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Research Article

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The Use of Water Quality Index Method to Determine water quality of Neer Garh waterfall, Rishikesh, Uttarakhand

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Abstract The dramatic increase of different human activities around the surface water system.The assessment of surface water suitability for drinking purpose is needed for water sustainability. The Water Quality Index (WQI) is an approach to identify and assess the drinking water quality suitability. Water crises and quality are serious concerns in a lot of countries, particularly in arid and semi-arid regions where water scarcity is widespread and water quality assessment has received minimal attention. So, it is important to assess the quality of water to be used, especially for drinking purposes. In this study, Water Quality Index (WQI) of Neer Garh Waterfall, Rishikesh 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 value of Calcium and Total Dissolved Solid which exceeded the permissible limit during pre monsoon seasons and during post monsoon season are average. The calculated Water Quality Index values are 81.149 during pre monsoon season and 73.811 during post monsoon season. This water quality rating study clearly shows that, the status of the water body is not suitable for drinking.

Keywords Assessment, Crises, Drinking, Human activities, Sustainability.

1. Introduction

"Water is life", "Health is Wealth" and "Waste to Wealth" are popular sayings relating to life and wealth. However, waste that is not properly managed in the vicinity of surface water and groundwater can be detrimental to life, health and wealth. Ever since the Earth Summit in Rio de Janeiro in June 1992, awareness on the environment and sustainable development has increased tremendously all over the world. More importantly, is the greater awareness of and concern over the growing scarcity of potable water [1]. This is not surprising as clean water supplies and sanitation remain persistent problems in many parts of the world, with approximately a fifth of the global population lacking access to potable water [2]. Water is the prime natural resource. Acknowledging the vital importance of this scarce resource for human and animal life, as well as for maintaining ecological balance for economic and developmental activities of all kinds is a matter of utmost concern [3-4]. In recent times, there has been a tremendous increase in demand for freshwater and water shortage in arid and semiarid regions due to population increase, urbanization, industrialization and intense agricultural activities in many parts of world. Due to inadequate supply of surface waters, most of the people are depending mainly on groundwater resources for drinking and domestic, industrial, irrigation uses. Innumerable large towns and many cities derive water supply from groundwater and surface water for different uses through municipality network and also from large number of private boreholes

[5-7]. Regular water quality monitoring of the water resources are absolutely necessary to assess the quality of water for ecosystem health and hygiene, industrial use, agricultural use and domestic use[8-9]. Assessment of water quality can be a complex process undertaking multiple parameters capable of causing various stresses on overall water quality [10]. Several states in the India are facing problems due to over exploitation of ground water resources and pollution of surface water. Its manifestations are declining per capita water availability, falling water tables and deterioration of water quality [11-12]. 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 [13-14]. 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 [15]. In many parts of the country available water is rendered non-potable because of the presence of heavy metal in excess. 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 [16]. Poor water quality is responsible for the deaths of an estimated five billion children annually in the developing countries. According to World Health Organization (WHO) survey 80% of all human diseases in developing countries are waterborne [17]. Water quality indices are tools to determine conditions of water quality and like any other tool require knowledge about principles and basic concepts of water and related issues [18]. It is a well-known method of expressing water quality that offers a stable and reproducible unit of measure which responds to changes in the principal characteristics of water. WQI is a mechanism for presenting a cumulatively derived numerical expression defining a certain level of water quality [19]. 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[20]. 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 municipal 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 etc. However, none of these studies give a comprehensive picture for major drinking water source of Neer Garh Waterfall, Rishikesh, Uttarakhand, India about suitability of their water quality for drinking purpose.

2. Materials and Methods

2.1 The Study Area

Neer Garh Waterfall is one of the most beautiful waterfalls in Rishikesh because it is situated amid the grandeur of the Himalayas and the lush greenery of the thick forests. The waterfall is quite high and the forces of the water are pretty fast and rich variety of flora and fauna flocking around the area. Neer Garh Waterfall from Rishikesh involves an approximately 5.2 km or 58-minute walk from the Laxman Jhula bridge in Tapovan and at a distance of 12.5 km from Rishikesh Railway Station. The latitude of Neer Garh waterfall is 30.1472° North and longitude is 78.32927° East [21].

