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Assessment of Water Quality in Surha Lake Based on Physiochemical Parameters, India

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Abstract
Surha Lake is an important oxbow lake, lies in the area of Jai Prakash Narayan Bird Sanctuary located in the eastern part of Uttar Pradesh (U.P), India. It is a major source of water of livelihood of huge populations. Therefore, the present study (2006-08) aims to classify the water quality of the lake using CPI and NSFWQI, based on physiochemical parameters like DO, BOD, COD etc. Pearson's correlation matrix was evaluated to find possible interrelations among assessed water quality parameters. The average CPI was found as 0.98, 1.11 and 1.16 in year 2006, 2007 and 2008 whereas NSFWQI were found as 47.25, 49 and 49.88 respectively. The results indicate that the water quality is polluted and the consistently rising from slight to moderate during 2006-08, due to increased input of domestic waste and agricultural runoff from the lake catchments. Therefore, the lake water is not suitable for drinking, bathing and other life supporting activity.

Keywords: Correlation analysis, CPI, NSFWQI, Surha Lake.

Nomenclature
BOD: Biological Oxygen Demand.
DO: Dissolve Oxygen.
COD: Chemical Oxygen Demand.
WQI: Water Quality Index.
EC: Electrical Conductance
WT: Surface Water Temperature.
TH: Total Hardness.
CPI: Comprehensive Pollution Index.
NSFWQI: National Sanitation Foundation Water Quality Index.

1. Introduction
Water is one of the most essential natural resource for sustenance of life gifted to human by nature. The availability of freshwater resources is important to meet the water use demand of rapidly growing population and spreading out of economic activities of any country. India is naturally supported by a large number of freshwater bodies in the form of rivers, lakes and wetland. But, in the present scenario, these fresh water bodies are polluting due to heavy influence of anthropogenic activities [1].The nutrient enrichment due to direct discharge of untreated industrial, domestic wastes and agricultural runoff, etc. supporting the eutrophication i.e. water unfit for human use, especially in lakes [2 & 3]. Therefore, it has become essential to assess the water pollution of these water bodies in a systematic manner so that suitable corrective actions could be recommended for conservation. In this respect, in the recent years, numerous water quality indices like Comprehensive Pollution Index (CPI) [4, 5 & 6], National Sanitation Foundation Water Quality Index (NSFWQI) [7 & 8] etc. have been developed to classify effectively the water pollution status of water bodies based on physiochemical and biological parameters. These water quality indices (WQI) give a single number based on data of several water quality parameters that defines the water pollution of a water body at each location considered in study, i.e. WQI converts the complex water quality data sets into the single number which is meaningful, understandable and usable information [9, 10 &11].

So, in the present study an effort has been made to assess the water quality status of Surha Lake which is situated in the Ballia district of U.P, India based on physiochemical parameters like DO, BOD, COD, etc. Surha Lake is an important source of water used for drinking, bathing, fishery and agriculture etc. by a large population of district Ballia. The numbers of studies have been conducted by some of the researchers, for identification of zooplanktons, molluscan fauna, diversity of aquatic insects [12 & 13], aqua status [14] and diversity of fishes [15] in catchment of Surha Lake. But a comprehensive study of water quality status of Surha Lake has not been done yet. Therefore, in the present paper water quality and tropical status of Surha Lake have been classified using the water quality indices CPI, NSFWQI and also statistical analysis of water quality parameters have been performed using SPSS 17.0 software.

2. Material and method

2.1. Details of study site

Surha Lake is in indo-gangetic plain, lies in the area of Jai Prakash Narayan Bird Sanctuary located in the district Ballia in eastern part of U.P, India at latitude $26^0$40' to $26^0$42' E and longitude $84^0$11' to $84^0$14' N (Figure 1). It is an ox-bow lake and its catchment area is about 34.329 km^2 while in summer its area shrinks to about 11.226 km^2. It receives major water supply during rainy season in addition to water from Ganga and Saryu River (Ghaghra River) through three small streams Gararai, Madha and Katehar nala. The area receives an average annual rainfall of about 1000 mm and temperature ranges from maximum 43^0C in summer to minimum 4^0C in winter. The lake area has a rich diversity of flora and fauna especially birds. The lake is surrounded by extensive agricultural land.

