Research Article

ANALYSIS OF WATER QUALITY OF DIVERSE SOURCES OF WATER IN DEHRADUN CITY

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ARTICLE INFO	ABSTRACT
	Water quality is the measure of physical, chemical and biological properties of water. Water quality depends upon the ecosystem, geology and human uses like industry pollution, water bodies as heat sink and disposal of sewage. Water is getting polluted with the rapidly increasing population, industries and agricultural water demand as well as due to scarcity so it is required to treat the water to get better quality of water for drinking and to find a solution to secure the existing resources. According to an estimate total water resources in India which can be utilised are 2112 mham including 69 mham surface water and 43m ham ground water. The current work deals with the analysis of water quality of different water sources in Dehradun city for which water samples were collected from various sources present from the entire city for analysis. The water samples were tested in laboratory for different water quality parameters as per IS 10500:2012 (Drinking Water Specifications) to determine the suitability in quality with regard to its potable use. The main outcome of this current study will lead to the finding of the exact quality of the sources present in diverse locations of the city.

INTRODUCTION

Water quality depends upon the rapid industrialization and urbanization leading to lower quality of water. For human consumption EPA (Environmental Protection Agency) has set some limits of the amount of contamination in drinking water. It has two standards: primary and secondary. Primary standard regulate substances that affect human health and secondary standard are those quality which affect taste, odour or turbidity. As in day to day life water is getting more and more polluted because of rapidly increasing population and the available water is also not fit for drinking purpose as it is highly polluted, so the treatment of water is pre-requisite. Water is made pure for end use purpose which includes-drinking, industrial water supply, irrigation and river flow. Treated water is more acceptable, as it removes undesirable components. In treatment the presence of inorganic substances in raw water poses a challenge for fresh water supply. Presence of bacteria is also undesirable as it is main source of infectious diseases.

The main sources of water are rain water, surface water, and underground water. In India monsoon is brief. We get about 100 hours of rain in an year. Water found in glaciers is not fit for drinking. If we collect rain water, we have to ensure that water is safe otherwise that water cannot be used for drinking purpose but it can be used for watering plant and cleaning purpose *(Gupta et al., December, 2016)*. Monitoring of drinking water is done by the standards set by Bureau of Indian Standards (BIS), which provides safe drinking water. It is required to test the drinking water sources time to time, to know the quality of water as per standards. If water is not meeting the standards of safe water then, it is necessary to know the amount of contamination. Ministry of Water Resources of India in 2005 has also set some safe water parameters. It comprises of different requirements for monitoring quality of water and set up of laboratory in a state or district so to provide safe water to consumer. Taste, odour, hardness, contamination are four of the most common reason why people install water treatment system. Water stored in this process is to be treated by number of processes such as screening, sedimentation, precipitation, flocculation and coagulation. All these methods are done to remove turbidity, odour, TDS, hardness of water and different type of harmful minerals like iron, zinc, manganese etc. An activated carbon filter removes organic matter and gases such as hydrogen sulphide. The degree of filtration depends upon the end use of water (*Seth et al., 2016*)

In Dehradun so many people use ground water for drinking and for other purposes. Thus it is required to check the ground water quality. Ground water comprises of biological, physical

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and chemical properties. There are mineral ions present in abundance in ground water. These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer. They are referred to as dissolved solids *(Madan et al., 2014, Rao et al., 2005)*. As an alternative source of water, rain water is the best option. Rain water that is captured and stored correctly is a safe economical and sustainable source of quality water. The cleanest water is always that which falls freely from the sky. The natural water cycle is very efficient in screening out contaminants that are naturally found in ground water and other sources. Rain water does not come in contact with soil, and so it does not contain contaminants such as harmful bacteria, dissolved salts, minerals or heavy metals *(Gupta et al., April, 2016)*

Study Area

Dehradun is a small city situated in Doon valley on the foothills of the Himalayas between the rivers- the Ganga on the east side and Yamuna on the west side. It is the capital of the northern state Uttarakhand. Dehradun is popularly called 'Rainy city of India' due to continuous and incessant rainfall especially in monsoon. There is a lot of temperature variation throughout the year ranging from 1º in winters to 40º in summers. The attractive landscape and milder climate of the city provides a nice getaway for the people *(Rajendra et al., 2012)*. The Fig. 1 shows the topographical map of Dehradun, it also shows where exactly Dehradun lies in India.

of water supply throughout the there are many Central and State Government Department functioning in this concern. Some of the water sectors working in Dehradun are- Uttarakhand Jal Sansthan(UJS), Uttarakhand Peyjal Sansadhan Vikas Evam Nirman Nigam(UPSVENN), Uttarakhand Environmental Protection and Pollution Control Board(UEPPCB), State Water Supply and Sanitation Mission, Swajal, etc. Some NGO's are also operating in Dehradun in assessing the water quality of Dehradun like People's Sciences Institute and SPECS.

