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Advances in Bioresearch

## ORIGINAL ARTICLE

# A Case study of underground drinking water in the south-western part of Haryana

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**ABSTRACT**
*In India, (urban and rural areas), the main source of drinking water is groundwater. Additionally, it is a significant supplier of water for the industrial and agricultural sectors. Groundwater usage is expected to be roughly 50% of total water consumption. Water shortages have developed in many places of the world as a result of rising water demand over time. The issue of water contamination or pollution makes the situation worse. Due to poor water resource management and environmental deterioration, which has resulted in millions of people without access to safe water supplies, India is on the verge of a freshwater crisis. The aim of present study is to analyse the groundwater quality of four districts of Haryana state Haryana. According to previous research investigations, it is observed that the fluoride and nitrate contamination in the groundwater of these areas is so high as compared to other areas of the Haryana. In this case study, total 55 groundwater samples were collected i.e., 15 from Bhiwani, 15 from Hisar, 15 from Mahendergarh and 10 samples from Rewari. The highest fluoride and nitrate were analysed as 11 mg/l and 394.5 mg/l in Mahendergarh district respectively.*
***Keywords**: Groundwater; pollution; water shortage; water quality*

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## INTRODUCTION

By 2050, the world's population is projected to be more than 9.8 billion (29). It is anticipated that the rapid population growth will have concomitant effects, such as increasing demand for food, water, and other essentials. As a result, the agricultural sector will be under more pressure to produce more food, putting further strain on resources like water and fuels (2). Agriculture uses almost 70% of the world's available freshwater (1). In every region, groundwater is a crucial component of the hydrologic cycle (9). It occurs in permeable geologic formations known as aquifers and is a valuable renewable resource for human life and economic growth. Groundwater resources have experienced tremendous development over the past few years. Nevertheless, despite its enormous relevance and expansion, groundwater irrigation is on the verge of a crisis and requires immediate attention and comprehension, especially in peri-urban agricultural contexts with competing demands for groundwater for public supply and irrigation. Groundwater resources are needed by 2.5 billion people worldwide, a sustainable groundwater supply is one of the most pressing challenges (7), (20). However, due to several anthropogenic and natural factors, groundwater supply and quality are always changing (19). According to a study, high levels of fluoride in groundwater primarily result from the interaction of meteoric water and surface runoff with fluoride-bearing minerals. As a result, its origin is primarily geogenic (12).
In nations like India, where the bulk of the population lives in villages with sparse infrastructure and inadequate sanitary facilities, the idea of clean drinking water gains increased significance (6). In this assessment, the drinking water quality in rural areas of northern Rajasthan, India, is briefly discussed. Although fluoride is an ongoing issue with the local groundwater in this area, other manmade pollutants

have lately been found there as well. According to recent case studies, the Bureau of Indian Standards' maximum allowable limit for fluoride in groundwater is exceeded at roughly 95% of the sites in this region. Nitrate pollution has emerged as yet another anthropogenic perk for portions of this region's intensively arable rural population (21). Another problem with unfit drinking water sources in the state's rural areas is biological contamination (16). Numerous dangerous bacteria, particularly those from the Enterobacteriaceae family, have been found in local drinking water sources, according to recent investigations. Overall, the area's drinking water does not meet safety standards, and much more work needs to be done before a safe drinking water supply scheme can be established.

The groundwater crisis was brought on by human activity rather than by natural causes. Due to an increase in extraction during the past 20 years, the water level has been quickly declining in numerous regions of the nation. Along with a rapid change in lifestyle, the number of wells being dug for irrigation of both food and cash crops has increased the residential demand for water. The amount of water needed by the sector is likewise rising overall. The groundwater table is falling as a result of an intense battle among consumers in the agricultural, industrial, and household sectors. Because of the widespread pollution of surface water, the quality of the subterranean is being negatively impacted (15). In addition, leachate from improperly disposed of solid wastes and discharge of untreated wastewater through bores both contaminate groundwater and lower the quality of freshwater supplies (19). Proper and strict implementation of government policies, spreading awareness among the society are the
ways by using which the issue of groundwater pollution can be mitigated. The current study will provide the actual groundwater data to the stakeholders, policymakers and government agencies to take appropriate steps to eliminate the groundwater pollution in the selected areas of the state.

