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***Research Article** (Open Access)*

PRE AND POST MONSOON MONITORING OF DRINKING WATER QUALITY STATUS BY WATER QUALITY INDEX: A CASE STUDY OF KEMPTY WATERFALL, TEHRI GARHWAL DISTRICT, UTTARAKHAND- INDIA

***S. Dwivedi**
Department Of Chemistry, D.B.S. (PG) College,
Dehradun- Uttarakhand
**Author for Correspondence: somdwivedi5@gmail.com*

ABSTRACT
Drinking water quality has emerged as major issue requiring immediate attention. Hence, regular monitoring of water quality is necessary to determine the pollution level of ground and surface waters. Surface water is commonly present with different degrees of availability and distribution of the earth. There has been an increase in surface water management and utilization for agriculture, domestic, industry and rural supply schemes for the development of nations. Increasing consumption of water resources due to anthropogenic influences on urban, industrial and agricultural needs and erratic precipitation due to metrological changes greatly degrade water sources. In this study, Water Quality Index (WQI) of Kempty waterfall, Tehri Garhwal District 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, Magnesium, Sulfate and Total Dissolved Solid which exceeded the permissible limit during pre monsoon seasons and value of Calcium, Magnesium and Total Dissolved Solid which exceeded the permissible limit during post monsoon season. The calculated Water Quality Index values are 114.106 during pre monsoon season and 85.169 during post monsoon season. This water quality rating study clearly shows that, the status of the water body is not suitable for drinking. Which according to Standard Rating of Water Quality is Unsuitable for Drinking Purpose in pre monsoon season and very poor in post monsoon season and not healthy for drinking purpose.

Keywords: *Development, Drinking water, Life, Physicochemical parameters, Surface water*

INTRODUCTION

Drinking water is the basic need of humans and it also has a great influence on the all aspects of life (Ahmad, 2005). 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)**. The most drinking fluid and is the universal solvent, 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 throughout the world (Thurman *et al.,* 1996; Leoni *et al.,* 2005). Generally discharge of direct domestic and industrial effluent wastes, leakage from improperly maintained septic water tanks and poor management of farm wastes are considered as the major sources of water pollution and ultimately of waterborne diseases (Chaterjee and Raziuddin, 2002; Prasad and Narayana, 2004). 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 (Jain and Sharma, 2005) wastes are considered as the major

sources of water pollution and ultimately of waterborne diseases. The sources of fresh water in Uttarakhand state are glaciers, rivers and lakes but due to the shortage of rains and snowfall and also because of pollution, in summer Uttarakhand state is suffering from water shortage. To overcome this situation, presently water is the most abundantly (>70 %) consumed natural resource for various human activities (Khanna and Bhutiani, 2013; Tyagi and Dobhal, 2013). 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 (Tebbutt, 1983). 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 (Liu and Kuo, 2003). 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 (Verma and Solanki, 2010). 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 (Thakor and Chauhan, 2011). 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 Kempty waterfall in Tehri Garhwal District of Uttarakhand, India about suitability of their water quality for drinking purpose.

MATERIALS AND METHODS

2.1 STUDY AREA

Kempty waterfall is a waterfall in Ram Gaon and at the south of Kempty, in the Tehri Garhwal District of Uttarakhand, India. It is 13 kilometres from Mussoorie on the Chakrata Road and 45 kilometres from Dehradun. It is nearly 1364 meters above sea level at 78°-02'East longitude and 30° -29'North latitude. The Kempty waterfall and the area around is surrounded by high mountain ranges at an altitude of 4500 feet. There is an estimated tourist inflow to the Falls of over 10 lakh. Kempty waterfall was developed as a tourist destination by British officer John Mekinan, around 1835. The name Kempty is probably derived from the word 'camp-tea'. A stream of water running throughout the year starting from

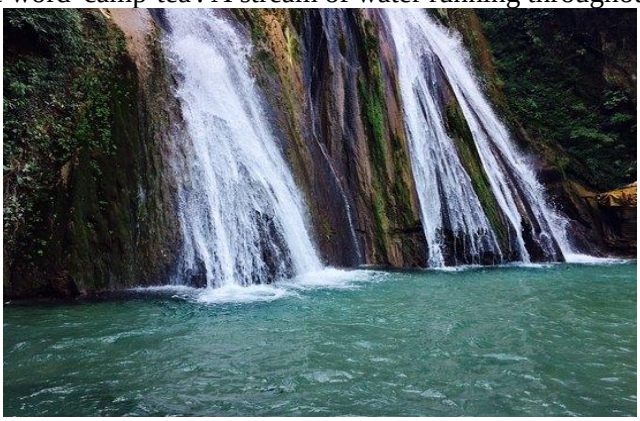

Fig 1. View of Study area

the southwest of the village of Banglow ki kandi moves northwest and falls from 4,500 ft. Splitting into five other cascades, the water falls a further 40 feet. Milky-white water cascades down a cliff face before bouncing off rocks and into a manmade waterhole. Admire the verdant foliage that frames both sides of

the waterfall. Listen to the invigorating sounds of the rushing water, which mingles with the excited cheering.

