

WATER QUALITY ASSESSMENT OF NAINITAL LAKE BY NUMERICAL INDICES

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ABSTRACT

Nainital Lake forms the nub of the beauty of Nainital, with its water emulating the mesmerizing colours of the surrounding green hills. In the past few years, it has been observed that Nainital fascinating a huge number of foreign and domestic tourists making it one of the most favoured tourist place which has led the lake to a state of misery. Moreover, Nainital Lake is the major source of drinking for the local population. Thus, the current work aims to examine the quality of water via the two indices: Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI) and National Sanitation Foundation Water Quality Index (NSFWQI) on the basis of various physiochemical water parameters like (Turbidity, DO, Electrical conductivity, BOD, TSS etc.). The samples were collected during the months of January to May 2018 at an interval of 15 days. On calculation of the water quality index using numerical indices it was found that the quality of water is "fair" by CCMEWQI and "medium" by NSFWQI. Also, it has been observed that quality of water was deteriorated in the month of April and May due to heavy tourist influx. Therefore, it is suggested that before using the water for drinking purpose prior treatment of lake water is required.

KEY WORDS : Water parameters, Nainital lake, WQI

INTRODUCTION

Water is a precious commodity for life. Various freshwater bodies such as rivers, lakes and wetlands have been gifted by the nature to the humans to fulfil their water demands. Nainital being the "Lake district of India" accomplished with *Naini Lake* which forms the nub of the beauty of Nainital, with its water emulating the mesmerizing colours of the surrounding green hills. According to Mishra and Garg (2011) 80% of total surface fresh water is comprised by the lakes. However, the presence of the still water deprived of the self-purification property it has been found that lakes are more susceptible to water pollution than any other water source.

According to Singh *et al.* (2001-2002), there have been adverse effects on the quality of lake water because of dumping the abundance of sewage in the water, increasing local population and heavy tourist

influx. The water which is considered to be fit for drinking should have qualities and parameters within the permissible limit. The primary goal of this work is to examine the water quality of the Nainital lake via different physio-chemical parameters (temperature, pH, TSS, turbidity, alkalinity, BOD, DO, etc.) using water quality indices: National Sanitation Foundation Water Quality Index (NSFWQI) and Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI). Also, the various sources that deteriorate the quality of lake water are being identified so that suitable measures can be computed to maintain the geo-environmental stability of the region.

METHODOLOGY

Details of study area

The Naini Lake being the sparkling gem in the

Himalayan kingdom is one of the major attractions for the tourists. A wide traverse of 100 m is separate it into two divisions (Tallital and Mallital). Water quality assessment is one of the key areas for this study.

Table 1. Geographical details of Nainital Lake

S.No	Parameters	Values
1	Surface area	0.48(km ²)
2	Altitude	1937(m msl)
3	Longitude	79°28'E
4	Latitude	29°23'N
5	Maximum length	1423(m)
6	Maximum width	423(m)
7	Maximum depth	27.3(m)
8	Mean depth	16.2(m)

Source: Nachiappan *et al.*, 2002

A British businessman P. Baron witnessed this lake in 1839 who came across this lake on a hunting expedition. The Naini Lake comprises the water intending from 22 inlets nallahs, springs and rainwater (Purushothaman *et al.*, 2012). Due to various anthropogenic events like disposal of domestic sewage, direct runoff, infrastructure work, and farming accomplishments have considerably altered the characteristics of the Naini Lake (Sharma 2014). Thus, to assess the quality of Naini lake the samples of water were taken from 4 locations. The locations of sample stations are shown in Fig. 1.

Sample Collection

In the present work to examine the water quality, the samples were taken from 4 different stations represented by S1, S2, S3 and S4 (S1: Boat Stand, Tallital; S2: Near Police Chowki, Thandi Sadak, Tallital; S3: Pedal Boat Stand, Mallital and S4: Naina

Devi Temple, Mallital) in the months of Jan, Feb, Mar, Apr and May, 2018. The water samples were collected after every 15 days interval in each month. To examine the quality of water sample various experimental test carried out in the laboratory. The different parameters like temperature, pH, electrical conductivity, turbidity, hardness, TSS, TDS, DO, BOD and alkalinity were measured via different analytical instruments as per IS CODE. Thereafter, the different parameters obtained through the laboratory investigation were being used to assess the WQI.

Water quality Index Assessment

The indices such as NSFQI and CCMEWQI were computed to examine the quality of Naini Lake.

National sanitation foundation WQI

Globally this index is extensively used categorized the water quality of different water sources. (Mishra *et al.*, 2016c, Chaudhary *et al.*, 2016). It is mathematically expressed as:

$$WQI = \sum_{i=1}^n QiWi$$

Where, Q_i represents the Q value of the i^{th} parameter W_i represents corresponding weights. The NSFQI categorized the water quality rank in range 0–100 as: 91–100 (excellent); 71–90 (good); 51–70 (medium); 26–50 (poor) and 0–25 (very poor).

Canadian council of Ministers of The environment WQI

The CCMEWQI is dependson the following 3 parameters F1, F2 and F3 (CCME 2001).