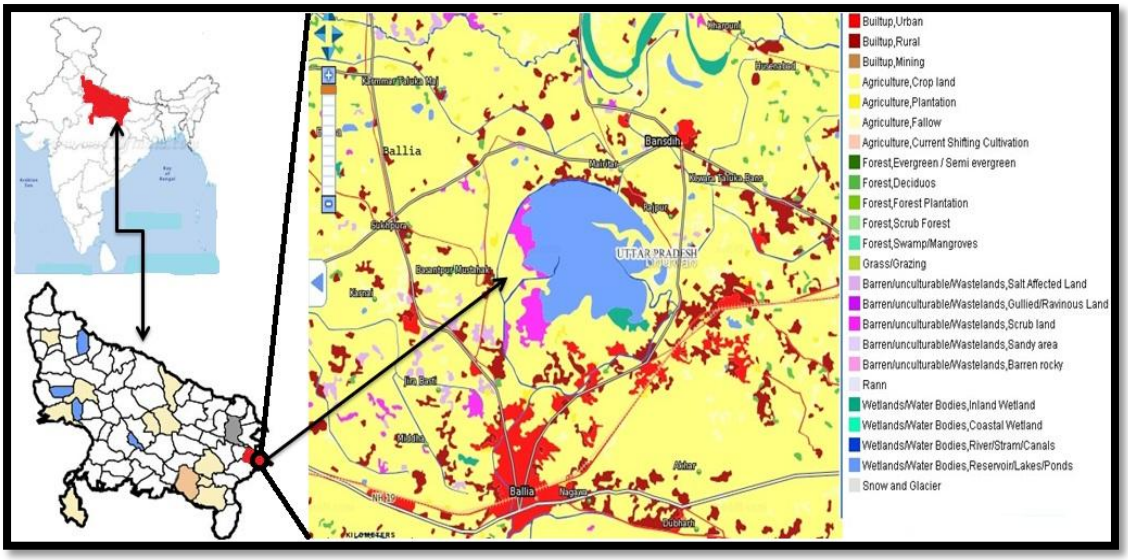

Figure 1. Schematic diagram of Surha Lake

2.2. Data collection and analysis

The water samples were collected monthly during April, 2006 to March, 2008 and analyzed in the laboratory as per the water quality guidelines [16]. Some parameters like WT, DO and pH were measured on site and rests of the parameters were taken to the laboratory for further analysis. The twelve physiochemical parameters were considered for analysis, such as pH, alkalinity, COD, BOD, turbidity, EC, TH, Cl, Ca and Mg. The measured unit of all the parameters was taken in mg/l except turbidity (NTU), EC (µg/cm), DO (% saturation) and WT (^{0}C). The mean and standard deviation (SD) of these parameters have been shown in Table 1. In order to assess the variation in the water quality of Surha Lake, the water quality data obtained from the laboratory were compared to the permissible limit of drinking water quality to evaluate CPI, NSFWQI and Pearson's correlation matrix.

2.3. Comprehensive pollution index (CPI)

The CPI has been applied to classify the water quality status by many of the research findings [4 & 5]. To evaluate this index all twelve parameters were used. It is evaluated by the following equations as:

$$PI = \frac{\text{Measured concentation of individual parameter}}{\text{Standard permisible concentration of parameter}} \quad \text{Equation 1}$$

$$CPI = \frac{1}{n}\sum_{i=1}^{n} PI \quad \text{Equation 2}$$

Where, PI is the pollution index of individual water quality parameter considered, n is the number of parameters and CPI is a comprehensive pollution index. The standard permissible concentrations of each parameter considered in the study drinking water standard values for the each parameter according to the Bureau of Indian standard [17] and World Health Organization [18]. CPI ranges from 0-2 classified in Table 2.

