



# International Journal of Pharmacognosy and Chemistry

Open Access

Research Article

Estimation of water quality status for drinking water sources of Doiwala block of Dehradun District, Uttarakhand

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## Article History

Received on: 13-01-2022

Revised on : 26-02-2022

Accepted on : 15-03-2022

**Keywords:** Groundwater, Health, Water Quality Index (WQI).

## DOI:

<https://doi.org/10.46796/ijpc.v3i1.298>



## Abstract

The ground water is contaminated, its quality cannot be restored by stopping the pollutants from the source. The common pollutants of groundwater are discharge of agricultural, domestic, and industrial waste, pesticides etc., which leads to water-borne diseases. Water-borne diseases may be of microbial origin such as diarrhoea, dysentery, cholera, typhoid and chemical origin such as fluorosis and methemoglobinemia. Water Quality Index (WQI) provides a single number that expresses overall quality at certain location and time based on several water quality parameters. The objective of an index is to turn complex quality data into information that is understandable and useable by the public. The present study was undertaken to assess the suitability of 8 drinking water sources of Doiwala block of Dehradun for drinking purpose during pre- and post-monsoon seasons of the year 2021. The obtained water quality data of drinking water sources was further applied for the calculation of weighted arithmetic Water Quality Index (WQI). Most of the water sources during pre-monsoon season were graded as 'A' with good quality due to having low WQI values. However, Two sites were found with 'B' class, another two were classified as 'C' grade owing to higher WQI values and thus, categorized as having poor water quality. Two sampling sites were recorded with highest WQI value (59.29) and (68.24) its water quality was found poor for drinking purpose. During post-monsoon season, all analyzed water sources showed low WQI values, which indicates 'A' class i.e. excellent water quality. The higher WQI values during pre-monsoon season have been inferred owing to relatively higher calcium, magnesium and iron concentrations assessed during the period of study.

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## Introduction

The three major sources of water are rain, surface water and ground water. Rain water percolating into ground constitutes the ground water. Ground water is superior

to surface water because of the effective filtering effect. It is the cheapest and most practical means of providing water to communities. The total annual replenishable ground water resources in India have been assessed as 433 billion cubic meters (BCM) and the net annual ground water availability is estimated as 399 BCM. Existing gross ground water draft for all uses is 231 BCM per year.

Groundwater occurs almost everywhere beneath the earth surface not in a single widespread aquifer but in thousands of local aquifer systems and compartments that have similar characters. Knowledge of the occurrence, replenishment, and recovery of groundwater has special significance in arid and semi-arid regions due to discrepancy in monsoonal rainfall, insufficient surface waters and over drafting of groundwater resources. Groundwater quality depends on the quality of re-charged water, atmospheric precipitation, inland surface water, and on sub-surface geochemical processes. Temporal changes in the origin and constitution of the re-charged water, hydrologic and human factors, may cause periodic changes in groundwater quality. Water pollution not only affects water quality but also threatens human health, economic development and social prosperity. For healthy living, potable safe water is absolutely essential. It is a basic need of all human being to get the adequate supply of safe and fresh drinking water. One of the most effective ways to communicate water quality is 'Water Quality Index (WQI)', where the water quality is assessed on the basis of calculated water quality indices. Quality of water is defined in terms of its physical, chemical, and biological parameters. However, the quality is difficult to evaluate from a large number of samples, each containing concentrations for many parameters. Water quality index provides a single number that expresses overall water quality at a certain location on several water quality parameters and turns complex water quality data into information that is understandable and useable by the general people. WQI is a mathematical instrument used to transform large quantities of water quality data into a single number, which represents the water quality level while eliminating the subjective assessments of water quality and biases of individual water quality experts. Comparison can be made through the WQI among the water bodies and a general analysis of water quality on different levels can be made. To determine the WQI of 8 drinking ground water sources in Doiwala block of Dehradun District of Uttarakhand state for one year period. Drinking water contamination and variation of drinking water quality in pre-monsoon and post monsoon seasons will be the basis of calculated values of WQI as concentrations of different water quality parameters tend to be at its worse condition during pre-monsoon season. Based on the WQI, an assessment will be made whether the selected drinking water sources being used by public are acceptable and safe for domestic use and even for drinking purpose. Local people living in Dehradun are completely dependent on these ground water sources as there

is no proper alternate water supply made to meet their needs. For this reason, this analysis is extremely necessary so that people living in these areas can mark out the best water source available. Also if they need more water, they can also determine, which water bodies can be used after proper treatment.

