values during the study period of four months. It depends on the disposal of partly treated or untreated domestic sewage, industrial wastewater or solid waste into the lake, however there is no unusual high or low deviation in such parameters.

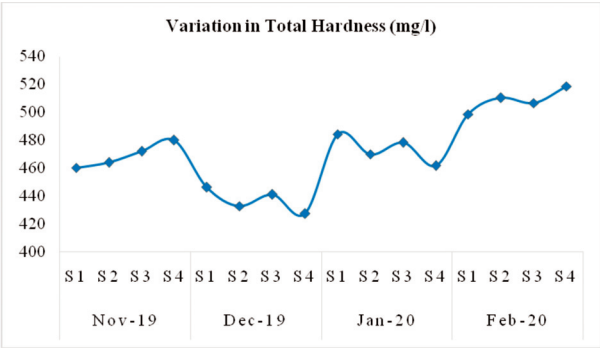
The variation in BOD values of the lake water is shown in Graph 12, in which there is an alarming point to note that during whole study period, the BOD of lake water is much larger than the maximum permissible limit of 3 mg/l as per the NPCA guidelines for varying usage. This clearly

Table 4. Physico-chemical Parameters of Lake Water during November–December 2019

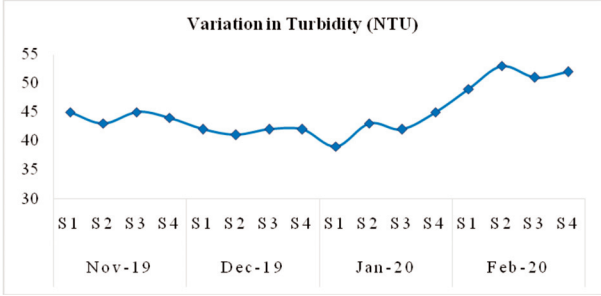
S. No.	Parameters	Unit	November 2019				December 2019			
			S1	S2	S3	S4	S1	S2	S3	S4
1.	Temperature	^{0}C	21.6	21.8	21.5	22.3	18.9	19.3	18.5	18.7
2.	pH	-	8.14	8.25	8.03	8.11	7.16	7.38	7.95	7.59
3.	TDS	mg/L	1498.0	1526.0	1510.0	1533.0	1267.0	1297.5	1310.7	1287.2
4.	Diss. Oxygen	mg/L	4.1	4.2	4.3	4.2	5.6	5.8	4.8	5.2
5.	Total Hardness	mg/L	460.0	464.0	472.0	480.0	446.0	432.5	440.8	427.3
6.	Ca Hardness	mg/L	120.0	108.0	112.0	116.0	107.0	112.5	102.3	116.8
7.	Mg Hardness	mg/L	340.0	348.0	360.0	354.0	310.7	302.6	298.7	307.5
8.	Turbidity	NTU	45	43	45	44	42	41	42	42
9.	Acidity	mg/L	20.0	22.0	18.0	21.0	17.5	18.2	18.7	17.9
10.	Alkalinity	mg/L	64.0	60.0	58.0	62.0	60.2	63.4	57.5	59.1
11.	Chloride	mg/L	482.89	487.82	492.75	477.97	462.2	458.7	459.5	465.0
12.	Fluoride	mg/L	1.19	1.23	1.34	1.14	1.18	1.26	1.95	1.37
13.	Nitrate	mg/L	4.40	4.38	4.46	4.30	3.97	4.38	4.46	4.30
14.	BOD	mg/L	26.4	25.8	28.0	27.9	18.2	18.7	17.9	19.0
15.	COD	mg/L	94.3	96.4	95.8	94.7	85.6	86.2	84.9	85.2



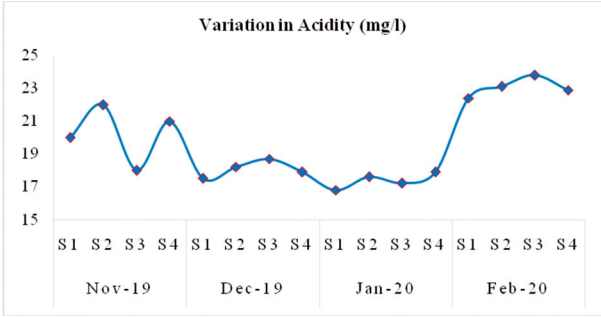
Graph 4. Variation in Dissolved Oxygen of lake water during study period



