

Ground Water Quality Assessment & Hydroponics Cultivation

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Abstract- Groundwater serves as a primary drinking water source for the rapidly growing population of Uttarakhand, where both natural factors and anthropogenic activities contribute to the deterioration of water quality. This study evaluates the seasonal variation in drinking water quality in the central region of Dehradun over a seven-month period (January–July 2024), covering winter, summer, and rainy seasons. Five physicochemical parameters—Colour, Turbidity, Total Dissolved Solids (TDS), pH, and Total Hardness—were analyzed following BIS IS: 10500 (2015) standards. The Horton Water Quality Index (WQI) method was applied to interpret overall water quality. Results indicate that pH remained within desirable limits throughout the study, while turbidity exceeded the desirable limit of 1 NTU in all seasons but stayed below the permissible limit of 5 NTU, colour values were within acceptable limits except in July, when monsoon runoff increased the concentration to 7 Hazen. TDS remained below the desirable limit of 500 mg/L, with the highest concentration observed in July. Total hardness was low in January but exceeded desirable limits in April and July, though remaining under the permissible level of 600mg/L. Seasonal

WQI values ranged from 26.36 to 33.88 consistently placing the groundwater in the —Goodll (Grade B) category. High grade ground water is very promising for cultivation of hydroponics. Groundwater quality varies; deep sources are usually clean, but high salt content might require treatment (like reverse osmosis) before use in hydroponics Overall, despite minor exceedances in turbidity, colour, and hardness during the rainy and summer seasons, the groundwater of central Dehradun remains suitable for drinking purposes. Continuous monitoring is recommended to detect early signs of contamination and ensure long-term water safety.

Key words: Ground Water, TDS, WQI, Total hardness

Introduction

While hydroponics reduces freshwater demand, it still needs water, often from bore wells (groundwater) or municipal sources, but can be made sustainable by integrating rainwater harvesting, which provides naturally soft, chlorine-free water, minimizing reliance on groundwater and lowering costs, though groundwater quality (salinity) must be monitored for hydroponic use.

The concept of water quality is not particularly the purity of water, but it attribute to physical, chemical and biological analysis of water that determine its use for different purposes. The most common use of evaluation of the water quality is associated to the health of the human beings and safety of the ecosystem. For the survival every human on this earth need drinking water. Beside their good health may be directly affected by the quality of drinking water. The depletion in the quality and quantity of drinking water and their sources has become a problem in Uttarakhand^[2-4].

For the deterioration of drinking water quality, the contamination of drinking water sources is mainly responsible. Degradation of water quality of drinking water resources is caused by both geogenic as well as anthropogenic activities including hydrological activities, climate change, precipitation, agricultural runoff and sewage discharge^[5, 6]. Other factors responsible for contamination of water sources are open defecation, dumping of household wastes, road side construction and development of infrastructure. Besides, rapid growth of tourism industry, urbanization, industrialization and rapid growth of population of state also other important factors, which degrade drinking water sources. Moreover, awareness of local people, insufficient enforcement of laws and lack of continuous monitoring of water quality of water sources are other leading causes due to which drinking water quality is greatly being influenced. These water sources are also getting contaminated due to increased deforestation, weathering of rocks,

erosion, growing construction activities and other exogenic factors along with a very high number of tourists as floating population. Also turbidity is generally found high in water sources owing to high velocity of water from upstream to downstream, as a result of which dust, soil, rock particles get suspended into fast flowing water. Moreover, disposal of human and animal faeces containing bacterial, viral and protozoan, pathogens as well as helminthes parasites in hill areas may result into serious water borne diseases such as typhoid, cholera, dysentery, polio myelitis etc due to slop factors of mountains and hills. Therefore, this is a big challenge for the drinking water supply and maintenance agencies to provide good quality of drinking water for the public use. The water-retaining capacity of these underground water storage depends on geomorphology, hydrology, rock type, porosity and permeability of rocks and soil. These natural sub-surface waters are mainly a very rich source of minerals, calcium, magnesium, potassium, sulfur and iron^[7-9]. However, due to the increase in urbanization, Industrialization and tourism in Uttarakhand these water resources have been contaminated with both chemical and biological contaminants. Almost all the springs and water sources are contaminated with microbial contamination. The density of microbes increases at the springs or a natural water source when it is located near a village or in an area with extensive wildlife and animal populations.