The CCMEWQI is computed as,

$$CCMEWQI = 100 - \left(\frac{\sqrt{F_1^2 + F_2^2 + F_3^2}}{1.732} \right)$$



Fig. 1. Plandisplaying the water samplings locations (Source: Google map)

Factor 1 (F1): Scope signifies the quantity of parameters which are not within the permissible limits.

Factor 2 (F2): Frequency signifies the percentage of individual failed tests.

Factor 3 (F3): Amplitude signifies the quantity by which the failed test values do not meet their permissible limits.

The numerical calculations gives a WQI value to depict the nature of water quality ranging 0 to 100. The quality of water classified as: Poor (E): 0–44, Marginal (D): 45–64; Fair (C): 65–79; Good (B): 80–95; Excellent (A): 95–100.

RESULTS AND DISCUSSION

In the present work the water quality is examined in the Nainital Lake during the months of January, February, March, April and May in the year 2018. On calculation of the water quality index by CCME the values recorded ranges between 68.99 to 69.33 for Mallital and 69.23 to 75.03 for Tallital which falls under the category of “fair” indicating that oftenly

the water quality is usually secured but sometimes conditions are threatened and the water quality is deprived from its desirable form [CCME 2001]. After calculation the NSFQI water quality comes under the category of “medium”.

On the basis of results, various water quality characteristics were computed and are compared with WHO/BIS/ICMR standards. From this comparison, presented in the current work the following conclusions can be attained:

- The pH value varies from 7.57 to 9.12 which depicts the alkaline nature of the lake water. The reason behind the alkalinity of the lake water may be the high rate of photosynthesis.
- Electrical conductivity ranges between 528 to 620 for Mallital and 520 to 620 for Tallital.
- Presence of high amount of suspended matter like organic matter, silt, clay, matter may leads to high turbidity of water. Turbidity ranges between 7.9 to 12.2 for Mallital and 7.4 to 10.1 for Tallital. High turbidity at Mallital was due to surface runoff and recreational activities. It is also observed that the amount of turbidity

Table 2. Drinking water quality standards

S. No.	Parameter/unit	Analytical Method	Permissible standards and suggested agencies
1	Temperature (degree Celsius)	portable Thermometer	-
2	pH (unit)	pH meter	6.5-8.5 (BIS)
3	Electrical conductivity ($\mu\text{s}/\text{cm}$)	conductivity meter	600 (WHO)
4	Turbidity (NTU)	Turbidity Meter	5 (BIS)
5	Total Hardness (mg/L as CaCO_3)	Titration	300 (BIS)
6	Total Suspended Solid (mg/l)	Gravimetric	500 (WHO)
7	Total Dissolved solid (mg/l)	Gravimetric and Filtration	500 (BIS)
8	Dissolved Oxygen (mg/l)	DO meter	5 (ICMR)
9	Biochemical oxygen demand (mg/l)	Winkler method and five days incubation	5 (ICMR)
10	Total Alkalinity (mg/L as CaCO_3)	Titrimetric	600 (BIS)

Table 3. Water quality parameters for station 1 of Nainital Lake

S. No.	Parameters	Station 1 (S1: Boat Stand, Tallital)									
		JAN		FEB		MAR		APR		MAY	
1	Temperature	13.8	13.5	12.4	12	14	14.3	14.4	13.8	14.2	15
2	pH	8.35	8.4	8.35	8.1	8.2	7.99	8.75	8.5	8.4	8.9
3	Electrical conductivity	530	536	520	528	620	590	580	570	608	590
4	Turbidity	8.6	8	7.4	8	9.2	8.9	8.4	8.3	10.1	9.8
5	Total Hardness	265	270	240	255	280	270	272	294	318	307
6	TSS	348	375	395	380	360	335	392	450	470	550
7	TDS	216	190	225	228	280	266	350	340	330	336
8	DO	7	7.5	6.5	7.4	8.1	7.9	8.4	8.3	8.6	8.3
9	BOD	2.6	2.5	3	2.9	2.8	3.1	3.7	3.8	3.9	4.2
10	Alkalinity	270	266	244	230	204	220	196	188	184	190

during all the months are above the permissible limit.

- Total hardness was recorded between 250 to 320 for Mallital and 238 to 318 for Tallital. The maximum value attained was 320 in the month of May. High temperature and weathering of rocks adds Ca^{2+} and Mg^{2+} salts and gives hardness in water.
- TSS ranges from 315 to 520 for Mallital and 348 to 550 at Tallital. Maximum value recorded was 550 in the month of May due to the surface runoff and heavy tourist influx.
- TDS ranges from 210 to 460 for Mallital and 190 to 350 at Tallital which are within the permissible limits.
- Dissolved oxygen (DO) indicates the health and condition of any water surface. DO is noticed to be within the range of 6.5 mg/l to 8.6 mg/l at Tallital and 6.4 mg/l to 8.6 mg/l at Mallital. Highest value of DO was found in the month of

