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Assessment of water quality status for drinking water sources of Sahaspur block of Dehradun district, Uttarakhand

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Abstract

This paper deals with the study on the influence of environmental parameters on the water quality of water body. There are several ways to assess the quality of water deemed fit for drinking, irrigation and industrial use. Water Quality Index, indicating the water quality in terms of index number, offers a useful presentation of overall quality of water for public or for any intended use as well as in the pollution abatement programmes and in water quality management. A number of parameters affect the usability of water for a particular purpose. Water Quality Index was determined on the basis of various physico-chemical parameters.

The present study was undertaken to assess the suitability of 8 drinking water sources of Sahaspur 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, One 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 (67.25) and (60.39) 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 Hardness, Calcium, Magnesium and Iron concentrations assessed during the period of study.

Keywords: Drinking water, Parameters, Pollution, Water Quality Index (WQI).

Introduction

The freshwater is of vital concern for mankind. The groundwater bodies are the most important sources of water for human activities are unfortunately under a severe environmental stress and are being threatened as consequence of developmental activities. Water quality index provides a single number that express overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is useful for public. A single number cannot tell the whole story of water quality there are many other water quality parameters that are not included in the index. However a water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water body with number.

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 Sahaspur 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 Sahaspur 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 well as laboratory analysis of parameters.

(7) 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):

$$WQI = \Sigma WiQi / \Sigma Wi \quad \text{---------- (1)}$$

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

$$Wi = K / Si$$

Where, K is proportionality constant and Si is the standard permissible value of ith parameter. The quality rating (Qi) of equation (1) is calculated as under-

$$Qi = 100 [(Vi – Vo/ Si – Vo)]$$

Where, Vi is estimated concentration of ith parameter in the analysed water and Vo 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 Sahaspur 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.

3. 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.

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)	**Water Quality Parameters to be Analysed on site**				
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)	**Water Quality Characteristics to be Analysed in Laboratory**				
4.	Nitrate, mg/l	45	100	IS3025 Pt-34-2003	UV Spectrophoto-metric 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 21st Ed., 4500-SO_4^{2-} E	Turbidimetric method
8.	Total Hardness, mg/l	300	600	IS3025 Pt-21-2003	EDTA method
9.	Calcium, mg/l	75	200	APHA 21st Ed.-3111.D	AAS method
10.	Magnesium, mg/l	30	100	APHA 21st Ed.-3111.B	AAS method
11.	Iron, mg/l	0.3	1.0	APHA 21st 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 Sahaspur block during pre-monsoon season of 2021

S.l. No	Name of Source	Latitude	Longitude	Elevation Height in Meter	Turbidity, NTU	pH	Total Hardness, mg/l	Alkalinity, mg/l	Total Dissolved Solids, mg/1	Calcium, mg/l	Magnesium, mg/l	Sulfate, mg/l	Nitrate, mg/l	Chloride, mg/l	Iron, mg/l
	Desirable Limit				**1**	**6.5 to 8.5**	**200**	**200**	**500**	**75**	**30**	**200**	**45**	**1.0**	**0.3**
	Permissible Limit				**5**	**No Relax.**	**600**	**600**	**2000**	**200**	**100**	**400**	**No Relax.**	**1.5**	**No Relax.**
1	Manaksidh	30°17’22.2”	077°55’07.3”	590	0.41	7.01	584	198	421	162.2	68.3	168	26	0.88	0.4
2	Jeevaradi	30°17’22.4”	077°55’07.5”	583	0.35	7.24	188	247	368	53.5	20.2	101	18	0.84	ND
3	JeevaRadi	30°17’55.1”	077°56’12.1”	572	0.18	7.11	144	238	364	54.8	19.5	135	14	0.72	ND
4	Sailok Colony	30°17’21.8”	077°56’08.7”	598	0.46	7.35	214	201	324	62.2	35.3	149	19	0.95	ND
5	Malam	30°17’41.0”	077°53’56.4”	591	0.98	7.26	158	125	398	45.6	27.3	63	15	0.86	ND
6	Mohammad Nagar	30°22’50.5”	077°55’032”	516	1.02	7.89	559	249	402	148.4	43.2	49	32	0.85	0.3
7	Shankarpur	30°23’23.6”	077°49’13.9”	480	0.98	7.02	158	214	258	45.3	30.2	42	11.2	0.74	ND
8	Shankarpur (Vyayamshala)	30°23’2.72”	077°49’30.3”	488	0.57	7.21	157	267	231	52.1	22.3	39	26	0.78	ND