Water Quality of Dehradun

Monitoring of water quality of drinking

water sources is therefore necessary to collect the information about existing status of water quality and source of contamination for the implementation of strategies by water management agencies to overcome the source of pollution and provide good quality water for the public use in future. Process of such water quality monitoring includes the continuous sampling, analyses and characterization of drinking water sources on regular time intervals.

Water Quality Index (WQI) is the most effective tool to analyse the water quality of the particular area and to produce information regarding water quality in the simplest form to the general community. The water quality data of Dehradun district has been established by the Central Ground Water Board (CGWB, 2013) in the study during 2007-2008 by observing 149 hand pumps, 9 dug wells, 23 springs and 4 exploratory wells. Water quality characteristics of these sources have been assessed by adopting pH, EC, carbonate, bicarbonate, chloride, total hardness, calcium and magnesium parameters. Most of the analyzed sources express the fresh water quality for domestic and irrigation purposes. Only some sources have high hardness, calcium or magnesium concentration than the desirable limits. Hand pump water at Maldevta location show high hardness, calcium and magnesium concentration as 485 mg/l, 104 mg/l and 55 mg/l, respectively. Spring water quality at Barlowganj has 400 mg/l total hardness and 63mg/l magnesium concentration^[10-12]. Water quality of two Sahastradhara springs has also revealed high hardness, calcium and

magnesium as 445 mg/l, 100 mg/l and 47 mg/l for first and 435 mg/l, 96 mg/l and 47 mg/l for second spring water sample. The ground water scenario of Uttarakhand expresses the deteriorated water quality of district due to high nitrate concentration (CGWB, 2010). According to survey of drinking water quality of India it was predicted that the drinking water resources of various districts in our country were contaminated due to the predominant concentrations of different ions or bacteria. For this study, water quality of 28 cities was assessed under CLEAN-India programme and output of the study showed the alarming condition of water. This study has also predicted the high degree of hardness in water sources of Dehradun district^[13-15].

Hydroponics is basically a contemporary method of horticulture or basically growing plants using farm produce, and the thing is without using soil. The method of hydroponics is nearly easy but it takes time to understand the method. In the method, crops are planted and grown on water. These crops are also found to be very efficient and filled with benefiting nutrients.

According to the scientist's plants in hydroponics method have direct connection to the roots in form of aqueous solvent instead of the soil. Hydroponics produce between three and ten times more food than conventional agriculture in the same space. The plants also grow in half the time. There is no need for herbicides or pesticides. While hydroponics reduces freshwater demand, it still needs water, often from bore wells (groundwater) or

municipal sources, but can be made sustainable by integrating rainwater harvesting, which provides naturally soft, chlorine-free water, minimizing reliance on groundwater and lowering costs, though groundwater quality (salinity) must be monitored for hydroponic use^(16,17).

Hydroponics and Groundwater

Source Dependency: Hydroponic systems need a consistent water supply, often sourced from groundwater via

bore wells, especially in large setups.

Water Quality- Ground water quality varies; deep sources are usually clean, but high salt content might require treatment (like reverse osmosis) before use in hydroponics.

Sustainability- Using groundwater heavily can lower water tables, creating environmental concerns, which rainwater harvesting helps mitigate⁽¹⁸⁾.



Figure-1 Hydroponics Cultivation

Study Area description- Dehradun district is situated in the north-western part of Uttarakhand state, extending from N Latitude $29^{\circ}56'39.33''$ to $30^{\circ}58'41.70''$ N and from E Longitude $77^{\circ}34'29.04''$ to $78^{\circ}18'41.21''$ E (GWBDDU, 2011). For this study, central region of Dehradun have been selected for sampling and monitoring of water quality for a period of 7 months i.e. from January to July of 2024 covering 3 seasons i.e. winter, summer and rainy. The selection criteria of drinking water source was based on information provided by Uttarakhand Jal Sansthan, Dehradun, which provided a piped drinking water supply to the study area. 3-3 samples of

drinking water have been collected in the months of January, April and July which covers winter, summer and rainy seasons respectively.