## MATERIAL AND METHODS

Groundwater samples were collected on January 7, 2023, from Mahendergarh and Rewari, January 8, 2023, from Bhiwani and Hisar areas. 15 groundwater samples were collected from different villages of the districts Mahendergarh, Bhiwani, and Hisar. 10 samples were collected from different villages of district Rewari.

To measure the Physico-chemical quality of groundwater at the village level, samples were taken from wells, hand pumps, and tube wells.

Pre-cleaned, sterilized polyethylene bottles with 1.0-liter capacities were used to collect samples. Before taking the sample, the hand pump was run for 4-5 minutes to remove all of the water that was in the pipes. In an icebox, the samples were stored.

### Physicochemical analysis

Within seven days, the entire Physico-chemical analysis of the water samples that were collected was finished. Throughout the examination, double distilled water was utilized to clean all the glassware and fulfil other requirements. The Physico-chemical parameters and methods used for analysis are mentioned in the table 2.

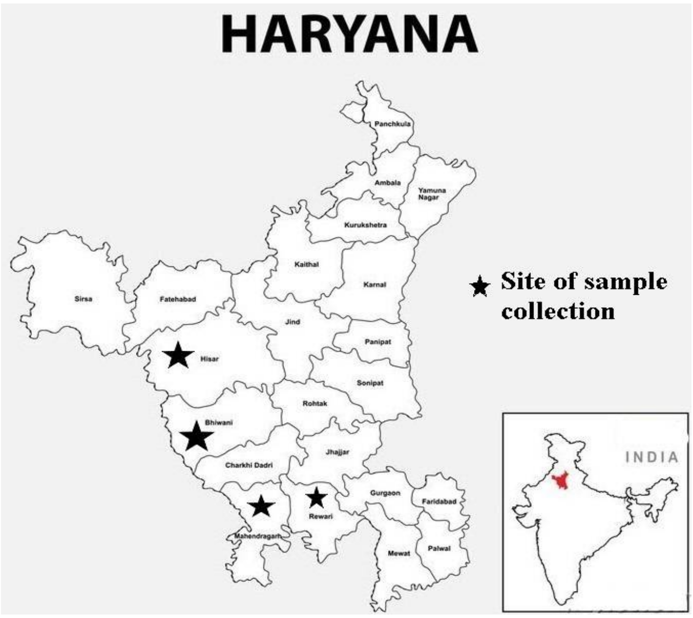


**Fig. 1 The cities of Haryana from where groundwater samples collected**

 

**Table 1: Groundwater sampling locations of Bhiwani, Hisar, Mahendergarh and Rewari district**

| District | Sample No. | Sampling Location |
|---|---|---|
| **Bhiwani** | 1. | Krishna colony |
| | 2. | Circle road |
| | 3. | Hansi gate |
| | 4. | Naya bazaar |
| | 5. | Ghanta Ghar |
| | 6. | Adarsh Nagar |
| | 7. | Old housing board |
| | 8. | HUDA sector 13 |
| | 9. | Agrasen Chowk |
| | 10. | Patel Nagar |
| | 11. | Baptist school |
| | 12. | Vijay Nagar |
| | 13. | BTM mill |
| | 14. | Anaj mandi |
| | 15. | TIT colony |
| **Hisar** | 1 | Lahoria chowk |
| | 2 | Housing board |
| | 3 | HUDA Sector 14 |
| | 4 | Barwala road |
| | 5 | Auto market |
| | 6 | Tilak market |
| | 7 | Bus Stand |
| | 8 | Rishi Nagar |
| | 9 | Nagori gate |
| | 10 | D.N. collage road |
| | 11 | Parijat Chowk |
| | 12 | Bishnoi market |
| | 13 | Pandav chowk |
| | 14 | Railway station |
| | 15 | Sabji mandi chowk |
| **Mahendergarh** | 1 | Raghunath Pura |
| | 2 | Rewari road |
| | 3 | Keshav Nagar |
| | 4 | Adarsh Nagar |
| | 5 | Kojinda |
| | 6 | Bus Stand |
| | 7 | Moti Nagar |
| | 8 | Daya Nagar |
| | 9 | Singhana road |
| | 10 | Nasibpur |
| | 11 | Purani mandi |
| | 12 | Jal Mahal |
| | 13 | Purani mandi road |
| | 14 | Ieedgaah colony |
| | 15 | Stadium |
| **Rewari** | 1 | Bawal road |
| | 2 | HUDA Sector 14 |
| | 3 | Bus Stand |
| | 4 | Railway station |
| | 5 | Naiwali chowk |
| | 6 | Brass market |
| | 7 | Kirti Nagar |
| | 8 | Delhi road |
| | 9 | Patal Nagar |
| | 10 | HUDA sector 1 |

