Evaluation of Water Quality Index of Surface Water for Drinking Purpose in Lachhiwala Canal, Dehradun District, Uttarakhand

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Abstract:
Water is the most frequently and thoroughly characterised product due to the impact of the chemical composition of water of different sources or destinations on public health and on economy. Water canals are superb habitats for the study of ecosystem dynamics: interactions among biological, chemical and physical processes are frequently either quantitatively or qualitatively distinct from those on land or in air. Humans frequently depend on canal for a great many 'goods and services' such as drinking water, waste removal, fisheries, agricultural irrigation, industrial activity and recreation. The present study was carried out for evaluation physico-chemical parameters of surface water quality in Lachhiwala canal of Dehradun district. The calculated value of Water Quality Index (WQI) as 111.259 according to Standard Rating of Water Quality water source of Lachhiwala canal was found 'E' grade and its water quality is explained as Unsuitable for drinking purpose. This research offered the need of an effective evaluation of the Surface water quality and its utility for human health.
Keywords: **Human health, Physico-chemical parameters, Surface water, Water Quality Index (WQI)**

I.INTRODUCTION
The availability of water both in terms of quality and quantity is essential for the very existence of mankind. Water, though indispensable and plays a pivotal role in our lives, is one of the most badly abused resources [1]. Canal of awareness and civic sense, use of inefficient methods and technology lead to more than 50% of water wastage in the domestic, agriculture & industrial sectors. Water pollution is rendering much of the available water unsafe for consumption. Surface water is the water that flows along the surface of the earth and is the second largest source of fresh water, the first being ground water. Precipitation, springs, melting of glaciers etc are the major sources of surface water [2-3]. The modern civilization, over exploitation, rapid industrialization and increased population has lead to fast degradation of our environment. There is heavy extraction of water for domestic, industrial and agricultural purpose. Age-old customs and habits of community, cattle bathing and washing in rivers are responsible for rampant pollution of river water [4]. The release of domestic waste water, agricultural runoff water & industrial effluents promote excessive growth of algae in water bodies, which results in their eutrophication. To meet the rising demand it is imperative to recognize the fresh water resources and also to find out remedial methods for improvement of water quality [5]. The quality of surface water depends on various chemical constituents and their concentration, which are

mostly derived from the geological data of the particular region. Industrial waste and the municipal solid waste have emerged as one of the leading cause of pollution of surface and ground water. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess [6-7]. The situation gets worsened during the summer season due to water scarcity and rain water discharge. Contamination of water resources available for household and drinking purposes with heavy elements, metal ions and harmful microorganisms is one of the serious major health problems. Several states in the country are facing problems due to over exploitation of surface water. Its manifestations are declining per capita water availability, falling water tables and deterioration of water quality [8]. Accurate information on the condition and trends of water resources quantity and quality is required as a basis for economic and social development, and for the development and maintenance of environmental quality. There has been increased interest and work over the past few years on the use of indicators to monitor change [9-10].

In Uttarakhand, a large portion of population lives in the hilly areas and about 90 % of the rural population depends upon the natural water sources for their daily water demand [11-12]. Due to the topography and high slops of the state, the drinking water supply department is mainly dependent on surface water sources to meet the rising demand of water. Therefore, economic, agricultural and social activities require urgent need to maintain the status of water sources [13]. The water quality analysis is a most important part of hydrogeological investigations to quantify the composition of chemical characters. The factors influencing the water quality are the degree of weathering of rocks, topography of ground, seasonal variation, and discrepancy in monsoonal rainfall [14]. Besides, the rapid growth of population, higher demand of agricultural products, unplanned urbanization, over exploitation of water sources and other anthropogenic activities on the ground also led to the deterioration of surface water quality [15].
The main problematic issue of hilly region is the bacterial contamination generating due to direct or indirect discharge of municipal waste in river system owing to the slope factor [16]. These coliform contaminations particularly fecal coliform, seriously affect the human health and entail the major water borne diseases such as diarrhea, cholera, typhoid, schistosomiasis etc. [17]. Water Quality Index (WQI) is the most effective tool to convey the water quality information in the simplest form to the general public and legislative decision makers [18]. WQI transforms the large and complexed information of raw water quality data into a simplified and logical form with different categories of water quality that reflects the overall water quality status [19]. It has become a central theme of many national and international environmental agencies in various countries to determine water quality status of any source for various uses and for comparative purposes between different stations [20-21].

The present study has been conducted to determine the concentration of physico-chemical parameters of Lachhiwala canal, Doiwala area of Dehradun district in Uttarakhand state of India and compared with Indian Standards related to its suitability for drinking purposes.

