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Research Article

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EVALUATION OF DRINKING WATER QUALITY STATUS BY WATER QUALITY INDEX: A CASE STUDY OF SHIKHAR WATER FALL, DEHRADUN (UK), INDIA

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Abstract: Water is an essential element for life. Safe drinking water is the basic need for safeguarding the health and well-being of humans all over the world. In the present study, the physico-chemical parameters such as chloride, electrical conductivity, pH, alkalinity, sulfate, total dissolved solid (TDS), total hardness, calcium, magnesium and water quality index (WQI) of Shikhar water fall, Dehradun was analyzed to know the suitability of water for drinking purpose during post-monsoon season in the year 2019. The values of Ca, Mg, SO_4 and TDS of the samples studied were found high from the WHO/ ISI recommended values of drinking water. The calculated value of WQI was 82.07, found not suitable for drinking purpose as per Standard Rating of Water Quality. Geological strata of the area, adjoining pollution sources, natural disaster and improper maintenance are the key factors responsible for water quality deterioration of the Shikhar water fall source.

Keywords: Drinking water, ISI, Physico-chemical parameters, WHO, WQI.

INTRODUCTION

Water is the basic need of all living organisms including humans and it has a great influence on the all aspects of life (Tyagi *et al.,* 2013). It has been estimated that a man can live for around 20 days without food but very difficult to survive just after one day if water is not available for drinking (Srivastava, 1995). Water is the most drinking fluid, therefore often a potential source of causing infections. The primary concern of the people living in most of the developing countries, throughout the world is that of obtaining clean and safe drinking water. In some parts of the world, this problem is much serious by the fact that the available water sources are non potable directly, without some forms of treatment (Joyce *et al.,* 1996). Drinking water quality has been debated generally discharge of direct domestic and industrial effluent wastes, leakage from improperly maintained water tanks and poor management of farm wastes (Prakash and Verma, 2020). This is considered as the major source of

water pollution that ultimately leads to waterborne diseases (Jain *et al.,* 2005). The sources of fresh water in Uttarakhand state are glaciers, rivers and lakes but due to the inappropriate rains and snowfall and also because of pollution, in summer, there is a water shortage. To overcome this situation, presently water is the most abundantly (>70 %) consumed natural resource for various human activities (Prasad and Narayana, 2004). Poor water quality is responsible for the deaths of an estimated five billion children annually in the developing countries. According to WHO (World Health Organization) survey 80% of all human diseases in developing countries are waterborne (Tebbutt, 1983).

The water quality index (WQI) is an important data assessment tool for the conversion of complex hydro-chemical data set into simplest and usable form to effectively convey the information to general public, policy makers and decision makers. It is an indicator of water quality, which reveals the composite influence of number of water quality parameters and is useful in determining suitability of water of any water body for drinking purpose. The water quality can be classified into various grades, which indicate the status of water quality. The concept of WQI for usefulness of representing the grading of water quality was first time introduced by Horton (1965). The WQI expresses the overall condition of water quality in any water body. Several studies on the evaluation of water quality for drinking purpose have been carried out by many researchers but none of these studies give a comprehensive picture for major drinking water source of Shikhar fall. Author attempted to determine the physico-chemical parameters such as chloride, electrical conductivity, pH, alkalinity, sulfate, total dissolved solid (TDS), total hardness, calcium, magnesium and water quality index (WQI) of Shikhar water fall, Dehradun for the suitability of water for drinking purpose during post-monsoon season in the year 2019.

MATERIALS AND METHODS

1. Study area:

Dehradun is the capital city and one of the most populous cities in the state of Uttarakhand, India. It is located at a latitude of 30°18'59.3856" N and longitude of 78°1' 55.8768" E at the foot of Himalaya and covers about 300 km². Dehradun has numerous beautiful parks and gardens, temples, streams and waterfalls etc. The water supply in the area is done through waterfalls, overhead tanks, tube wells, trunks and other supply lines. Shikhar fall is one of the famous waterfalls in Dehradun. It provides genuine feel like of nature, many species of butterfly and birds. It also provides fresh and clear water. Therefore, frequent water quality monitoring of drinking water source of Shikhar fall, Dehradun is essential in order to protect its mass population from waterborne diseases and to develop appropriate preventive measures, in case of contamination (en wikipedia).