Graph 5. Variation in Total Hardness of lake water during study period



Graph 6. Variation in Turbidity of lake water during study period

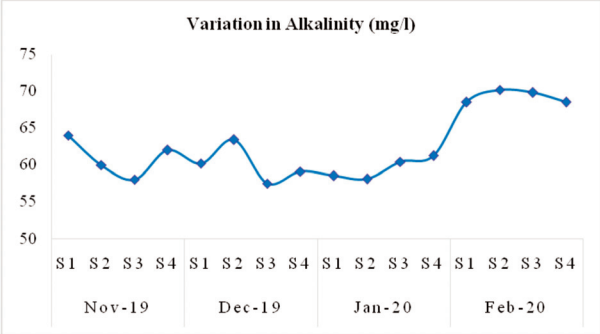


Graph 7. Variation in Acidity of lake water during study period

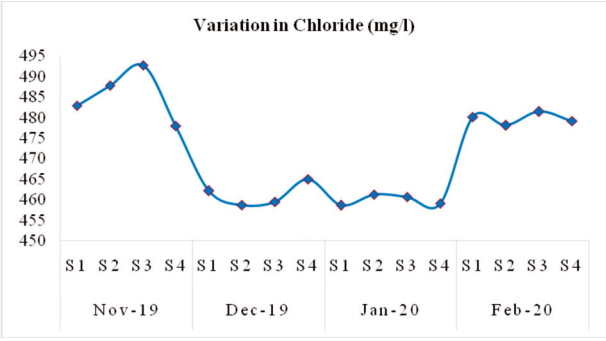
indicates that the lake water is polluted with organic matter either through domestic sewage or through municipal solid waste. Hence, it needs to be first treated for any kind of further usage as well as it creates unhygienic conditions and foul smell in the water and may also be dangerous for aquatic life as the organic matter will absorb the dissolved oxygen available in water to get itself oxidized. The variation in COD values is shown in Graph 13, in which the range of COD is from 84.2 mg/L to 96.4 mg/L, indicating that there is some entry of industrial effluents into the lake water.

Table 5. Physico-chemical Parameters of Lake Water during January–February 2020

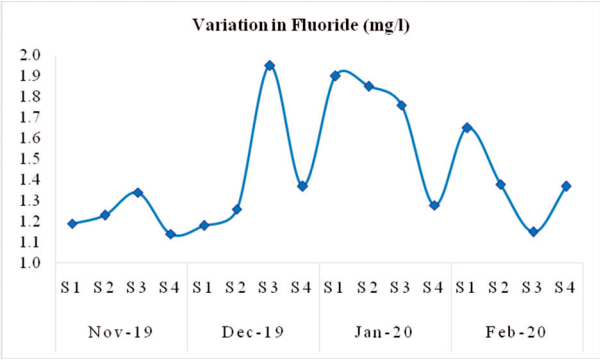
S. No.	Parameters	Unit	January 2020				February 2020			
			S1	S2	S3	S4	S1	S2	S3	S4
1.	Temperature	^{0}C	17.6	17.2	16.9	17.9	19.3	19.9	20.2	19.4
2.	pH	-	7.49	7.87	8.12	7.95	8.85	8.62	8.75	8.55
3.	TDS	mg/L	1347.2	1376.6	1368.2	1402.6	1560.2	1587.9	1618.5	1602.3
4.	Diss. Oxygen	mgL	5.1	4.9	4.8	5.0	3.6	3.9	3.7	4.0
5.	Total Hardness	mg/L	484.2	469.8	478.3	461.5	498.5	510.3	506.7	518.5
6.	Ca Hardness	mg/L	106.7	108.5	110.2	105.3	128.6	130.8	127.9	127.2
7.	Mg Hardness	mg/L	304.5	309.8	307.2	306.7	321.5	319.2	319.5	320.7
8.	Turbidity	NTU	39	43	42	45	49	53	51	52
9.	Acidity	mg/L	16.8	17.6	17.2	17.9	22.4	23.1	23.8	22.9
10.	Alkalinity	mg/L	58.5	58.1	60.4	61.2	68.5	70.2	69.8	68.5
11.	Chloride	mg/L	458.6	461.3	460.7	459.1	480.2	478.1	481.5	479.2
12.	Fluoride	mg/L	1.90	1.85	1.76	1.28	1.65	1.38	1.15	1.37
13.	Nitrate	mg/L	6.2	7.5	6.9	6.7	8.1	8.6	7.9	8.0
14.	BOD	mg/L	15.4	15.8	16.9	17.3	20.5	21.9	19.8	21.2
15.	COD	mg/L	84.5	86.7	84.2	86.2	91.8	92.1	90.5	92.5



