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Assessment of Drinking Water Quality Status by Water Quality Index: A Case Study of Bhatta Waterfall, Dehradun, Uttarakhand - India

Sonu Dwivedi

Associate Professor, Department of Chemistry, D.B.S. (PG) College, Dehradun, Uttarakhand, India
Email: *somdwivedi5[at]gmail.com*

Abstract: ***Water is the most important natural resource in the world since without it life cannot exist and most industries could not operate. Hence water resources should be used in the best possible economic way and research should be carried on for finding out dry methods of production. In this study, Water Quality Index (WQI) of Bhatta waterfall, Dehradun was analyzed with the help of ten physicochemical parameters such as Alkalinity, Calcium, Chloride, Electrical Conductivity, Magnesium, Nitrate, pH, Sulfate, Total Dissolved Solid, Total Hardness to know the suitability for drinking purpose during pre and post monsoon seasons of the year 2022. The values of Calcium, Magnesium which exceeded the permissible limit during both monsoon seasons. The calculated Water Quality Index value are 115.115 during pre-monsoon season and 92.618 during post-monsoon season. This water quality rating study clearly shows that, the status of the water body is not suitable for drinking.***

Keywords: Drinking, Industries, Waterfall, Water Quality Index (WQI)

1. Introduction

The quality of water resources in the world is increasingly despoiled as a consequence of overex ploitation[1]. Water quality has noticeably been deteriorated in many countries during the past few years[2]. The overexploitation of surface water has affected groundwater quality as well as quantity. The portability of surface water is essentially based on the kinds and concentrations of ionic constituents in water[3-4]. The chemistry of water is determined as the results of various chemical variations of meteoric water in geological systems. Water quality is naturally influenced by geochemical compositions of the rocks along with various hydrodynamic factors[5-8]. Water resources play a vital role to continually increasing demands of agriculture, industry and domestic parts of India[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]. 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[12]. Therefore, economic, agricultural and social activities within Dehradun district require urgent need to maintain the status of water sources. The water quality analysis is a most important part of hydro geological investigations to quantify the composition of chemical characters. Water quality indices are contraption to govern circumstances of water quality and, such as any other contraption vital apprehension concerning controller and pivotal theory of water. It is a conventional process of demonstrate water quality that extend a steady and standardized unit of calculate whatever greet to substitute in the predominant manner of water. WQI is a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality[13]. In other words, WQI summarizes large amounts of water quality data into simple terms e.g., excellent, good, bad, etc. for reporting to management and the public in a consistent manner[14]. The analysis of the water is extremely important as it contains A large number of impurities which are necessary to be checked before the water is used for any Specific purpose.

2. Materials and Methods

Study area

Dehradun valley that lies between Shivalik range of Himalaya that's the reason found many waterfall near Dehradun district and Bhatta waterfall is one of them. Bhatta waterfall is strategically situated on Mussoorie–Dehradun road, near Bhatta village. It is located at a distance of 17 km from Dehradun. The Mountains make this area as one preferred destination for people to experience green mountain peaks from so near. Bhatta Fall is grandiose waterfall drops from a height of 30 feet above ground level. The sudden gush of water of this fall bounces on the terrains and tumbles down to form a freshwater icy pool. It lies on 30° 23' 51.36" N latitude and 78° 04' 40.548" E longitude. Therefore, frequent water quality monitoring of water source of Bhatta waterfall. Bhatta village and surrounding locality are essential in order to protect its mass population from waterborne diseases and to develop appropriate preventive measures, in case of contamination [15].

Figure: View of Study area

Collection and Analysis of Water Sample

The water specimen were calm in the pre and post monsoon season 2022 and scrutinize for 10 physicochemical parameters by following the usual method. The parameters pH are electrical conductivity were watched at the specimen area and other parameters like TDS, alkalinity, total hardness, calcium, magnesium, chloride, nitrate and sulphate were analyzed in the laboratory as per the slandered methods of APHA[16]. During study period WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO), Bureau of Indian Standards BIS[17].

Calculation of Water Quality Index

WQI is defined as a rating technique that demonstrates the composite influence of individual water-quality parameters on the overall quality of water for human consumption[18]. For this study, 10 water-quality parameters were selected. The parameters used to develop a WQI depend on the purpose for which the water is used. Parameters were selected according to the availability of data as well as their relative importance in defining water quality for human consumption. The parameters for this purpose follow the WHO guidelines. WQI is calculated by assigning weights to the measured parameters based on their relative importance. WQI tool is used successfully to state the quality of water for water bodies. The calculation of the WQI is well explained[19] and the same formula was applied to calculate the WQI The weighted arithmetic index method[20] has been used for the calculation of WQI in this research .