Table 4. Water quality parameters for station 2 of Nainital Lake

S. No	Parameters	Station 2 (S2: Near Police Chowki, Thandi Sadak, Tallital)									
		JAN		FEB		MAR		APR		MAY	
1	Temperature	13.5	14.5	12	10	12	11.4	12	14	13.5	14.2
2	pH	8.2	8.15	8.6	8.8	8.29	8.48	8	7.57	8.4	8.6
3	Electrical conductivity	538	520	527	530	580	577	544	568	588	594
4	Turbidity	8.4	7.9	7.4	8.1	8.8	8.9	8.3	8.5	9.7	9.6
5	Total Hardness	260	272	238	245	265	280	265	280	306	296
6	TSS	360	362	402	410	424	410	440	446	486	526
7	TDS	226	210	230	232	268	266	342	348	328	332
8	DO	7.2	7.6	6.8	7.2	7.9	8.1	8.5	8.3	8.4	8.5
9	BOD	2.5	2.5	2.8	2.6	3.1	3.4	3.6	3.8	3.8	4
10	Alkalinity	230	275	245	210	236	240	196	208	190	186

Table 5. Water quality parameters for station 3 of Nainital Lake

S. No	Parameters	Station 3 (S3: Pedal Boat Stand, Mallital)									
		JAN		FEB		MAR		APR		MAY	
1	Temperature	14.6	14	13.4	13	14.8	14.6	15	14.9	14.9	15.6
2	pH	8.4	8.7	8.23	7.8	8.37	8.4	8.8	7.9	8.1	8.35
3	Electrical conductivity	538	528	549	540	588	576	584	592	612	620
4	Turbidity	9.2	9.1	8.6	8.5	7.9	8.2	10.4	10.3	11.8	12.2
5	Total Hardness	310	295	290	270	250	280	265	280	315	320
6	TSS	340	365	315	350	338	310	328	405	515	520
7	TDS	290	280	305	320	210	215	368	410	390	460
8	DO	6.8	7.1	6.6	7.2	7.8	7.6	8.33	8.3	8.2	8.6
9	BOD	2.5	2.2	2.8	2.5	3.1	3	3.8	4	3.9	4.4
10	Alkalinity	250	270	290	280	210	245	220	205	220	210

Table 6. Water quality parameters for station 4 of Nainital Lake

S. No	Parameters	Station 4 (S4: Naina Devi Temple, Mallital)									
		JAN		FEB		MAR		APR		MAY	
1	Temperature	14.5	14.6	13.6	13.2	14.6	14.7	15.1	15	15.3	15.2
2	pH	8.3	8.5	8.3	7.6	8.2	8.4	8.7	8.2	8.1	8.6
3	Electrical conductivity	540	485	535	560	610	542	568	580	595	615
4	Turbidity	8.8	9	8.5	8.7	8.1	8.15	9.8	9.65	10.7	12
5	Hardness	300	290	285	280	275	285	240	260	310	285
6	TSS	348	385	329	332	404	380	402	440	435	520
7	TDS	275	303	295	290	256	228	360	370	366	380
8	DO	7	6.9	6.4	7.1	7.7	7.7	8.2	8.3	8.4	8.5
9	BOD	2.3	2	2.5	3	2.9	3	3.6	3.5	3.8	4.2
10	Alkalinity	236	245	285	280	225	230	215	212	230	235

May because during this period active photosynthesis takes place leading to the increase of DO content in the lake (Singhal *et al.*, 1984).

- BOD being the pollution parameter is primarily used to assess the quality of the water. It also signifies biodegradable load in the lake. The BOD value was found to be within the permissible limits at all the testing stations, its values ranges from 2 to 4.4 at Mallital and 2.5 to 4.2 at Tallital. Highest BOD was found in the month of May, high tourist influx and recreational activities may be the reasons behind it.

Table 7. Estimated indices at all sample stations

S.No	Sampling Station	CCMEWQI	NSFWQI
1	S1 (Tallital)	69.23	67.84
2	S2 (Tallital)	75.03	69.51
3	S3 (Mallital)	68.99	68.5
4	S4 (Mallital)	69.33	68.53

Total alkalinity is found to be in the range of 184 mg/l to 275 mg/l at Tallital and 210 mg/l to 290 mg/l at Mallital. Total alkalinity was observed to be higher at Mallital as compared to Tallital in the month of February, decomposition of organic matter and release of CO₂ may cause formation of carbonates which increases the alkalinity of the lake water.

CONCLUSION

The results of the current work present the various physical and chemical water parameters and the quality assessment of Nainital Lake by CCMEWQI and NSFWQI. The WQI values depict that state of water comes under the category "fair" by CCMEWQI and "medium" by NSFWQI and requires the appropriate treatment before drinking. It has been observed that quality of water was deteriorated in the month of April and May due to heavy tourist influx. On comparing the Mallital and Tallital it has been observed that by virtue of intense recreational activities and Naina Devi Mandir drain, Mallital was found to be polluted site. Tallital on the other hand was considered to be relatively less polluted. On comparison with BIS/ICMR/WHO work also tells that electrical conductivity, turbidity,

pH, hardness were not falls under the permissible value.

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