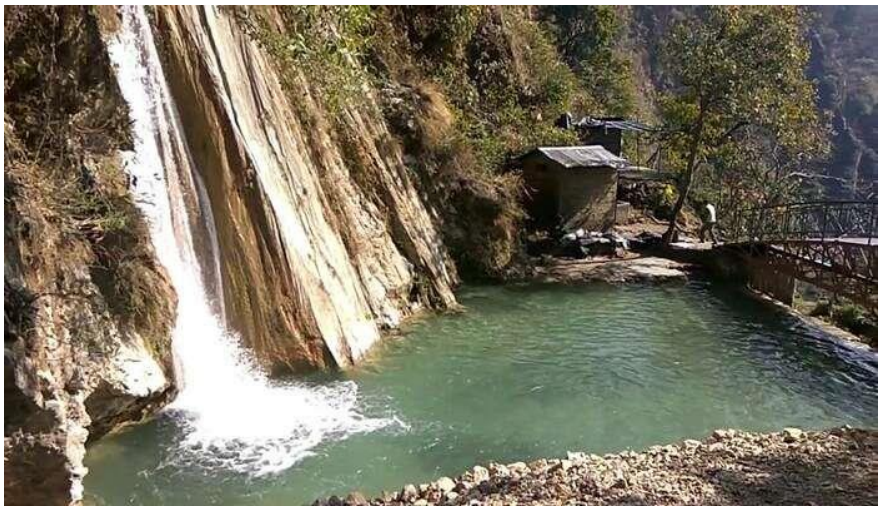

Figure 1: View of Study Area

2.2 Collection and Analysis of Water Sample

The water sample were collected in the pre and post monsoon season 2022 and analyzed for 10 physicochemical parameters by following the established procedure. The parameters pH and electrical conductivity were monitored at the sampling site and other parameters like TDS, alkalinity, total hardness, calcium, magnesium, chloride, nitrate and sulfate were analyzed in the laboratory as per the slandered methods of APHA[22]. 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 [23].

2.3 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[24]. 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[25] and the same formula was applied to calculate the WQI The weighted arithmetic index method[26] has been used for the calculation of WQI in this research .

2.4 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.

2.5 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

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

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 municipal 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 Neer Garh Waterfall, Rishikesh obtained from pre and post monsoon season 2022 and standard permissible value WHO and ISI was presented in Table 1 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	75
2.	Calcium	EDTA titration	75	75	76
3.	Chloride	Argentometric titration method	250	250	86
4.	Electrical Conductivity	Conductometry	400	300	95
5.	Magnesium	EDTA titration	150	30	21
6.	Nitrate	UV Spectrophoto-metric method	50	45	26
7.	pH	pH metery	8.0	8.5	7.8
8.	Sulfate	Turbidimetric method	250	200	162
9.	Total Dissolved Solid	Filtration Method	1000	500	685
10.	Total Hardness	EDTA titration	100	300	67

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	30
2.	Calcium	EDTA titration	75	75	51
3.	Chloride	Argentometric titration method	250	250	88
4.	Electrical Conductivity	Conductometry	400	300	76
5.	Magnesium	EDTA titration	150	30	19
6.	Nitrate	UV Spectrophoto-metric method	50	45	26
7.	pH	pH metery	8.0	8.5	7.4
8.	Sulfate	Turbidimetric method	250	200	135
9.	Total Dissolved Solid	Filtration Method	1000	500	401
10.	Total Hardness	EDTA titration	100	300	63

The values of various physicochemical parameters of Neer Garh 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 to be 75 mg/L during pre-monsoon season and 30 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 76 mg/L, Which according to WHO /ISI standards is high concentration for drinking water during pre-monsoon season and 51 mg/L during post-monsoon season, Which according to WHO /ISI standards is average concentration for drinking water.