### Methodology

- (1) Ground drinking water sources 8 Nos.(S-1 to S-8), which are being used by Uttarakhand Jal Sansthan (UJS), Dehradun (which is Uttarakhand's drinking water supply and maintenance agency) for supply of domestic/drinking water in Doiwala block of Dehradun District will be identified and selected, which cater maximum population of their region/ vicinity.
- (2) Generally, grab sampling was preferred for sample collection. Water samples were taken in washed and sterilized Tarson bottles after 3 times rinsing with the sample. Metal ions e.g. iron may subject to loss or adsorption or ion exchange with walls of glass container. Therefore, sample for iron was collected in acid-leached Tarson bottles with 10% nitric acid and then with water again and finally rinsed with ion exchange water. Before sample collection, these bottles were 3 times rinsed with the sample and preserved immediately by adding ultra pure nitric acid of analytical grade (5ml/l) to maintain the pH<2 to minimize precipitation and adsorption.
- (3) All the samples after maintaining in the cold chain were brought to the laboratory in sampling box at 4°C and stored at the same temperature (4°C).
- (4) The onsite as well as laboratory analysis was carried out for 11 water quality parameters for precise quantitative analysis according to BIS(10500 : 2012) guidelines and international APHA specifications.
- (5) The physico- chemical parameters selected for the study are pH, Alkalinity, Turbidity, Total Dissolved Solids (TDS), Nitrate, Sulphate, Chloride, Iron, Hardness, Calcium, Magnesium.
- (6) The different analytical techniques and methods to be employed for the analysis of above eleven drinking water quality characteristics are summarized as under in TABLE-1 for onsite analysis as
- (7) well as laboratory analysis of parameters The eleven parameters of ground water sources were analyzed twice in one year in order to study the effect of monsoon on water quality i.e. studies were also be undertaken during pre-monsoon and post-monsoon seasons.

- (8) The analyzed water quality is categorized in various grades that indicate the status of water quality with the help of Water Quality Index (WQI). The concept of WQI is used to represent the grading of water quality of ground water sources. The weighted arithmetic index method is used for calculation of WQI by using the following equation (1):

$$WQI = \frac{\sum W_i Q_i}{\sum W_i} \text{----- (1)}$$

The unit weight ( $W_i$ ) for each water quality parameter is calculated by using the following formula:

$$W_i = K / S_i$$

Where,  $K$  is proportionality constant and  $S_i$  is the standard permissible value of  $i$ th parameter. The quality rating ( $Q_i$ ) of equation (1) is calculated as under-

$$Q_i = 100 [(V_i - V_o) / (S_i - V_o)]$$

Where,  $V_i$  is estimated concentration of  $i$ th parameter in the analysed water and  $V_o$  is the ideal value of this parameter in pure water. All ideal values are taken as zero for drinking water except pH =7.0. The rating of water quality according to WQI, is given in TABLE- 2.

- (9) In the above manner, the WQI approach is utilized after calculation by using water quality data of eleven water quality parameters viz. turbidity, pH, hardness, alkalinity, chloride, TDS, calcium, magnesium, sulphate, nitrate and iron analyzed, which are mainly contributing the water quality of Doiwala block of Dehradun. On the basis of WQI, the description is made for the suitability as well as safety of ground drinking water sources at each of selected site of Dehradun District of Garhwal region of Uttarakhand and water will be categorized as above from excellent to unsuitable depending upon the value of WQI.