Table 1. Water quality parameters measured during year 2006-08

Sl. No.	Parameters	Mean ± SD
1	WT	22.24 ± 7.32
2	DO	8.15 ± 0.92
3	BOD	2.33 ± 0.69
4	COD	15.75 ± 3.42
5	EC	226.79 ± 34.66
6	Turbidity	7.21 ± 1.02
7	pH	8.06 ± 0.48
8	Cl	26.00 ± 6.12
9	Alkalinity	237.00 ± 54.67
10	Ca	135.75 ± 32.49
11	Mg	111.67 ± 33.03
12	TH	236.88 ± 48.11

Table 2. Description of water quality indices

Sl. No	CPI	NSFWQI	Characteristic
1.	0-0.20	91-100	Clean water, suitable for drinking, domestic and other life supporting purposes.
2.	0.21-0.4	71-90	Moderately clean, suitable for outdoor bathing, aesthetic, agriculture and fisheries.
3.	0.41-1.00	51-70	Slightly polluted, aesthetic, support fisheries and can be used for agricultural.
4.	1.01-1.20	31-50	Moderately polluted, algal growth, not suitable for human use and may support fisheries.
5.	≥2.01	0-30	Severely polluted with no life support.

2.4. National Sanitation Foundation Water Quality Index (NSFWQI)

In the recent years, this methodology has been commonly used for classification of water quality [2, 7 & 8]. To evaluate these index five parameters (pH, DO, BOD, turbidity and surface temperature) were used. Each of these parameters was assigned with a definite weightage factor (W_i) according to its significant influence on the water quality. The individual Qi for each parameter and overall WQI was evaluated using equation 4 and 5.

$$W_i = k/X_i \quad \textbf{(Equation 2)}$$

$$k = 1/\sum_{i=1}^{n}\frac{1}{X_i} \quad \textbf{(Equation 3)}$$

Where, Wi is the weightage factor of i^{th} parameter; k is the proportionality constant; Xi is the maximum permissible concentration limit of i^{th} parameter in drinking water [17 & 18].

$$Q_i = M_i/X_i \quad \textbf{(Equation 4)}$$

Where, Qi is the quality index of individual heavy metal; Mi is the monitored value of the i^{th} parameter and Xi is the standard or permissible limit for the i^{th} parameter.

$$WQI = \sum_{i=1}^{n} Q_i W_i / \sum_{i=1}^{n} W_i \quad \textbf{(Equation 5)}$$

Where, n is the number of parameters considered in the present study. For the present study, the NSFWQI ranges from 0-100 classified in Table 2.

2.5. Evaluation of correlation coefficient

In order to classify the source or probable cause of water pollution in lake, Pearson correlation coefficient analysis was performed using SPSS 17 software based on the CPI and water quality parameters [19, 20, 21, 22 & 23].

3. Results and Discussions

3.1. Assessment of water pollution

The analyses of the CPI and NSFWQI have been shown in Table 3. NSFWQI and CPI are a mean to convert large amounts of water quality data into a single value usable by environmentalist/policymakers and the public on a regular basis. Such a rating scale allows for simplicity and consumer comprehensibility. The water quality indices are different types depending on its final purpose. These can be highly specific for different water bodies or could be a general one for all types of useful water for human consumption/utilization. NSFWQI and CPI can also be based not just on readings on a single point of time, but also on the data collected over a period of time.

Table 3. Status of water quality year 2006-08

Months	**CPI**	**NSFWQI**	**Water quality pollution**
April,2006	1.00	42	Moderately
May	0.92	52	Slightly
June	0.80	59	Slightly
July	0.98	56	Slightly
Aug	1.10	45	Moderately
Sept	1.14	47	Moderately
Oct	1.03	44	Moderately
Nov	0.98	51	Slightly
Dec	0.83	53	Slightly
Jan,2007	1.10	49	Moderately
Feb	0.87	53	Slightly
March	1.21	47	Moderately
April	0.96	42	Slightly
May	1.02	43	Moderately
June	1.16	49	Moderately
July	1.05	46	Moderately
Aug	1.27	48	Moderately
Sept	1.04	49	Moderately
Oct	1.04	45	Moderately
Nov	1.04	47	Moderately
Dec	1.10	49	Moderately
Jan,2008	1.02	50	Moderately
Feb	1.03	48	Moderately
March	1.04	49	Moderately

From the above Table 3, it can be observed that the water quality of the lake is moderately polluted in most of the sampling months. A slight rise in the CPI and NSFWQI was found during sampling period 2006-08 (slightly polluted to moderately polluted). The average CPI was found as 0.98, 1.11 and 1.16 in the year 2006, 2007 and 2008 whereas NSFWQI were found as 47.25, 49 and 49.88 respectively. The rise in water pollution of the lake during these sampling years has also been graphically shown in Fig. 2. In above Fig. 2, it can be observed that there had been a consistent increase in the water pollution during year 2006 to 2008, due to significant change in physiochemical characteristic of water. The illustration of alteration in the PI of physiochemical parameters has been shown in Fig. 3.