METHODOLOGY

Firstly, map of Dehradun city was studied to select the locations of the sources of water so as to cover the whole city. All the populated and prime locations were considered in the process. 9 locations for the analysis of ground water and supply water and 4 locations of running water were selected for samples. Water samples were then collected from these sites in such a way that testing could be performed within 48 hours on them *(Indian Standard 3025, 1964)*.

Collection of Water Samples

For this study water is collected from three different types of sources:
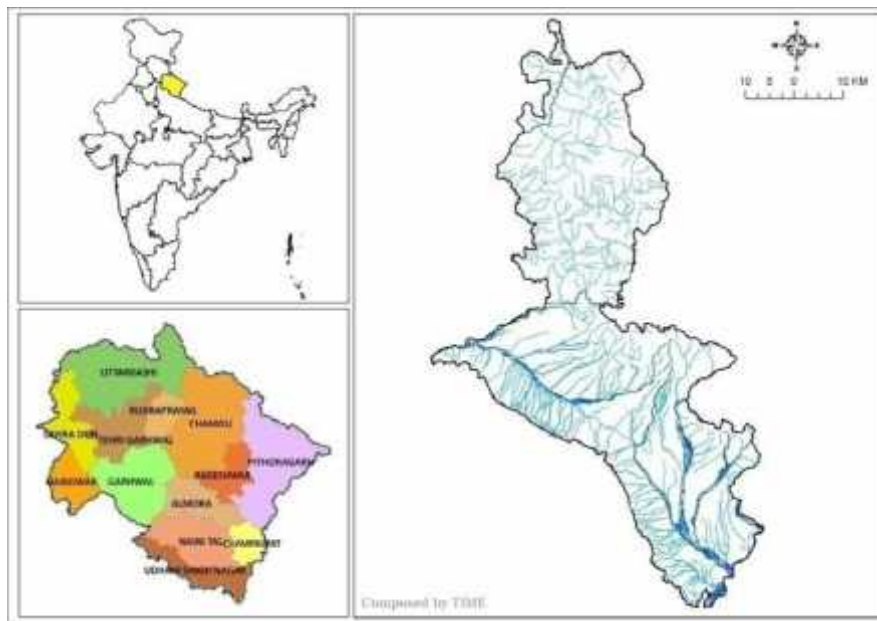
- GOV. supply(tap water)
- Private supply
- Rivers

Fig 1 Map of Dehradun

The tributaries of the two rivers-Asan and Song contribute as the main source of water for Dehradun. Asan River discharges its water into Yamuna and Song River to Ganga. Apart from these rivers some springs from Lesser Himalayas and Shiwalik Range also contribute as water source. Also dugwells, tubewells and handpumps draw water from shallow and deep aquifers. The water level in these sources is declining progressively due the ambiguity in monsoon in addition to drying of existing sources due to excessively hot weather in summers. Lesser rainfall also causes a lesser amount of recharge of ground water sources. To assess proper execution

In Gov. Supply, the initial source of water is rivers and ground water but that water is treated and then supplied to people for consumption. In private supply, the main source of water is ground water and there is no treatment of water so the quality is different from tap water. River water is another source of water as Dehradun is situated in a hilly region. This water is not treated and some people are directly consuming this water.

Testing of water samples

Each sample was tested for Total Alkalinity, Acidity, Total Dissolved Solids (TDS), Suspended Solids, Turbidity, Chloride

Sahastradhara   **Tapkeshwar**

Fig 2 Images of River sources

Conductivity meter   **pH Meter**

COD Analyser   **Turbidity Meter**

Fig 3 Images of instruments used

Content, Hardness, Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), pH Value. IS: 3025 was followed for the testing procedures for physio-chemical analysis. The values of total alkalinity, acidity, chloride content, hardness, dissolved oxygen and biological oxygen demand were obtained from simple titration using the required reagents and titrating solutions as per the property to be determined.

Turbidity, COD and pH value was determined with the help of turbidity meter, COD analyser and pH meter respectively. Total dissolved solids and suspended solids were calculated using the oven drying method *(Seth et al., 2016)*.

The obtained results were then analysed and compared with the Indian standard values given by IS 10500:2012 (Drinking Water Specifications) to determine the quality of water and its suitability for usage.

Permissible Limits According to is: 10500-2012

In the Indian Standards: 10500-2012 (Drinking Water Specifications) some limits are specified for each quality parameter so as to determine the quality of given water. The value obtained after performing the respective test should not exceed the acceptable limit for good quality of water. If there is no alternative source of water than the obtained value of test can reach up to permissible limit. As stated in the IS Code values in excess of those mentioned under 'acceptable' render the water not suitable, but still may be tolerated in the absence of an alternative source but up to the permissible limits. Above the permissible limit the sources are to be rejected. (2. IS10500, B. I. S.)