## Results and Discussion

The analytical results obtained for different study parameters such as turbidity, pH, hardness, alkalinity, chloride, TDS, calcium, magnesium, sulphate, nitrate and iron from different sampling locations in monsoon and post-monsoon of the year 2021 as summarised in Table 3 & 4. Permissible limits and recommended agencies are described in Table 2. The results obtained for Monsoon and post-monsoon are discussed below.

Doiwala block of Dehradun was selected for the study of water quality index through water quality estimation. Eight ground drinking water sources (S-1 to S-8) were selected. All the water samples have been collected and analyzed twice during pre-monsoon and post-monsoon seasons during the year 2021 following the specifications for drinking water prescribed by Bureau of Indian Standard (BIS) i.e. IS 10500:2012. The values of analyzed water quality parameters have been given under TABLE-3 and TABLE-4 for pre- and post-monsoon seasons, respectively. Water quality index have been computed using weighted arithmetic index method for all ground water sources of Doiwala block of Dehradun. These eleven drinking water characteristics values have been analyzed and then calculated water quality index during pre-monsoon and post-monsoon season of 12 months of one year i.e. 2021. These Water Quality Index (WQI) values of both seasons are provided under TABLE-5 and TABLE-6. Water quality index values derived have provided useful information about suitability of drinking water sources of Dehradun with respect to their safety for human consumption i. e. potability.

Under the present study suitability of drinking water sources of Doiwala block of Dehradun have been estimated using water quality index. The population of Dehradun is facing the problems of poor drinking water quality as well as quantity. The water quality index values have been estimated to the influence of eleven water quality parameter analyzed. The weighted arithmetic water quality index used for present studies has ensured suitability of studied water sources for drinking purpose.

The studies have shown that most of the water sources good quality. On the basis of combined results during pre- and post-monsoon seasons of 2021, it is inferred that except S-3 site(Ghanuled), and S-8 site(Missarwala Khurd) (with precaution), rest of the drinking water sources can be used for supply of potable water to local population, which are safe for human consumption and use for domestic needs by citizens of Dehradun, which is also capital of Uttarakhand state.

**Table 1: Protocol and Adopted Method as per BIS and APHA Specifications for 11 Water Quality Characteristics/ Parameters**

S. N.	Parameter/Characteristic	IS:10500 Specification		Protocol	Adopted Method
		Desirable Limit (DL)	Permissible Limit (PL)		
(A)	<b>Water Quality Parameters to be Analysed on site</b>				
1.	pH value	6.5 to 8.5	No Relaxation	IS3025 Pt-11-2002	Electrometric method
2.	Alkalinity, mg/l	200	600	IS3025 Pt-23-2003	Sulfuric acid (Titration) method
3.	Turbidity, NTU	5	10	IS3025 Pt-10-2006	Turbidimetric method
(B)	<b>Water Quality Characteristics to be Analysed in Laboratory</b>				
4.	Nitrate, mg/l	45	100	IS3025 Pt-34-2003	UV Spectrophotometric method
5.	Total Dissolved Solids, mg/l	500	2000	IS3025 Pt-16-2002	Gravimetric method
6.	Chloride, mg/l	250	1000	IS3025 Pt-32-2003	Argentometric method
7.	Sulfate, mg/l	200	400	APHA 21 <sup>st</sup> Ed., 4500-SO <sub>4</sub> <sup>2-</sup> E	Turbidimetric method
8.	Total Hardness, mg/l	300	600	IS3025 Pt-21-2003	EDTA method
9.	Calcium, mg/l	75	200	APHA 21 <sup>st</sup> Ed.- 3111.D	AAS method
10.	Magnesium, mg/l	30	100	APHA 21 <sup>st</sup> Ed.- 3111.B	AAS method
11.	Iron, mg/l	0.3	1.0	APHA 21 <sup>st</sup> Ed.- 3111.B	AAS method