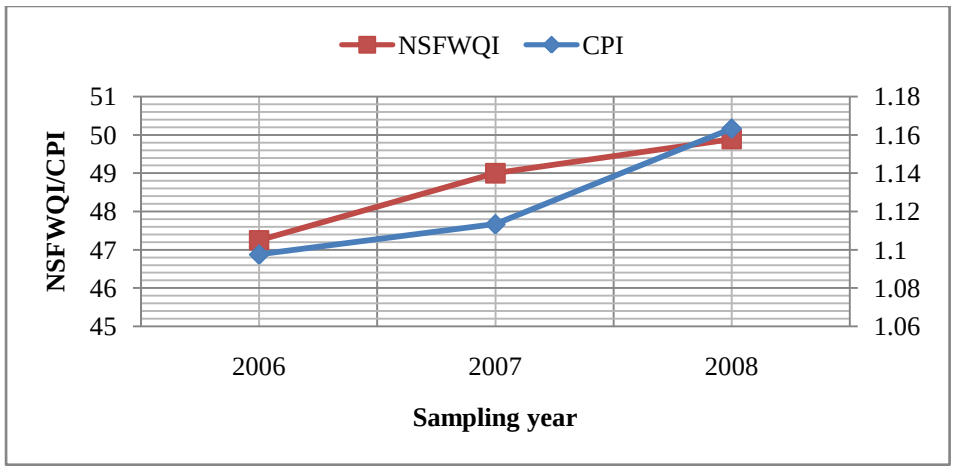

Fig. 2. NSFWQI and CPI during 2006-08

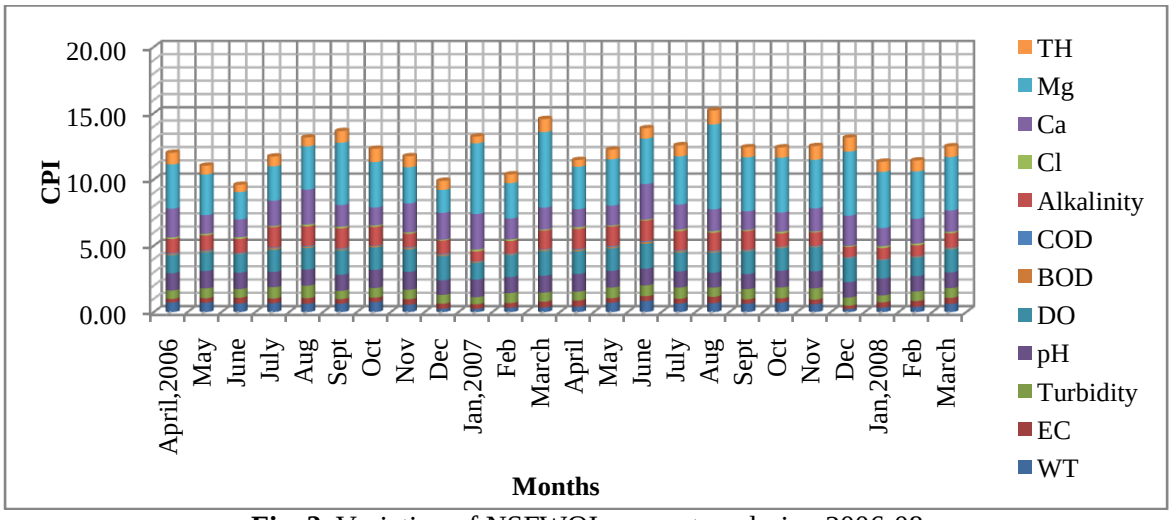

Fig. 3. Variation of NSFWQI parameters during 2006-08

From the above Fig. 3, a significant variation in water pollution can be observed during the sampling period. There had been a considerable decrease in DO (as PI decreases) and increase in surface temperature, pH, alkalinity, BOD, Cl, Mg and TH (as PI increases), while no significant change has been found in COD, turbidity, and Ca. The variation in these parameters may be due to influence of rural waste and agricultural runoff in the lake catchment. Therefore, to find out the probable cause of rise in pollution level, the change in concentration of physiochemical parameters, Pearson's correlation matrices had been developed among the CPI and water quality parameters which have been shown in Table 4.