Table 1 Limits as per IS: 10500-2012

Test	Permissible limit	Acceptable limit
Total Alkalinity	600	200
Electrical Conductivity	2500 μmoh/cm	800 μmoh/cm
Dissolved Solid	2000	500
Chloride Content	1000	250
Hardness	600	300
Ph	No relaxation	6.5-8.6
Turbidity	10	5

Observations of Tests Conducted on Water Samples

In total there were 12 tests performed on 21 different water samples in order to analyze the water quality of Dehradun. The results are listed in the following tables:

The water quality for each region was further analysed according to each parameter to locate the places where treatment is required.

Total alkalinity

Total alkalinity of each location was found to be within the acceptable limit which deems the water of Dehradun region to be safe according to this parameter (Table 1-4).

Electrical conductivity

Electrical Conductivity of tap water of Niranjanpur, Rajpur Road, Kargi Chowk and Rispana was found to be above acceptable limit. Ground water of Niranjanpur and Kargi Chowk was found to be above acceptable limit. Electrical Conductivity of flowing water of Sahastradhara, Tapkeshwar, Robbers Cave was found to be above acceptable limit. Among these all samples lie below permissible limit and water of Sahastradhara is highly conductive (Table 1-4).

Total dissolved Solids

Total dissolved Solids in tap water of Niranjanpur, Rajpur Road, Kargi Chowk and Rispana was found to be above acceptable limit. Ground water of Niranjanpur and Kargi Chowk was found to be above acceptable limit. Total dissolved solids in flowing water of Sahastradhara, Tapkeshwar, Robbers Cave was found to be above acceptable limit.

Table 2 Government Supply (Tap Water)

Location	Clock Tower	Ballupur	Garhi Cant	Rajpur Road	Niranjanpur	Clement Town	Rispana	Kargi Chowk	Selaqui
Total Alkalinity (mg/l)	80	60	80	64	44	48	24	93	104
Electrical Conductivity (μmol/cm)	640.34	580.16	609.12	1247.95	1567.9	766.50	814.98	1444.26	374.43
Total Dissolved Solids (mg/l)	416.22	377.10	35.92	811.16	1019.13	498.23	529.73	938.76	243.37
Chloride Content (mg/l)	112	78	108	108	178	120	176	120	152
Turbidity (NTU)	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL
Suspended Solids (mg/l)	40	20	60	20	60	20	40	40	20
Acidity (mg/l)	18	32	12	12	24	28	16	28	20
Hardness (mg/l as CaCO$_3$)	552	484	476	512	548	272	488	994	168
Dissolved Oxygen	7.5	8.3	9	9.5	8.5	9.2	8	10.3	9.3
COD	10	28	38	30	40	27	26	24	36
BOD	2.5	3.1	3.6	3.2	4.3	2.2	1.8	3.4	1.8
pH Value	6.90	6.18	7.25	6.88	6.42	5.71	6.86	6.74	5.32

Table 3 Ground Water (PUMP)

Location	Clock tower	Ballupur	Garhi Cant	Niranjanpur	Clement Town	Rispana	Kargi Chowk	Selaqui
Total Alkalinity (mg/l)	98	24	114	65	52	44	76	96
Electrical Conductivity (μmol/Cm)	629.75	614.33	286.77	904.93	666.30	686.23	1071.25	350.27
Total Dissolved Solids(mg/l)	409.33	399.31	186.4	588.20	433.09	446.04	696.31	227.67
Chloride Content (mg/l)	136	96	96	154	124	100	176	178
Turbidity (NTU)	NIL	5	5	8	NIL	NIL	NIL	NIL
Suspended Solids(mg/l)	60	180	120	200	80	100	80	60
Acidity (mg/l)	20	36	16	12	20	24	36	24
Hardness(mg/l as CaCO$_3$)	528	488	308	436	256	496	648	152
Dissolved Oxygen	11	5.5	10	7.5	7.8	9.6	9	6.3
COD	52	12	19	23	37	44	18	27
BOD	2.3	2	4.3	2.5	2.1	4.3	3.5	2.1
pH Value	7.29	6.36	6.69	6.65	5.84	6.73	6.48	5.21

RESULT ANALYSIS AND CONCLUSION

Analysis of Diverse Sources of Water in the City

The following locations were found to be most suitable according to drinking water specifications:

Among these all samples lie below permissible limit and water of Sahastradhara has maximum concentration of dissolved solids (Table 1-4).