**Table 2: Rating of Water Quality as Per Water Quality Index (WQI)**

WQI Scale	Water Quality Rating	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very Poor water quality	D
Above 100	Unsuitable for drinking purpose	E

Table-3: Water Quality Data of Different Drinking Water Sources of Doiwala Block during Pre-Monsoon Season Of 2021

S.I. No	Name of Source	Latitude	Longitude	Elevation Height in Meter	Turbidity, NTU	pH	Total Hardness, mg/l	Alkalinity, mg/l	Total Dissolved Solids, mg/l	Calcium, mg/l	Magnesium, mg/l	Sulfate, mg/l	Nitrate, mg/l	Chloride, mg/l	Iron, mg/l
	<b>Desirable Limit</b>				1	6.5 to 8.5	200	200	500	75	30	200	45	1.0	0.3
	<b>Permissible Limit</b>				5	No Relax.	600	600	2000	200	100	400	No Relax.	1.5	No Relax.
1	Dandi	30°10'42.3"	078°13'44.7"	565	0.3	7.28	324	220	424	58.0	53.5	96	5.6	1.02	ND
2	Raipur	30°10'53.7"	078°12'42.5"	559	0.43	7.72	304	237	395	72.0	36.2	77	3.7	0.95	ND
3	Ghanuled	30°10'34.0"	078°12'37.6"	374	0.18	7.81	244	238	364	114.8	86.6	37	3.7	1.45	0.2
4	Ranipokhari	30°10'53.7"	078°07'27.3"	478	0.17	8.83	308	239	387	75.5	61.4	59	3.2	1.05	ND
5	Lachchhiwala	30°11'44.3"	078°07'32.6"	497	0.98	7.72	254	275	425	75.6	37.3	63	3.9	0.96	ND
6	Mis-sarwala	30°11'01.8"	078°07'29.3"	488	0.50	7.24	245	249	402	58.4	46.3	53	8.3	1.0	ND
7	Mis-sarwala Kalan	30°11'06.3"	078°07'18.8"	491	0.44	7.38	249	314	488	76.8	45.9	60	4.7	0.91	ND
8	Mis-sarwala Khurd	30°10'58.3"	078°07'40.5"	474	0.28	7.57	287	324	428	125.5	87.6	52	4.9	1.5	0.24

Table 4: Water Quality Data of Different Drinking Water Sources OF Doiwala Block during Post-Monsoon Season OF 2021

S.I · No	Name of Source	Latitude	Longitude	Elevation Height in Meter	Turbidity, NTU	pH	Total Hardness,	Alkalinity, mg/l	Total Dissolved Solids, mg/l	Calcium, mg/l	Magnesium, mg/l	Sulfate, mg/l	Nitrate, mg/l	Chloride, mg/l	Iron, mg/l
	<b>Desirable Limit</b>				1	6.5 to 8.5	200	200	500	75	30	200	45	1.0	0.3
	<b>Permissible Limit</b>				5	No Relax.	600	600	2000	200	100	400	No Relax.	1.5	No Relax.
1	Dandi	30°10'42.3"	078°13'44.7"	565	0.18	7.58	324	285	398	42.7	51.255	49	4.6	1.02	ND
2	Raipur	30°10'53.7"	078°12'42.5"	559	0.54	7.26	324	324	417	56.6	44.258	74	5.3	0.78	ND
3	Ghanuled	30°10'34.0"	078°12'37.6"	374	0.24	7.96	244	246	468	57.3	27.357	64	5.4	0.99	ND
4	Ranipokhari	30°10'53.7"	078°07'27.3"	478	0.65	7.84	29	251	417	64.0	43.187	69	2.9	0.89	ND
5	Lachchhiwala	30°11'44.3"	078°07'32.6"	497	0.98	7.54	218	298	456	42.4	26.992	58	2.6	1.04	ND
6	Mis-sarwala	30°11'01.8"	078°07'29.3"	488	1.02	7.12	220	215	413	80.0	42.895	87	5.8	0.97	ND
7	Mis-sarwala Kalan	30°11'06.3"	078°07'18.8"	491	1.24	7.58	249	208	487	87.0	52.064	74	4.9	1.3	ND
8	Mis-sarwala Khurd	30°10'58.3"	078°07'40.5"	474	0.65	7.02	291	268	475	52.6	32.321	81	5.6	1.01	ND