Adopted Methods- The Bureau of Indian Standard, 2015 has recommended Indian water quality standards for water quality parameters, to examine the water quality of water sources for the suitability of drinking purpose by describing their desirable and permissible limits. According to IS: 10500 (2015), desirable limits are the acceptable limits above which water is not suitable for drinking, but still may be used for drinking purpose up to permissible limits in the absence of

alternate drinking water sources^[19]. The protocols and adopted methods for analysis of 5 drinking water quality parameters including both physico-chemical adopted as per guidelines of Bureau of Indian Standard

{IS:10500(2015)} are given under **Table-1** for

- (a) on site analysed 2 parameters namely turbidity and pH and
- (b) laboratory analyzed parameters i.e. Colour, Total Hardness, TDS.

Table-1 Methodology Adopted and Instrumentation Technique used for Analysis

| S. No. | Water Quality Parameter | Type of Parameter | Adopted Methodology | Instrumental Technique Used | Protocol used |
|--------|-------------------------|-------------------|---|-----------------------------|----------------------|
| 1 | Colour | Physical | Spectrophotometric single wavelength method | UV-Vis Spectrophotometer | APHA24thEd. 2120 C |
| 2 | Turbidity | Physical | Nephelometric method | Nephelometer | BIS 3025Pt-10 (2015) |
| 3 | Total Dissolved solid | Physical | Gravimetric Method | TDS meter APHA | 24thEd. 2120-C |
| 4 | pH | Physical | Electrometric method | pHmeter | BIS 3025Pt-11 |
| 5 | Total Hardness | Chemical | EDTA Titration method | Volumetric titration | BIS 3025Pt-21 (2015) |

Procedure used for Analysis of Water Quality Parameters

Analysis of Colour

Water colour is an important visual indicator of water quality. It can be influenced by natural factors such as dissolved organic matter or human activities like industrial discharges or pollution. For the appearance of colour in drinking water, various factors are responsible such as turbidity, corrosion, algal bloom and suspended solid particles etc.

Unusual or significant changes in water colour can suggest the

presence of contaminants or pollutants. The Hazen color scale (APHA 24th Ed. 2120-C) was utilized to measure the color of analyzed drinking water samples using a UV-Visible spectrophotometer (Hach, USA; Model: DR-5000). The spectrophotometer was set to operate within a wavelength range of 450 – 465 nm, as recommended by APHA guidelines (2012). Specifically, the instrument was typically configured at a wavelength of 456 nm to establish standard curve. Prior to

analysis, the spectrophotometer was warmed up for 15 minutes, following the manufacturer's instructions^[20].

Analysis of Turbidity

The cloudiness of water, measured as turbidity, is a crucial parameter for assessing water quality. In the case of drinking water samples, turbidity was quantitatively measured using the Nephelometric method in Nephelo-metric Turbidity Units (NTU). This measurement was conducted using a Nephelometer (Model: Turbi Check; Make: Aqualytic, Germany) directly at the water source site.

The Nephelometric method (IS 3025 Pt-10-2006) quantifies turbidity by measuring the intensity of scattered light by the water sample. This is compared to the intensity of light scattered by a standard reference solution (Formazin) under identical experimental conditions. Higher intensity of scattered light indicates higher turbidity in the sample.

Before starting the analysis, the turbidity meter was allowed to warm up for approximately 15 minutes to stabilize. Calibration of the instrument was then performed using standard reference suspensions with turbidity levels of 1 NTU, 10 NTU, 100 NTU, and 1000 NTU.

Analysis of Total dissolved Solids

The Total Dissolved Solids (TDS) in drinking water samples were analyzed using the electrometric method (APHA 24th Ed. 2540-C) with a TDS meter (Make: Hach,

USA; Model: Sension-5) in a laboratory setting. The TDS meter was calibrated using a standard sodium chloride solution with a conductivity of 1000 $\mu\text{S}/\text{cm}$. Calibration ensures that the instrument provides accurate readings based on known standards. After calibration, the electrode of the TDS meter was rinsed thoroughly with de-mineralized water to remove any residues and wiped dry with tissue paper. To verify the accuracy of the TDS meter, it was cross-checked using the earlier standard solution. This step ensures that the instrument maintains its accuracy over time and between measurements.