 

**Table 2: Different methods used for the analysis of collected water samples**

| Name of Parameter | Method used |
|---|---|
| pH | IS 3025, Part-11 |
| Electrical conductivity | IS 3025, Part-14 |
| Total dissolved solids/salts | IS 3025, Part- 16 |
| Total alkalinity | IS 3025, Part- 23 |
| Total hardness | IS 3025, Part-21 |
| Calcium | IS 3025, Part-40 |
| Chloride | IS 3025, Part-32 |
| Sulphate | IS 3025, Part-24 |
| Nitrate | IS 3025, Part-34 |
| Sodium | IS 3025, Part-45 |
| Potassium | IS 3025, Part-45 |
| Phosphate | IS 3025, Part-31 |
| Fluoride | IS 3025, Part-60 |
| Magnesium | IS 3025, Part-46 |
| Carbonates | IS 3025, Part-51 |
| Bicarbonates | IS 3025, Part-51 |

## RESULTS AND DISCUSSION

All samples have a pH between 6.5 and 8.8, with a mean of 7.7. Even though pH doesn't directly affect human health, it does have close relationships with a few other chemical components of water. All biological processes are sensitive to pH changes. The pH value of 7.0 is thought to be optimal and ideal for most reactions as well as for people.

EC values represent the overall number of dissolved salts, which in turn represents the amount of inorganic contamination in the water (25). The EC values varied greatly between samples taken from the same village as well as samples taken from separate villages. According to Table 3, the EC of drinking water ranged from 0.171 µS (Bhiwani) to 7.538 µS (Rewari) (Table 6). High salinity and high mineral content in the water samples may be responsible for the increased EC. TDS also reveals how salt affects the behaviour of groundwater. The TDS levels in the drinking water ranged from 120 ppm (Narnaul) to 4940 ppm (Rewari), as shown in Tables (5) and (6) respectively. The WHO states that 500 ppm of TDS is the permitted level in groundwater for home use.

From a household standpoint, the total hardness (TH) of subsurface water is a crucial characteristic. Hardness in groundwater is mostly caused by carbonates, bicarbonates, sulphates, and calcium and magnesium chlorides. From 132 mg/l (Narnaul) to 1767 mg/l (Rewari), the values of TH were recorded. Total Hardness (measured as $CaCO_3$) must not exceed 200 mg/l but may be increased to 600 mg/l if no other water source is available. The total hardness of the 8 investigated water samples is less than 200 mg / l, the total hardness of the 17 other water samples is between 200 and 600 mg / l, and the total hardness of the 30 other water samples is greater than 600 mg / l. According to Total Hardness, water is categorized by Durfor and Becker (1964) as gentle, moderately hard, hard, and very hard (17). This rating places 8 water samples in the moderately hard category, 17 in the hard category, and 30 in the very hard category.

Magnesium and calcium are crucial components of overall hardness. For domestic use, the permitted limits for calcium and magnesium are 75 and 30 mg / l, respectively. Calcium concentrations in the research range from 43.5 mg/l (Bhiwani) to 791 mg / l. (Rewari). The calcium level of 41 water samples is more than the permissible limit whereas it is below acceptable limits in 14 water samples.