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 86 mg/L during pre-monsoon season and 88 mg/L during post-monsoon season. Which according to WHO /ISI standards are 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 95 µs/cm during pre-monsoon season and 76 µs/cm low during post-monsoon season. Which according to WHO / ISI standards are 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 21 mg/L during pre-monsoon season and 19 mg/L during post-monsoon season. The values of Magnesium ions suggest of pre-monsoon season and post-monsoon season are average according to WHO / ISI standards.

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 26 mg/L during pre-monsoon season and 26 mg/L during post-monsoon season. Which according to WHO/ ISI standards are average.

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 7.8 during pre-monsoon season and 7.4 during post-monsoon season. Which according to WHO and ISI standards are average during pre-monsoon season and post-monsoon season.

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 162 mg/L during pre-monsoon season and 135 mg/L during post-monsoon season. Which according to WHO/ISI standards are average during pre-monsoon season and post-monsoon season.

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 685 mg/L during pre-monsoon season and 401 mg/L during post-monsoon season. Which according to ISI standard is the value of pre-monsoon season suggest high concentration and according to WHO standard is the value of pre-monsoon season suggest average concentration. The value of post-monsoon season is average concentration according to WHO/ ISI standards.

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 67 mg/L during pre-monsoon season and 63 mg/L during post-monsoon season. Which according to WHO / ISI standards are average.

Water quality index (WQI) is one of the meaningful approaches in surface water and ground water quality assessment. 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	75	200	0.005	37.500	0.187
2.	Calcium	76	75	0.013	101.333	1.317
3.	Chloride	86	250	0.004	34.400	0.137
4.	Electrical Conductivity	95	300	0.003	31.667	0.095
5.	Magnesium	21	30	0.033	70.000	2.310
6.	Nitrate	26	45	0.022	57.777	1.271

7.	pH	7.8	8.5	0.117	91.764	10.736
8.	Sulfate	162	200	0.005	81.000	0.405
9.	Total Dissolved Solid	685	500	0.002	137.000	0.274
10	Total Hardness	67	300	0.003	22.333	0.066
				Σ Wi = 0.207		**Σ WiQi= 16.798**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 81.149					

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	30	200	0.005	15.000	0.075
2.	Calcium	51	75	0.013	68.000	0.884
3.	Chloride	88	250	0.004	35.200	0.140
4.	Electrical Conductivity	76	300	0.003	25.333	0.075
5.	Magnesium	19	30	0.033	63.333	2.089
6.	Nitrate	26	45	0.022	57.777	1.271
7.	pH	7.4	8.5	0.117	87.058	10.185
8.	Sulfate	135	200	0.005	67.500	0.337
9.	Total Dissolved Solid	401	500	0.002	80.200	0.160
10	Total Hardness	63	300	0.003	21.000	0.063
				Σ Wi = 0.207		**Σ WiQi= 15.279**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 73.811					

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 81.149 (Table 3) during pre monsoon season and 73.811 (Table 4) during pre-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 season. This might be due to the domestic waste is directly discharge in the surrounding people also use this lake to wash their cloths, take bath, sanitation etc., the cattle of the villagers also take bath in this water body.

4. Conclusion

Application of WQI in this study has been found useful in assessing the overall quality of water. This method appears to be more systematic and gives comparative evaluation of the water quality in different seasons of the year. It has been observed that the values of water quality parameters of the study area are lower during post monsoon period reflecting an improvement in quality due to fresh recharge and clearly indicated seasonal variation and also water quality analysis results indicated that most of the physicochemical parameters investigated were within the Standard values for drinking water except Calcium and Total Dissolved Solid which exceeded the permissible limit during pre monsoon seasons and average during post monsoon season.WQI results suggested that the water source

of Neer Garh Waterfall are 'D' grade during pre and 'C' grade during post monsoon season. Therefore, the water cannot be recommended for drinking and other domestic purposes without subjecting it to purification.

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