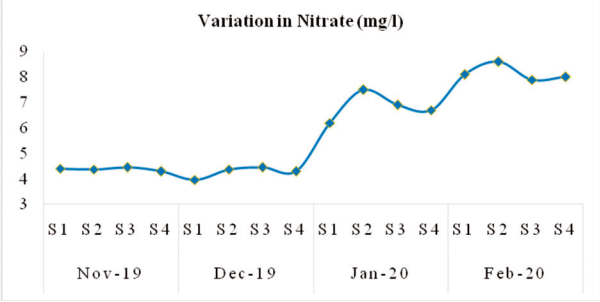
Graph 8. Variation in Alkalinity of lake water during study period



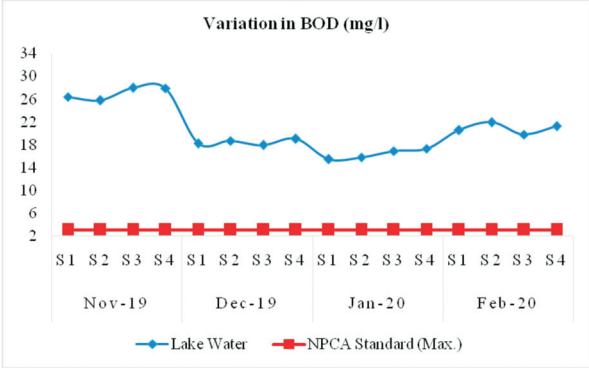
Graph 9. Variation in Chloride of lake water during study period



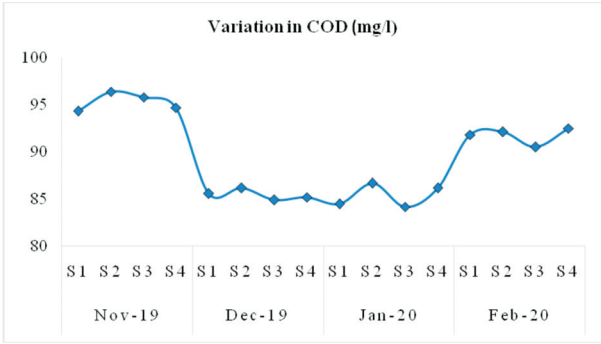
Graph 10. Variation in Fluoride of lake water during study period



Graph 11. Variation in Nitrate of lake water during study period



Graph 12. Variation in BOD of lake water during study period



Graph 13. Variation in COD of lake water during study period

CONCLUSION

By comparing the assessed parameters of lake water with standards prescribed by the NPCA, we can interpret that the water of Man Sagar Lake is having pH in the range of 7.16–8.85, which is suitable for C category but somehow slightly exceeds for other categories. In respect to dissolved oxygen, it has been found in the range of 3.6–5.8 mg/L, which is suitable for B, C and D categories of use of water. In case of BOD, which is found in range of 15.4–27.9 mg/L, it is not suitable for any of the category as per the NPCA guidelines. Therefore, in nutshell, it can be deduced that the quality of Man Sagar Lake water is at present not suitable for any of the usage according to the NPCA norms. Therefore, measures like identifying the point sources of pollution, sewage treatment and management, proper disposal of industrial effluents, removal of sediment/dredging, deweeding/weed control, restoration of feeding drains, treatment of catchment area, proper management of solid waste, public awareness and public participation in maintenance, monitoring and evaluation of

conservation plans can be taken to control the BOD and reduce the pollution in the lake. For the time being, cascade aerators or fountains can be installed in the lake which will not only increase the dissolved oxygen level and reduce the BOD but will also prove helpful in improving the aesthetic view of the lake.

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