Alkalinity in groundwater is mostly brought on by OH-, $\mathbf{CO_3^{2-}}$, and HCO3-. The examined water samples' total alkalinity ranges from 29.2 mg/l (Bhiwani) to 690 mg / l. (Hisar). The 200 mg/l WHO recommended limit for alkalinity may be increased to 600 mg/l in the absence of an alternative water supply. The data revealed that 1 water sample had total alkalinity (TA) that was more than the permitted level while 54 water samples had TA within the range of the WHO-approved standard. $\mathbf{CO_3^{2-}}$ was essentially nil. Carbonate concentrations range from 27.50 mg/l in Bhiwani to 637 mg/l in Hisar.

Cl- is a significant inorganic component of the water that has the potential to seriously impair the quality of drinking water. In all types of natural water, chloride is present. In India, conditions may further lower the maximum allowed amount of chloride in drinking water to 1000 mg/l. It ranges from 34 mg/l (Narnaul) to 1408 mg/l (Hisar). Out of 50 analysed water samples, 25 had low chloride concentration that was below the allowed limit, 28 had chloride content that was between 200 and 1000 mg / l, and 2 had greater chloride content than the permissible limit.

From an agricultural perspective, phosphorus is a crucial component. It enters groundwater through both natural and artificial processes. It is produced naturally and in anthropogenic operations by the leaching of phosphate fertilizer. The maximum amount of phosphate that can be present in drinking water is 10 mg /l. The concentration of phosphate in the water samples under study ranges from 0.117 mg/l (Rewari) to 0.985 mg/l (Narnaul). All 55 examined water samples have phosphate contents that are within the range of the allowable limit.

Groundwater naturally contains sodium and potassium ions, but it also contains additional ions from home and industrial wastes. WHO states that water with a $Na^+$ content of more than 50 mg /l is unfit for home use and poses a number of health risks. In the groundwater samples under the study area, sodium concentration ranges from 45 mg/l (Narnaul) to 394.5 mg/l (Narnaul). While the Sodium concentration of 53 water samples exceeds the allowable limit and 2 water samples have less than 50 mg/l.

Most frequently, natural water contains $SO_4^{2-}$. The range of sulphate content was 9.5 mg/l (Bhiwani) to 362 mg/l (Rewari). The WHO recommends a sulphate concentration of 150 mg/l for household and drinking water. 28 water samples are greater than the allowed limit whereas 27 water samples fall within the range.

Ions of fluoride in water systems have two purposes. Dental fluorosis is brought on by fluoride levels that are too high. Dental caries develops when the concentration is less than 0.6 mg/L (12). Therefore, it is crucial to keep the fluoride concentration in drinking water between 0.6 and 1.2 mg/L. Fluoride levels in the examined groundwater samples range from 0.59 mg/l (Hisar) to 11 mg /l (Narnaul).

Each state's subsurface water level is evaluated every five years by the CGWB (Central Ground Water Board) in coordination with the state governments. In Haryana, a similar exercise wasn't conducted since 2013. 64 of the 119 blocks that were evaluated at that time—representing 21 districts—were discovered to be "over-exploited" or "dark zones."

The entire exercise was repeated in 2017 in 22 districts and it was discovered that 78 of the state's 128 blocks were "over-exploited," adding 12 additional "black zones" compared to 2013 (13).

The worst-affected districts are Faridabad, Gurugram, Mahendragarh, Bhiwani, Dadri, Palwal, Mewat, Kurukshetra, Kaithal, Panipat, and Sirsa. Every year, the water level in these locations has decreased by one meter. If more than 100% of the underground water is being pumped out of a zone, it is said to be "over-exploited." In 19 of the 22 districts, the subsurface water level has dropped by 20–60 meters, with south Haryana and areas around the GT Road belt experiencing the biggest drops. Three districts in the state, though, have seen constant or rising groundwater levels. Waterlogging has occurred in Rohtak, Sonipat, and Jhajjar districts as well as some Jind blocks as a result of an overabundance of canal waters and salinity in the groundwater. The state's significant paddy growing can be blamed for the declining groundwater level in Haryana. Around 1.92 lakh hectares of land were being used for paddy cultivation when Haryana was created as a distinct state; this number increased to 14.22 lakh hectares last year, a seven-fold increase in just 50 years.