Calculation of Quality rating (Q_i):

Quality rating scales have been chosen so that each characteristics is assigned as a value depending on observed concentration. A survey of literature revealed that there are following 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, Weighted geometric index.

In this study, weighted arithmetic index is used to formulate rating curve. Permissible limits 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

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

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):

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 Water Quality Index (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

3. Results and Discussion

The analysis of the water is extremely important as it contains A large number of impurities which are necessary to be checked before the water is used for any Specific purpose. In water, which is used for drinking purpose, it is most essential to determine Alkalinity, Calcium, Chloride, Electrical Conductivity, Magnesium, Nitrate, pH, Sulfate, Total Dissolved Solid, Total Hardness. The data of physicochemical parameters water of Bhatta waterfall obtained from pre and post monsoon season 2022 and standard permissible value WHO and ISI was presented in Table1 and Table 2.

Table 1: Water quality parameters and there WHO & ISI standards in Pre-monsoon season-2022

S. No.	Parameters	Method	WHO Standards	ISI Standards	Sample
1.	Alkalinity	Titration Method	120	200	192
2.	Calcium	EDTA titration	75	75	98
3.	Chloride	Argentometric titration method	250	250	173
4.	Electrical Conductivity	Conductometry	400	300	245
5.	Magnesium	EDTA titration	150	30	76
6.	Nitrate	UV Spectrophotometric method	50	45	37
7.	pH	pH metery	8.0	8.5	8.2
8.	Sulfate	Turbidimetric method	250	200	173
9.	Total Dissolved Solid	Filtration Method	1000	500	485
10.	Total Hardness	EDTA titration	100	300	202

Table 2: Water quality parameters and there WHO & ISI standards in Post-monsoon season-2022

S. No.	Parameters	Method	WHO Standards	ISI Standards	Sample
1.	Alkalinity	Titration Method	120	200	137
2.	Calcium	EDTA titration	75	75	84
3.	Chloride	Argentometric titration method	250	250	134
4.	Electrical Conductivity	Conductometry	400	300	157
5.	Magnesium	EDTA titration	150	30	38
6.	Nitrate	UV Spectrophoto-metric method	50	45	33
7.	pH	pH metery	8.0	8.5	7.6
8.	Sulfate	Turbidimetric method	250	200	170
9.	Total Dissolved Solid	Filtration Method	1000	500	401
10.	Total Hardness	EDTA titration	100	300	168

The values of various physicochemical parameters of Bhatta water source for drinking purpose is discussed here under in detail:

Alkalinity
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 found 192 mg/L during pre-monsoon season and 137 mg/L during post-monsoon season. Which according to WHO/ ISI standards is average.

Calcium
Calcium is an essential nutrient for aquatic organisms and regulates physiological functions. It is very common in all water bodies Many organism use calcium as a structural or

skeletal material. The presence of Calcium ions was found to be high 98 mg/L during pre-monsoon season and 84 mg/L high during post-monsoon season. Which according to WHO /ISI standards are very high concentration for drinking water in both season.

Chloride

Chloride is an essential anion of water. Table salt is the main source of chloride in water, in addition to potassium chloride and magnesium chloride which also make appreciable contribution. In the present study the chloride was found 173 mg/L during pre-monsoon season and 134 mg/L during post-monsoon season. Which according to WHO /ISI standards is average.

Electrical conductivity

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 245µs/cm during pre-monsoon season and 157µs/cm during post-monsoon season. Which according to WHO / ISI standards is average.

Magnesium

Magnesium is very important element for enzyme activation, growth of chlorophyll and phytoplankton. The main source of Mg is sewage inflows and minerals generate from soil erosion. Magnesium serves mainly as a transition metal in the chlorophyll molecule and play important role in algal photosynthesis. Magnesium ions according to ISI standards should not be exceed 30 mg/L but in the present study it was found 76mg/L during pre-monsoon season and 38 mg/L during post-monsoon season. This value suggests high concentration of Magnesium ions.