In the above Table 4, a significant negative relationship can be observed between pH and other water quality parameters except BOD, chloride and temperature which has a strong positive relationship. Furthermore, the negative relationship has also been found between alkalinity with Ca and Cl while, positive with DO, Mg and turbidity which can be due to less/no interference of carbonate salt and inorganic chemicals in the dissolution of oxygen [24, 25 & 26]. The BOD and DO are found in the major factor in the water quality change in the lake, as the BOD & DO has strong relationships with all water quality parameters except Cl, Mg and TH. Therefore, these relationships signify that the major contribution in rise of water pollution is due to the increased influence of agricultural and rural domestic waste which contains negligible influence of toxic effluents [27]. The results indicate that the water quality is polluted and the consistently rising from slight to moderate during 2006-08, due to increased input of domestic waste and agricultural runoff from the lake catchments. This requires taking corrective measures so that further pollution in lake may not increase.

Table 4. Pearson's correlation matrix between CPI and water quality parameters

		WT	EC	Turbidity	pH	DO	BOD	COD	Alkalinity	Cl	Ca	Mg	TH	CPI
WT	P. Cor.	1												
EC	P. Cor.	-0.096	1											
	Sig.	0.656												
Turbidity	P. Cor.	0.564**	-0.003	1										
	Sig.	0.004	0.99											
pH	P. Cor.	0.165	-0.103	-0.142	1									
	Sig.	0.442	0.633	0.507										
DO	P. Cor	0.047	-0.017	0.324	-0.161	1								
	Sig.	0.827	0.939	0.122	0.453									
BOD	P. Cor.	0.418*	0.124	0.410*	0.114	0.384	1							
	Sig.	0.042	0.563	0.047	0.597	0.064								
COD	P. Cor.	0.289	-0.069	0.210	-0.098	0.206	0.577**	1						
	Sig.	0.171	0.75	0.324	0.649	0.334	0.003							
Alkalinity	P. Cor.	0.590**	0.164	0.508*	-0.023	0.382	0.737**	0.550**	1					
	Sig.	0.002	0.444	0.011	0.914	0.065	0	0.005						
Cl	P. Cor.	-0.054	0.204	-0.297	0.319	-0.706**	-0.335	-0.348	-0.201	1				
	Sig.	0.803	0.338	0.159	0.128	0	0.11	0.096	0.347					
Ca	P. Cor.	-0.128	-0.183	0.086	-0.058	-0.01	0.232	0.235	-0.104	-0.143	1			
	Sig.	0.55	0.392	0.69	0.786	0.962	0.275	0.268	0.628	0.504				
Mg	P Cor.	-0.127	0.078	-0.3	-0.048	-0.016	-0.187	-0.24	0.006	0.117	0.039	1		
	Sig.	0.555	0.717	0.155	0.824	0.941	0.382	0.259	0.976	0.586	0.856			
TH	P. Cor.	0.149	-0.19	0.06	-0.12	0.337	-0.025	-0.141	0.033	-0.397	-0.03	0.484*	1	
	Sig.	0.488	0.373	0.781	0.577	0.107	0.908	0.512	0.877	0.055	0.889	0.017		
CPI	P. Cor.	0.194	0.041	0.087	-0.034	0.263	0.243	0.065	0.376	-0.129	0.308	0.841**	0.557**	1
	Sig.	0.365	0.851	0.685	0.874	0.215	0.253	0.761	0.07	0.549	0.143	0	0.005	

N is 24 among all parameters and Significance (Sig.) is (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Conclusions