Table-4: water quality data of different drinking water sources of Sahaspur block during post-monsoon season of 2021

S.l. No	Name of Source	Latitude	Longitude	Elevation Height in Meter	Turbidity, NTU	pH	Total Hardness, mg/l	Alkalinity, mg/l	Total Dissolved Solids, mg/1	Calcium, mg/l	Magnesium, mg/l	Sulfate, mg/l	Nitrate, mg/l	Chloride, mg/l	Iron, mg/l
	Desirable Limit				1	6.5 to 8.5	200	200	500	75	30	200	45	1.0	0.3
	Permissible Limit				5	No Relax.	600	600	2000	200	100	400	No Relax.	1.5	No Relax.
1	Manaksidh	30°17’22.2”	077°55’07.3”	590	0.45	7.41	187	193	347	48.2	25.1	124	24	0.7	ND
2	Jeevaradi	30°17’22.4”	077°55’07.5”	583	0.52	7.03	154	177	365	42	26.2	124	18	0.81	ND
3	JeevaRadi	30°17’55.1”	077°56’12.1”	572	0.65	7.41	187	169	414	50.2	21.5	186	26	0.75	ND
4	Sailok Colony	30°17’21.8”	077°56’08.7”	598	0.75	7.25	93	125	325	36.3	23.1	102	19	0.65	ND
5	Malam	30°17’41.0”	077°53’56.4”	591	0.54	7.14	125	141	365	39.6	24.2	121	21.8	0.74	ND
6	Mohammad Nagar	30°22’50.5”	077°55’032”	516	0.89	7.77	187	178	409	62.2	23.7	97	24.6	0.91	0.1
7	Shankarpur	30°23’23.6”	077°49’13.9”	480	075	7.02	142	162	356	36.8	19.2	89	14.2	0.65	ND
8	Shankarpur (Vyayamshala)	30°23’2.72”	077°49’30.3”	488	0.58	7.13	158	174	387	43.3	18.3	96	16.2	0.81	ND

Sahaspur 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 Sahaspur 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.

Table-5: Calculated WQI values of 8 drinking water sites of sahaspur 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	51-75	67.25	C	Poor
2.	S-2	0-25	21.56	A	Excellent
3.	S-3	0-25	14.56	A	Excellent
4.	S-4	26-50	39.47	B	Good
5.	S-5	0-25	18.58	A	Excellent
6.	S-6	50-75	60.39	C	Poor
7.	S-7	0-25	11.24	A	Excellent
8.	S-8	0-25	17.51	A	Excellent

Table- 6: Calculated WQI values of 8 drinking water sites of Sahaspur 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	17.25	A	Excellent
2.	S-2	0-25	08.65	A	Excellent
3.	S-3	0-25	09.21	A	Excellent
4.	S-4	0-25	13.42	A	Excellent
5.	S-5	0-25	07.37	A	Excellent
6.	S-6	0-25	14.25	A	Excellent
7.	S-7	0-25	07.45	A	Excellent
8.	S-8	0-25	10.89	A	Excellent

Under the present study suitability of drinking water sources of Sahaspur 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-1 site (Manaksidh), and S-6 site (Mohammad Nagar) (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.

4. Conclusion

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, one sites (Sailok Colony) was found with 'B' grade i.e. good water quality. However, two study sites (Manaksidh and Mohammad Nagar) were classified as 'C' grade and categorized under poor water quality which may be due to Hardness, Calcium, Magnesium and 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. 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.

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Conflict of Interest

The author declare that he has no conflict of interest.

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