Table 4 Running Water (Rivers)

Location	Sahastradhara	Tapkeshwar	Robbers Cave	Galjwani
Total Alkalinity (mg/l)	64	80	80	84
Electrical Conductivity (µmol/Cm)	2009.52	1763.58	896.48	452.44
Total Dissolved Solids(mg/l)	1306.18	1146.32	582.71	294.08
Chloride Content (mg/l)	88	136	106	178
Turbidity (NTU)	16	18	14	16
Suspended Solids(mg/l)	220	180	200	220
Acidity (mg/l)	8	16	8	12
Hardness(mg/l as $CaCO_3$)	1048	576	388	348
Dissolved Oxygen	6.5	5	6.3	5.2
COD	12	40	30	24
BOD	4.5	1.9	2.5	2.3
pH Value	7.46	7.36	7.28	7.58

Table 5 Locations with best quality of water with respective parameter

Water Quality Parameters	Supply Water	Ground Water	River
Total Alkalinity	Rispana	Ballupur	Sahastradhara
Electrical Conductivity	Selaqui	Garhi Cant	Galjwani
Dissolved Solid	Selaqui	Garhi Cant	Galjwani
Chloride Content	Ballupur	Ballupur, Garhi Cant	Sahastradhara
Turbidity	All	All except Niranjanpur	Robbers Cave
Suspended Solids	Ballupur, Rajpur Road, Clement town, Selaqui	Selaqui, Clock Tower	Tapkeshwar
Acidity	Garhi Cant, Rajpur Road	Niranjanpur	Sahastradhara, Robbers cave
Hardness	Selaqui	Selaqui	Galjwani
Dissolved Oxygen	Kargi Chowk	Clock Tower	Sahastradhara
COD	Clock Tower	Ballupur	Sahastradhara
BOD	Rispina, Selaqui	Ballupur	Tapkeshwar
pH	Garhi Cant	Clock tower	Robbers Cave

Chloride Content

Chloride content of each sample was found to be within the acceptable limit which deems the water of Dehradun region to be safe according to this parameter (Table 1-4).

Turbidity

Turbidity of tap water of all location is found to be nil since the water is pre treated before supply. Ground water of Niranjanpur exceeds the acceptable limit of turbidity but is under permissible limit. All samples of river water exceed even the permissible limit of turbidity (Table 1-4).

Hardness

Hardness in tap water of Clock Tower, Ballupur, Garhi Cant, Rajpur Road, Niranjanpur, Rispana and Kargi Chowk was exceeding the acceptable limits. In ground water region of Clock Tower, Ballupur, Garhi Cant, Rajpur Road, Niranjanpur, Rispana and Kargi Chowk are exceeding acceptable limits. All samples of running water are exceeding acceptable limit of hardness given by IS Code (Table 1-4). Moreover the tap water and ground water of Kargi Chowk and running water of Sahastradhara region are exceeding the permissible limit of Hardness which creates the need of treatment of water in this region for this parameter.

pH

pH of tap water Ballupur, Niranjanpur, Clement town and Selaqui was found to be less than 6.5 i.e. the water is acidic in nature. Ground water of Ballupur, Clement Town, Kargi Chowk and Selaqui also lie towards the acidic region. pH of River water lies within the acceptable range (Table 1-4).

RESULTS

- Tap water of Niranjanpur, Rajpur Road, Kargi Chowk and Rispana has higher concentration of dissolved solids and electrical conductivity. Tap water of Ballupur exceeds the acceptable limit of hardness and pH. Clock tower and Garhi Cant's supply water is also hard. The tap water of Niranjanpur, Selaqui and Clement town was found to be acidic in nature and it exceeds the pH limits. (Table 1,2)
- Ground water of Niranjanpur and Kargi Chowk has higher concentration of dissolved solids and electrical conductivity. Also, ground water of Niranjanpur exceeds the acceptable limit of turbidity. All the water samples except for Clement town and Selaqui exceed the acceptable limits for hardness. Ground water of Ballupur, Clement Town, Kargi Chowk and Selaqui also lie towards the acidic region. (Table 1,3)
- River water of Sahastradhara, Tapkeshwar and Robbers Cave has higher concentration of dissolved solids and electrical conductivity. River water of all the considered locations is found to be highly turbid and hard as they exceed even the permissible limits in this parameter and thus needs to be treated before use. (Table 1,4)

CONCLUSIONS

- River water cannot be consumed directly and needs to be treated before use.
- The tap water as well as ground water of the Kargi Chowk exceeds the permissible limit of hardness and needs to be treated before use or an alternative source needs to be found. (Table 1-3)
- Ground water of Clement town, Garhi Cant, Kargi Chowk and Selaqui are exceeding the acceptable limit

of hardness but are okay to use according to all other parameters. Therefore these sources can become an alternative source for this region. (Table 3)

- The water of Dehradun region is hard water and is also a little bit acidic in nature at some places but apart from this the overall quality of water of Dehradun is good.

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