II.METHODS AND METHODOLOGY

A.Study Area

Present study was conducted in Lachhiwal canal of Doiwala area of Dehradun district, Uttarakhand. The main water source of Lachhiwala warer canal is Song river. The covered area of Dehradun district is 3088 sq.km. with 30.2230^{o} N latitude and 78.0766^{o} E longitude and at an elevation of 643.8 m above the sea level. The regional climatic condition lies within the range of about 6.2 ^{0}C to 40.4 ^{0}C temperature. Dehradun District population in 2021 is 1,850,314 (estimates as per aadhar uidai.gov.in Dec 2020 data) [22] .

B.Collection of samples and analysis

Sample was collected from Lachhiwala canal from Doiwala area of Dehradun district in May 2021. Sample was collected in acid-washed Nalgene Wide-Mouth Natutal HDPE polypropylene, 1000 ml bottles. Before collection of water in a particular bottle, the bottle was rinsed thoroughly with the respective sample of the surface water. The bottle was filled to the brim with water taking care that no air bubble was trapped within the water sample. In order to prevent evaporation, the bottle was sealed with double plastic caps and precaution was also taken to avoid sample agitation during transfer to the laboratory. Immediately after collection, sample was transferred to the laboratory. A total of 9 physico-chemical parameters like pH, Electrical conductivity (EC), Total Dissolve Solids (TDS), Sulfate, Chloride, Alkalinity, Calcium, magnesium and Total hardness were analyzed out of them pH, EC and TDS were observed with the use of Portable Multi-Parameter Instrument, Model – TMULTI 27 (TOSHCON) and remaining were analyzed as per standard methods of APHA, (2012). These parameters help to evaluate the drinking, irrigational as well as domestic suitability of surface water in the study area.

C.Statistical analysis

The water quality index (WQI) by weighted arithmetic index is used to formulate rating curve. Permissible limit of variables is taken as the minimum and maximum values of the rating scale (varying from 0 to 100) and adopted for the classification of water quality into different classes of water for the suitability of drinking and irrigation purposes.

D.Analysis Procedure of Water Sample

The analyses of collected water sample for various physico-chemical characteristics were carried out by adopting APHA and BIS protocols and methodologies [23-24]. A total of nine water quality parameters were analyzed and used for the determining weighted arithmetic WQI value at drinking water source. The water quality parameter namely pH was analyzed on-site, while remaining eight variables viz. total hardness, alkalinity, chloride, total dissolved solids, calcium, magnesium, sulfate, and Electrical Conductivity were analyzed in the laboratory.

E. Calculation of Water Quality Index

The complicated scientific information can be converted into a single number through WQI. It is a dimensionless number that can be arrived by studying many parameters that affects water quality into a single number making it easy for a common man to understand the quality of water. WQI is calculated on the basis of several physico – chemical parameters which is then

multiplied by a weighing factor and the final aggregate is obtained using arithmetic mean. WQI tool is used successfully to state the quality of water for water bodies. The calculation of the WQI is well explained **[25]**, the same formula was applied to calculate the WQI in the present study.

Calculation of Quality rating (Q_i):
Quality rating for each parameter was calculated by using the following equation

$$Q_i = \frac{(V_{actual} - V_{ideal})}{(V_{standard} - V_{ideal})} \text{ X } 100$$

Where,
Q_i = Quality rating of i^{th} parameter for a total of n water quality parameters.
V_{actual} = Actual value of the water quality parameter obtained from laboratory analysis
V_{ideal} = Ideal value of that quality parameter can be obtained from the standard tables.
V_{ideal} for pH = 7 and for other parameters it is equating to zero and V_{ideal} DO = 14.6 mg / L
$V_{standard}$ = Recommended WHO standard of the water quality parameter.

Calculation of Unit weight (W_i):
Unit weight was calculated by a value inversely proportional to the recommended standard (SI) for the corresponding parameter using the following expression

$$W_i = \frac{K}{S_i}$$

Where,
W_i = Unit weight for n^{th} parameter
S_i = Standard permissible value for n^{th} parameter
K = proportionality constant, For the sake of simplicity, K is assumed as 1,
The overall WQI is calculated by aggregating the quality rating with unit weight linearly using the following equation

$$WQI = \frac{\Sigma W_i Q_i}{\Sigma W_i}$$

Where,

Q_i = quality rating,
W_i = Unit weight

III. RESULTS AND DISCUSSION

The detailed discussion of analysed physico-chemical characteristics of collected water sample from Lachhiwala canal, Doiwala area of Dehradun district is presented under the Table 2. These results are also compared with Bureau of Indian Standard IS 10500 recommended for drinking purpose [24].

Chloride is an essential anion of water. Table salt is the main source of chloride in water. In addition, potassium chloride and magnesium chloride were also available appreciable contribution. In the present study, the chloride was found to be 138 mg/L, which is average according to WHO /ISI standards.

Sulfate is a common anion of water, which comes from its naturally occurring minerals in some soil and rock formations that contains water. In the present study, the sulfate was found to be 241 mg/L, which is very high according to ISI and WHO standards.