In the present study, CPI and NSFWQI were used to evaluate variations in surface water quality of the Surha Lake during 2006-08. The average CPI was found as 0.98, 1.11 and 1.16 in year 2006, 2007 and 2008 whereas NSFWQI were found as 47.25, 49 and 49.88 respectively. The results indicate that the water quality is polluted and the consistently rising from slight to moderate during 2006-08, due to increased input of domestic waste and agricultural runoff from the lake catchments. In addition to this, the statistical analysis, among physiochemical parameter reveals that the BOD is the main parameter that governs other parameters of water quality in lakes. Therefore, it is recommended that there should be regular monitoring of lake water to find out factor responsible for the change in water quality. The present study could be beneficial for environmentalists or policy makers to strategize the conservative measure to maintain its ecological health.

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References

1. Khan F. A., Ansari A. A., *Bot. Rev.* 71 (2005) 449-482.
2. Sheela A. M., Letha J., Joseph S., Ramachandran K. K., Justus J., *Geophys. Remote. Sens.* 2 (2013) 1.
3. Zhai X., Xia J., Zhang Y., *Sci. Total Environ.* 496 (2014) 594–606.
4. Shoji H., Yomamoto T., Nakamura T., *J. Air Water Int. Poll.* 10 (1966) 291-299.
5. Zhao Y., Xia X. H., Yang Z. F., Wang F., *Pro. Environ. Sci.* 8 (2012) 1213 – 1226.
6. Barnwal P., Mishra S., Singhal S. K., *J. Integr. Sci. Technol*. 3 (2015) 22-27.
7. Kumar A., Sharma M. P., Yadav N. S., *J. Mater. Environ. Sci.* 5 (2014) 1781-1785.
8. Yadav N. S., Kumar A., Sharma M. P., *J. Integr. Sci. technol.* 2 (2014) 52-56.
9. Jindal R., Thakur R. K., Singh U. B., Ahluwalia A. S., *Chem. Ecol.* 30 (2014) 328-338.
10. Lobato T. C., Davis H. R. A., Oliveira T. F., Silveira A. M., Silva H. A. N., Tavares A. C. F. Saraiva M. R. M., *J. Hydro.* 522 (2015) 674–683.
11. Parmar K., Parmar V., *Int. J. Environ. Sci.* 1 (2010) 77.
12. Sharma R. K., Agrawal N., *J. Appl. Nat. Sci.* 3 (2011) 295-297.
13. Sharma R. K., Agrawal N., *J. Appl. Nat. Sci.* 4 (2012) 60-64.
14. Sharma R. K., Soni D. K., *J. Environ. Res. Develop.*7 (2013) 4A.
15. Pandey K. C., Agrawal N., Sharma R. K., *J. App. Nat. Sci.* 2 (2010) 22-25.
16. APHA, 1998. 20th Edition. *American Public Health Association*, Washington, DC.
17. Indian Standard Specification for Drinking Water, Bureau of Indian Standards. BIS: 10500, (1991).
18. World Health Organization, 2011. *Guidelines for Drinking Water Quality*, fourth Ed.
19. Bu H., Mengb W., Zhang Y., Wan J., *Ecol. Ind*. 41 (2014) 187–197.
20. Hameed A., Alobaidy M. J., Abid H. S., Mauloom B. K., *J. Water Resour. Prot.* 2 (2010) 792–798.
21. Nnane D. E., Ebdon J. E., Taylor H. D., *Water Res.* 45 (2011) 2235-2246.
22. Parmar K. S., Bhardwaj R., *Appl. Math. Comput.* 219 (2013) 10172–10182.
23. Venkatesh K. R., Rajendran M., Murugappan A., *Nat. Environ. Poll. Tech.* 8 (2009) 141-145.
24. Manache G., Melching C.S., *Environ. Model. Soft.* 23 (2008) 549-562.
25. Muyzer G., Stams A. J. M., *Nat. Rev. Microbiol.* 6 (2008) 441–454.
26. Sharma P., Meher P.K., Kumar A., Gautam Y. P., Mishra K.P., *Sust. Water Qual. Ecol.* 3-4 (2014) 67–76.
27. Boyacioglu H., Gundogdu H., Boyacıoglu H., *Marine Poll. Bul.* 69 (2013) 48–54.