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 (American Public Health Association, 2017). 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 (Bureau of Indian Standards, 2012).

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 (Verma and Chandawat, 2011). [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 (Upadhyay and Chandrakala, 2017) and the same formula was applied to calculate the WQI The weighted arithmetic index method (Brown and O' Connor, 1972) 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

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 Kempty waterfall, Tehri Garhwal District 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	36
2.	Calcium	EDTA titration	75	75	103
3.	Chloride	Argentometric titration method	250	250	183
4.	Electrical Conductivity	Conductometry	400	300	181
5.	Magnesium	EDTA titration	150	30	78
6.	Nitrate	UV Spectrophoto-metric method	50	45	18
7.	pH	pH metery	8.0	8.5	7.8
8.	Sulfate	Turbidimetric method	250	200	264
9.	Total Dissolved Solid	Filtration Method	1000	500	877
10.	Total Hardness	EDTA titration	100	300	68

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	28
2.	Calcium	EDTA titration	75	75	76
3.	Chloride	Argentometric titration method	250	250	125
4.	Electrical Conductivity	Conductometry	400	300	162
5.	Magnesium	EDTA titration	150	30	39
6.	Nitrate	UV Spectrophoto-metric method	50	45	21
7.	pH	pH metery	8.0	8.5	7.1
8.	Sulfate	Turbidimetric method	250	200	186
9.	Total Dissolved Solid	Filtration Method	1000	500	589
10.	Total Hardness	EDTA titration	100	300	89

The values of various physicochemical parameters of Kempty 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 36 mg/L during pre-monsoon season and 28 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 103 mg/L Which according to WHO /ISI standards are very high concentration for drinking water during pre-monsoon season and 76 mg/L during post-monsoon season. Which according to WHO /ISI standards are high 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 183 mg/L during pre-monsoon season and 125 mg/L low 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 181 µs/cm during pre-monsoon season and 162µs/cm low 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 78 mg/L during pre-monsoon season and 39 mg/L during post-monsoon season. The value of pre-monsoon season suggest very high concentration and value of post-monsoon season suggest 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 18 mg/L during pre-monsoon season and 21 mg/L during post-monsoon season. Which according to WHO/ ISI standards is 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 7.1 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 264 mg/L during pre-monsoon season and 186 mg/L during post-monsoon season. Which according to WHO/ISI standards the value of pre-monsoon season suggest high concentration and value of post-monsoon season suggest average concentration of sulfate ions for drinking water.

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 877 mg/L during pre-monsoon season and 589 mg/L during post-monsoon season. Which according to WHO standards is average in both monsoon season but according to ISI standards is high 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 68 mg/L during pre-monsoon season and 89 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 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	36	200	0.005	18.000	0.090
2.	Calcium	103	75	0.013	137.333	1.785
3.	Chloride	183	250	0.004	73.200	0.292
4.	Electrical Conductivity	181	300	0.003	60.333	0.180
5.	Magnesium	78	30	0.033	260.000	8.58
6.	Nitrate	18	45	0.022	40.000	0.880
7.	pH	7.8	8.5	0.117	91.764	10.736
8.	Sulfate	264	200	0.005	132.000	0.660
9.	Total Dissolved Solid	877	500	0.002	175.400	0.350
10	Total Hardness	68	300	0.003	22.666	0.067
				Σ Wi = 0.207		**Σ WiQi= 23.62**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 114.106					

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	28	200	0.005	14.000	0.070
2.	Calcium	76	75	0.013	101.333	1.317
3.	Chloride	125	250	0.004	50.000	0.200
4.	Electrical Conductivity	162	300	0.003	54.000	0.162
5.	Magnesium	39	30	0.033	130.00	4.290
6.	Nitrate	21	45	0.022	46.666	1.026
7.	pH	7.1	8.5	0.117	83.529	9.777
8.	Sulfate	186	200	0.005	93.000	0.465
9.	Total Dissolved Solid	589	500	0.002	117.800	0.235
10	Total Hardness	89	300	0.003	29.666	0.088
				Σ Wi = 0.207		**Σ WiQi= 17.63**
	Water Quality Index (WQI) = Σ WiQi / Σ Wi = 85.169					

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 114.106 (Table 3) during pre monsoon season and 85.169 (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.

CONCLUSION

The quality of surface water varies from one season to another season due to the heavy rainfall of the region. The water quality of surface water sources of study area has been assessed for drinking uses by analyzing various physico-chemical parameters during pre- and post-monsoon seasons. The water quality analysis results in the present study indicated that most of the physicochemical parameters investigated were within the Standard values for drinking water except Calcium, Magnesium, Sulfate and Total Dissolved Solid which exceeded the permissible limit during pre monsoon seasons and Calcium, Magnesium and Total Dissolved Solid which exceeded the permissible limit during post monsoon season. WQI results suggested that the water source of Kempty is 'E' grade during pre-monsoon season and 'D' grade during post-monsoon season. Therefore, the water cannot be recommended for drinking and other domestic purposes without subjecting it to purification. Thus, there is a need to properly manage wastes in the surrounding and control and monitor human activities in Kempty waterfall.

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