2. Collection and Analysis of Water Sample:

The water sample was collected through grab sampling method during post-monsoon season in the year 2019. Sample was taken in clean and sterilized Tarson (high-density polyethylene) bottles after 2-3 times rinsed with the water sample. The collection of water sample, their preservation and transportation to the laboratory was carried out as per APHA (2017) protocols and methods. Water sample for the analysis of various metals/ metal ions was collected in acid leached sterilized Tarson bottles and preserved by adding ultrapure grade nitric acid (2 ml/L) to reduce the pH below 2. The collected water sample was stored in ice box and brought to the laboratory by maintaining the cold chain at 4°C and within specified period. For determining the WQI, total nine water quality parameters *viz.* total hardness, alkalinity, chloride, total dissolved solids, calcium, magnesium, sulfate, and electrical conductivity were taken as per APHA (2017) and BIS (2012).

3. Calculation of Water Quality Index:

WQI tool is used successfully to state the quality of water for water bodies (Khanna *et al.,* 2013). The calculation of the WQI is well explained (Upadhyay and Chandrakala, 2017) and the same formula was applied to calculate the WQI in the present study. The standard values are given in table 3.

Calculation of Quality rating (Q_i):
Quality rating scales was chosen so that each characteristic is assigned as a value depending on observed concentration. A survey of literature revealed that there are six different methods of combining water quality rating curves and associated weightings: unweighted arithmetic index, weighted arithmetic index, unweighted solway index, weighted solway index, unweighted geometric index and weighted geometric index.

In this study, 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). When water quality rating (Q_i) is proportional to zero, it indicates the absence of such parameter for the rating. However, when Q_i rating is 100, it means that respective parameter is within the prescribed limit and if rating is more than 100, it signifies the parameter is above the standard limit.

Quality rating for each parameter was calculated by using the following equation:

$$Qi = \frac{(Vactual - Videal)}{(Vstandard - Videal)} X100$$

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):
The specific weight, also known as the unit weight, is the weight per unit volume of a material. The unit weight of water is one such property. It can be expressed in a variety of ways, depending on the particular units chosen. Results of total unit weight (W_i) of all the parameters used to find out WQI.

Unit weight is 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,
W_iQ_i = Weighted value
W_i = Unit weight

RESULTS AND DISCUSSION
The data of physico-chemical parameters water of Shikhar fall obtained and standard permissible value WHO and Indian Standards Institution (ISI) was presented in table 1. The data obtained during present study is applied for the calculation of WQI.

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 145 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 234 mg/L, which is very high according to ISI and WHO standards.

Temperature is an important parameter as it is responsible to increase the solubility of many minerals, salts and gases. It was found to be 18^{0}C for the sample studied. 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 105 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 7.9, 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 125 mg/L.

Total dissolved solid is an aggregate of all the dissolved solids present in the water. The amount of TDS was reported as 620 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 180 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 96 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 44 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 Shikhar waterfall
1.	Chloride	Argentometric titration method	250	250	145
2.	Temperature	Thermometric	-----	-----	180C
3.	Electrical Conductivity	Conductometry	400	300	105
4.	pH	pH metery	7.0 – 8.0	6.5 – 8.5	7.9
5.	Alkalinity	Titration Method	120	200	125
6.	Sulfate	Turbidimetric method	250	200	234
7.	Total Dissolved Solid	Filtration Method	1000	500	620
8.	Total Hardness	EDTA titration	100	300	180
9.	Calcium	EDTA titration	75	75	96
10.	Magnesium	EDTA titration	150	30	44

Table 2 : Calculation of WQI for sample studied.

S.No.	Parameters	Observed values	Standard values	Unit weight (Wi)	Quality rating (Qi)	Weighted values (WiQi)
1.	Chloride	145	250	0.004	58.000	0.232
2.	Electrical Conductivity	105	300	0.003	35.000	0.105
3.	pH	7.9	8.5	0.117	60.000	7.020
4.	Alkalinity	125	200	0.005	62.000	0.310
5.	Sulfate	234	200	0.005	117.000	0.585
6.	TDS	620	500	0.002	124.000	0.248
7.	Total Hardness	180	300	0.003	60.000	0.180
8.	Calcium	96	75	0.013	128.000	1.664
9.	Magnesium	44	30	0.033	146.660	4.839
				Σ Wi = 0.185		**Σ WiQi= 15.183**
	WQI = Σ WiQi / Σ Wi = 82.070					

Table 3: Standard Rating of Water Quality as per WQI values 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 82.07 (Table 2). As per Standard Rating of Water Quality (Table 3), water source of Shikhar fall was found 'D' grade and its water quality is explained as very poor 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 strongly suggests cleaning the Shikhar water fall regularly for the proper health of general public. Good quality of water is not only the requirement of human beings but also necessary for the maintenance of biodiversity and ecological balance (Verma, 2016, 2017, 2018).

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