**Table 5: Calculated WQI Values of 8 Drinking Water Sites of Doiwala Block During Pre-Monsoon Season, 2021**

S.N .	Code of Sampling Sites	WQI Specification	Calculated WQI Value	Water Quality Grading	Water Quality Status
1.	S-1	0-25	07.26	A	Excellent
2.	S-2	0-25	13.12	A	Excellent
3.	S-3	51-75	59.29	C	Poor
4.	S-4	0-25	16.09	A	Excellent
5.	S-5	26-50	29.31	B	Good
6.	S-6	26-50	35.25	B	Good
7.	S-7	0-25	09.87	A	Excellent
8.	S-8	51-75	68.24	C	Poor

**Table- 6: Calculated WQI Values of 8 Drinking Water Sites of Doiwala Block During Post-Monsoon Season, 2021**

S.N.	Code of Sampling Sites	WQI Specification	Calculated WQI Value	Grading	Description of Water Quality Status
1.	S-1	0-25	09.25	A	Excellent
2.	S-2	0-25	11.02	A	Excellent
3.	S-3	0-25	06.56	A	Excellent
4.	S-4	0-25	17.61	A	Excellent
5.	S-5	0-25	10.32	A	Excellent
6.	S-6	0-25	05.36	A	Excellent
7.	S-7	0-25	14.01	A	Excellent
8.	S-8	0-25	17.65	A	Excellent

### Conclusion

The water quality assessment is an effective tool to get the critical information about natural or anthropogenic processes occurring near the region. In the present study indicated that The Water Quality Index was calculated for all the Samples and analytical data of samples reveal that all the parameters show slight variations and no major changes have been observed in water quality during study period. During pre-monsoon four sites were found excellent owing to lower WQI values and thus, water quality was graded as 'A' Whereas, two sites were found with 'B' grade i.e. good water quality. However, two

study sites(Ghanuled, Missarwala Khurd) were classified as 'C' grade and categorized under poor water quality which may be due Calcium, Magnesium Iron content. It has been observed that the values of water quality Index were lower found with 'A' grade during post-monsoon period reflecting an improvement in quality due to fresh recharge and clearly indicated seasonal variation. Besides water quantity, the quality is also being depleted during distribution system of water supply due to malfunctioning of treatment plants, lack of advanced treatment technologies, unplanned developmental activities, application of inorganic fertilizers, leakage from old pipes and huge quantities of municipal solid waste. In

addition to these issues, seasonal fluctuation, erosion, slope factor, open defecation, abundance of calcium and magnesium rich rocks, etc. are also responsible for deterioration of water quality in the region. Hence, water quality deterioration has become a major concern related to water supply particularly in capital city Dehradun of Uttarakhand state to cater its mass population along with large number of floating tourists. The quality related issues are most prominent especially during summer season owing to drying of drinking water sources and in rainy season due to high turbidity.

However, none of these studies give a comprehensive picture for major drinking water sources of Doiwala block of Dehradun District of Uttarakhand, (India) about suitability of their water quality for drinking purpose with effect of seasonal variation. Therefore, water quality monitoring of drinking water sources of Dehradun, through Water Quality Index (WQI) estimated during present studies in the year 2021 twice for seasonal variation has provided very useful information to its citizens and society about safety of water, being used for drinking and domestic requirements. This study has further helped in protecting its mass population from water-borne diseases and to develop appropriate preventive measures.

### Acknowledgement

The author is sincerely thankful to D. B. S. (P. G.) College, Dehradun and Uttarakhand Jal Sansthan (UJS), Dehradun for providing technical support to carry out the study.

### Conflict of Interest

The author declare that he has no conflict of interest.

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