Analysis of pH

The acidity or alkalinity of a drinking water sample, expressed as pH or negative logarithm of hydrogen ion concentration, is a critical characteristic that varies with naturally occurring minerals and biological activities. Typically, the pH of natural drinking water sources ranges from 5.0 to 9.0, reflecting important ecological characteristics of aquatic environments. The pH measurement (BIS 3025 Pt-11-2002) utilizes the electromotive force (EMF) of a cell containing two electrodes: a glass electrode (indicator electrode) to measure hydrogen ions in the sample, and a calomel electrode (reference electrode). These electrodes are in contact through a liquid junction, and the EMF of the cell is measured using a pH meter.

Analysis of Total Hardness

Total hardness of water indicates the presence of calcium and magnesium salts. To determine total hardness using the EDTA method (as per BIS 3025 Pt-212015), volumetric titration method was employed. Eriochrome Black T served as the complexometric indicator in the titration process. Initially blue in color, Eriochrome Black T turns red upon binding with calcium and magnesium ions to form complexes.

Determination of Water Quality Index

Water quality of analyzed drinking water sources is often summarized using a single number known as the Water Quality Index (WQI) [21]. The primary aim of WQI is to simplify complex water quality data and present it in a comprehensible form. In the current study, the Horton water quality index WQI method was employed to assess the water quality of drinking water sources in Dehradun. This method provides a score between 0 to 100, which reflects the quality of drinking water in terms of an index number. The higher the index number, the poorer the quality of drinking water.

Table-2 Water Quality Index Vs Water Quality Grade

| S. No. | WQI Values | Water Quality Grade | Water Quality Rating |
|--------|---------------|---------------------|----------------------|
| 1 | 0-25 | A | Excellent |
| 2 | 26-50 | B | Good |
| 3 | 51-75 | C | Average |
| 4 | 76-100 | D | Poor |
| 5 | 100 and above | E | Unsuitable to drink |

Table-3 Indian Standard for selecting Drinking Water parameters

| S. No. | Nature of Parameter | Water Quality parameters | Accepted Limit | Permissible Limit |
|--------|---------------------|--------------------------|----------------|-------------------|
| 1 | Physical | Colour | 5 hazen | 15 hazen |
| 2 | Physical | Turbidity | 1NTU | 5NTU |
| 3 | Physical | Total Dissolved Solids | 500 mg/l | 2000 mg/l |
| 4 | Physical | pH | 6.5-8.5 | 6.5-8.5 |
| 5 | Chemical | Total Hardness | 200 mg/l | 600 mg/l |

Result and Discussion

Water Quality Analysis of Drinking water

Water quality data of all 6 water quality parameters are described in **Table-4**. The overall description of water quality data is described under:-

Colour- The analytical data of colour is compiled in **Table-4**. The concentration of colour in water sample of January and April were under its desired limit i.e. 5 hazen while the sample of July month showed the maximum value for colour which was over the desired limit of 5 hazen but under the permitted limit i.e. 15 Hazen.

Turbidity- The variation in Turbidity is compiled in table. The turbidity for all months were well over its desired limit i.e. 1 NTU but were under the permitted limit of 5 NTU. The sample collected in the month of July showed the maximum turbidity value respectively.

High turbidity of water attributed the presence of suspended solid matter as clay, silt and organic solids etc. due to various geographical activities such as precipitation, weathering of rocks, soil erosion and growth of some phytoplankton and other microorganisms [22, 23].

Total Dissolved Solids (TDS)-The variation in TDS value is described in

Table 4. The result of analysis of data of TDS was found to well below desired limit i.e. 500 mg/l. It was also noticed that the sample collected in month of July had the maximum TDS value.

The Characteristics of TDS may be attributed to the influence of various natural activities, like leaching of minerals and percolation of water from rock minerals and soil, and Anthropogenic activities like waste dump water run-offs, agricultural field run-offs and industrial water dumping^[24].

pH-The pH of all analyzed water samples from January to July were found to be within the desired limit range of 6.5-8.5 as per BIS drinking water standards.