Electrical conductivity is capacity of water to conduct electrical current. It is due to the presence of dissolved salts and minerals. The conductivity was found to be 178 μs/cm for sample examined.

pH is defined as the negative logarithm of hydrogen ion concentration. The pH for potable water should be between 7 and 8. There are many factors that affect the pH of the water such as presence of dissolved gases, salts, bases, acids. In the present study, the pH was found to be 8.4 which is high according to ISI and WHO standards.

Alkalinity is the capacity of water to neutralize the acids. The presence of bicarbonates, carbonates and hydroxides causes alkalinity in the water. These salts in water are due to the dissolution of minerals from rocks, soils, plant and microbial activities. The alkalinity that was reported in the present study was also found to be on the higher end 132 mg/L.

Total dissolved solid is an aggregate of all the dissolved solids present in the water. The amount of TDS was reported as 598 mg/L for sample, which is high according to ISI standards but average according to WHO standards.

Hardness is an important property of water that prevents lathering of water with the soap solution and if exceeds the tolerance limit may lead to serious illness. It causes serious damage to the products of industries and machinery if untreated water is used. The main causes of hardness in water are the presence of bicarbonates, chlorides and sulfates of calcium and magnesium. Total hardness was reported as 213 mg/L sample, which is high according to WHO standards but average according to ISI standards.

The presence of calcium and magnesium ions leads to hardness in the water.They are responsible for the formation of scales and sludge. The presence of calcium ions was found to be 94 mg/L,

which is a very high concentration for drinking water. Magnesium ions should not be exceeding 30 mg/L according to ISI standards but in the present study it was found to be 51 mg/L for sample. This value suggests a very high concentration of magnesium ions.

Table1: Water quality parameters studied with WHO and ISI standards.

S. No.	Parameters	Method	WHO Standards	ISI Standards	Sample of Lachhiwala canal
1.	Chloride	Argentometric titration method	250	250	138
2.	Electrical Conductivity	Conductometry	400	300	178
3.	pH	pH metery	7.0 – 8.0	6.5 – 8.5	8.4
4.	Alkalinity	Titration Method	120	200	132
5.	Sulfate	Turbidimetric method	250	200	241
6.	Total Dissolved Solid	Filtration Method	1000	500	598
7.	Total Hardness	EDTA titration	100	300	213
8.	Calcium	EDTA titration	75	75	94
9.	Magnesium	EDTA titration	150	30	51

TABLE 2 : Calculation Of WQI For Sample

S.No.	Parameters	Observed values	Standard values	Unit Weight (Wi)	Quality rating (Qi)	Weighted values (WiQi)
1.	Chloride	138	250	0.004	55.200	0.220
2.	Electrical Conductivity	178	300	0.003	59.333	0.178
3.	pH	8.4	8.5	0.117	98.882	11.562
4.	Alkalinity	132	200	0.005	66.000	0.330
5.	Sulfate	241	200	0.005	120.500	0.602
6.	Total Dissolved Solid	598	500	0.002	119.600	0.239
7.	Total Hardness	213	300	0.003	71.000	0.213
8.	Calcium	94	75	0.013	125.333	1.629
9.	Magnesium	51	30	0.033	170.000	5.610
				Σ Wi = 0.185		**Σ WiQi= 20.583**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 111.259					

TABLE 3: Standard Rating of Water Quality as per WQI Values for Determining for Drinking Purpose

S.N.	WQI Classification	Water Quality Grading	Water Quality Rating
1.	0-25	A	Excellent
2.	26-50	B	Good
3.	51-75	C	Poor
4.	76-100	D	Very Poor
5.	Above 100	E	Unsuitable for Drinking Purpose

Author found the calculated value of WQI as 111.259 (Table 2). As per Standard Rating of Water Quality (Table 3), water source of Lachhiwala canal of Doiwala area was found 'E' grade and its water quality is explained as Unsuitable for drinking purpose. The reasons for this water quality deterioration include geological stratum of the area, adjoining pollution sources, natural disaster and improper maintenance and lack of public awareness. Author suggests before consuming the water by the people, the water should be free from impurities, hence the water should be subjected to treatment.

IV.CONCLUSION

In the present investigation, author reviewed that due to presence of impurities in the Lachhiwala canal, there are many different parameters found to be high in may 2021. Purification methods should exist from filtration processes that should be carried out before introducing any foreign

material into the water body. The observed value of WQI indicate that during summer season, canal water is more affected and unsuitable for drinking purpose. This could be due to the fact that discharge of untreated domestic sewage, washing clothes, vehicles, animals and immersion of idols at the time of festivals contributing to the pollution. The suggested measures to improve the canal water quality include total ban on the activities that cause pollution. Proper bioremediation techniques should also be used to improve that water quality. The effects of climate change need to be considered in tandem with atmospheric pollution policies.

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