Nitrate

Nitrate was higher in winter because of decreased microbial and bacterial activity that reduces the nitrogen conversion into nitrate and nitrite. Lower concentrations of nitrate in surface waters during the summer may be caused by lower nitrate concentrations in ground water discharging to streams and uptake by plants. In the present study the chloride was found 37 mg/L to be average during pre-monsoon season and 33 mg/L average during post-monsoon season. Which according to WHO/ ISI standards is average in both season.

pH

pH is defined as the negative logarithm of hydrogen ion concentration. The pH for potable water should be between 7 to 8.5. 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. In the present study was found 8.2 during pre-monsoon season and 7.6 low during post-monsoon season. Which according to WHO and ISI standards is average during pre-monsoon season and post-monsoon.

Sulfate

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 173 mg/L during pre-monsoon season and 170 mg/L during post-monsoon season. Which according to WHO/ISI standards are average in both monsoon.

Total Dissolved Solids

Total Dissolved Solids is an aggregate of all the dissolved solids present in the water. The amount of Total Dissolved Solids was reported as 485 mg/L during pre-monsoon season and 401mg/L during post-monsoon season. Which according to WHO and ISI standards is average concentration for drinking water in both monsoon season.

Hardness

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 202 mg/L during pre-monsoon season and 168 mg/L during post-monsoon season. Which according to WHO / ISI standards is average.

Water quality index (WQI) is one of the meaningful approaches in surface water and ground water quality analysis. The values of WQI in the sampling location are summarized in Table 3 and Table 4 during pre and post monsoon season-2022.

Table 3: Calculation of WQI For Pre-monsoon season-2022

S.No.	Parameters	Observed values	Standard values	Unit Weight (Wi)	Quality rating (Qi)	Weighted values (WiQi)
1.	Alkalinity	192	200	0.005	096.000	0.480
2.	Calcium	98	75	0.013	0130.666	1.698
3.	Chloride	173	250	0.004	069.200	0.276
4.	Electrical Conductivity	245	300	0.003	081.666	0.244
5.	Magnesium	76	30	0.033	253.333	8.359
6.	Nitrate	37	45	0.022	106.700	2.347
7.	pH	8.2	8.5	0.117	082.222	9.619
8.	Sulfate	173	200	0.005	086.500	0.432
9.	Total Dissolved Solid	485	500	0.002	086.500	0.173
10	Total Hardness	202	300	0.003	067.333	0.201
				Σ Wi = 0.207		**Σ WiQi= 23.829**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 115.115					

Table 4: Calculation of WQI For Post-monsoon season-2022

S. No.	Parameters	Observed values	Standard values	Unit Weight (Wi)	Quality rating (Qi)	Weighted values (WiQi)
1.	Alkalinity	137	200	0.005	68.500	0.3425
2.	Calcium	84	75	0.013	112.000	1.456
3.	Chloride	134	250	0.004	53.060	0.212
4.	Electrical Conductivity	157	300	0.003	52.333	0.156
5.	Magnesium	38	30	0.033	126.666	4.179
6.	Nitrate	33	45	0.022	73.333	1.613
7.	pH	7.6	8.5	0.117	89.411	10.461
8.	Sulfate	170	200	0.005	85.000	0.425
9.	Total Dissolved Solid	401	500	0.002	80.200	0.160
10	Total Hardness	168	300	0.003	56.000	0.168
				Σ Wi = 0.207		**Σ WiQi= 19.172**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 92.618					

Table 5: 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

The calculated Water Quality Index value are 115.115(Table 3) during pre-monsoon season and 92.618 (Table 4) during post-monsoon season. This water quality rating study clearly shows that, the status of the water body is not suitable for drinking. It is also observed that the pollution load is relatively high during pre-monsoon season when compared to the post-monsoon seasons. This is might be due to The domestic waste is directly discharge in, The surrounding Peoples also use this to wash their cloths, take bath, sanitation etc., The cattle of the villagers also take bath in this water body.

4. Conclusion

Waterfalls are extremely foremost as they sustain into and design our substantial water sources. These water sources relax deprecatory part in the status and provide of drinking water by confirm a sustained move of surface water and serving recreate hypogeal water level. The water quality of the Bhatta waterfall in Dehradun has been check out on the basis of ramification of analysis of water samples for important physicochemical parameters at site. The water quality probe consequency in the present study indicated that most of the physicochemical parameters investigated were within the WHO limits and ISI for drinking water except that Calcium, Magnisium which exceeded the permissible limit during both monsoon seasons. WQI results suggested that the water source of Bhatta waterfall is 'E' grade during pre-monsoon season and 'D' grade during post-monsoon season. Consequently, the water cannot be mention for drinking and other domestic purposes beyond command it to disinfection.

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