Total Hardness- The variation of total hardness in drinking water samples for period of 6 months are depicted in table. Result of drinking water quality showed that the total hardness for the month of January was under the desired limit of 200 mg/l while for the months of April and July, the total hardness values were above desired limit but lower than the permissible limit i.e. 600 mg/l as per BIS (2015) drinking water standards.

The characteristic values of Total hardness indicates of interaction (percolation) of water with minerals in soil and rocks and weathering impact as well as anthropogenic sources like industrial, agricultural, and untreated water run-off^[25, 26].

Table-4 Water Quality Data of central region of Dehradun during January to July 2024

| S. No. | Water Quality Parameters | Months of Sample Collection (2024) | | | As per IS10500-2015 | |
|--------|--------------------------|------------------------------------|-------|------|---------------------|-------------------|
| | | January | April | July | Acceptable Limit | Permissible Limit |
| 1 | Colour(Hazen) | 2 | 4 | 7 | 5 | 15 |
| 2 | Turbidity (NTU) | 1.51 | 1.87 | 2.83 | 1 | 5 |

| | | | | | | |
|---|---|------|------|------|---------|---------------|
| 3 | Total Dissolved Solids(mg/l) | 300 | 345 | 372 | 500 | 2000 |
| 4 | pH at25°C | 7.90 | 7.67 | 7.41 | 6.5-8.5 | No Relaxation |
| 5 | TotalHardness as CaCO ₃ (mg/l) | 125 | 246 | 298 | 200 | 600 |

Table-5 Calculated Water Quality Index with Grade and Rating

| Month | WQI | WQI Grade | WQI Rating |
|---------|-------|-----------|------------|
| January | 26.36 | B | Good |
| April | 27.89 | B | Good |
| July | 33.88 | B | Good |

Conclusion

The overall results of the research work carried for the time period of 7 months from January to July, 2024 have been tabulated.

Analysis of 5 Physico-chemical Water Quality Parameters under 2 categories such as

- (i) Physical Parameters
- (ii) Chemical Parameters for Drinking Water of central region of Dehradun as per IS:10500 (2012) have been covered.

From the result above, the conclusion can be made that the water quality analysis of central region of Dehradun, conducted over the months of January, April, and July 2024, reveals the following key points regarding the water quality parameters:

1. **pH Value:** The pH levels of the water samples were consistently within the desirable range of 6.5-8.5 as per BIS standards. This indicates that the water is neither too acidic nor too alkaline, which is ideal for drinking purposes.
2. **Turbidity:** The turbidity values were above the desirable limit of 1 NTU but remained below the permissible limit of

3 NTU for all sampled months. This suggests that while the water is somewhat turbid, it does not exceed acceptable levels, likely due to natural processes affecting particle suspension.

3. **Colour:** The colour of the water samples was well within the desirable limit of 5 Hazen in January and April months however, raised to 7 in the month of July.

This indicates that the water is clear and free from significant color contamination in January and April. In July due to heavy muddy rains water on ground the value might have got affected, which are the signs of some contamination.

4. **Total Dissolved Solids(TDS):** The TDS levels were above the desirable limit of 500 mg/L in all months but remained under the permissible limit of 2000 mg/L. While the levels were higher than ideal, they were still within an acceptable range for drinking water.
5. **Total Hardness:** Total hardness was under the desirable limit of 200 mg / L in January but exceeded this limit in April and July, although it remained below the permissible limit of 600 mg/L. This suggests that the water may have some

mineral content but is not excessively hard. The Water Quality Index (WQI) calculated for February, May, and July month indicated a rating of "Excellent" for all months. This reflects that, despite some parameters exceeding the desirable limits, the overall water quality remains within acceptable standards for drinking purposes.

In summary, the drinking water of central region of Dehradun, is generally of high quality with only minor issues that do not significantly compromise its safety or suitability for consumption. It can be useful for the hydroponics cultivation for sustainable agriculture and adopting this technique can increase food production.

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