The state government has also suspended the new tube-well connections in the over-exploited zones in light of the growing number of "dark zones." Although the government continues to provide tube-well connections for drip and micro irrigation in these regions despite rejecting more than 44,000 of these applications (13), Haryana's total water requirement is 20-million-acre-feet (MAF). The Yamuna River and Bhakra systems provide the state with about 2.3 MAF of water, while 12 MAF of water is extracted using 8.47 lakh tube wells and roughly the same number of diesel pumps. The state still has a 5.7 MAF water shortfall every year (11).

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$NO_3$(mg/l)** | 3.6 | 4.9 | 3.2 | 2.7 | 12.9 | 5.8 | 6.3 | 3.9 | 13.6 | 9.1 | 3.5 | 4.2 | 2.7 | 12.9 | 3.0 |
| **$SO_4^{2-}$(mg/l)** | 192.2 | 301.3 | 129.2 | 164.4 | 96.6 | 112.3 | 280.3 | 73.2 | 167.1 | 213.9 | 53.03 | 9.5 | 46.7 | 56.8 | 269.7 |
| **$F^-$(mg/l)** | 1.3 | 3.5 | 6.9 | 10 | 1.1 | 10 | 6.9 | 5.5 | 6.3 | 10 | 2.1 | 0.6 | 0.8 | 0.9 | 1.3 |
| **$K^+$(mg/l)** | 113.1 | 73.1 | 81.9 | 115.9 | 91.1 | 83.6 | 78.3 | 144.3 | 80.9 | 92.9 | 81.9 | 44.7 | 79.5 | 49.8 | 71.9 |
| **$Na^+$(mg/l)** | 218.5 | 108.1 | 156.4 | 285.2 | 133.4 | 110.4 | 82.8 | 195.9 | 103.5 | 128.5 | 50.6 | 69 | 87.4 | 55.2 | 78.2 |
| **$PO_4^{3-}$(mg/l)** | 0.303 | 0.543 | 0.790 | 0.536 | 0.867 | 0.270 | 0.598 | 0.972 | 0.112 | 0.438 | 0.365 | 0.827 | 0.602 | 0.523 | 0.239 |
| **$Cl^-$(mg/l)** | 440.20 | 417.48 | 710 | 220.1 | 262.7 | 142 | 117.86 | 78.68 | 103.66 | 150.52 | 36.92 | 61.07 | 66.74 | 56.80 | 45.44 |
| **$HCO_3^{2-}$ (mg/l)** | 27.50 | 97.61 | 136.64 | 68.32 | 112.24 | 97.60 | 58.56 | 87.84 | 63.44 | 112.23 | 39.04 | 29.28 | 39.04 | 58.56 | 39.04 |
| **$CO_3^{2-}$(mg/l)** | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| **TA (mg/l)** | 29.2 | 96 | 134.4 | 67.2 | 110.4 | 96 | 57.6 | 86.4 | 62.4 | 110.4 | 38.4 | 29 | 38.4 | 57.6 | 38.4 |
| **$Mg^{2+}$(mg/l)** | 372.83 | 304.2 | 383.08 | 290.84 | 217.16 | 326.47 | 319.7 | 156.64 | 206.91 | 120.04 | 78.56 | 76.12 | 171.28 | 190.80 | 150.79 |
| **$Ca^{2+}$(mg/l)** | 148.5 | 281.1 | 315 | 131.8 | 272.5 | 284 | 44.5 | 51.5 | 261 | 43.5 | 52 | 35.5 | 59.5 | 68 | 58.2 |
| **TH (mg/l)** | 762 | 781 | 945 | 609 | 625 | 824 | 567 | 305 | 605 | 247 | 181 | 162 | 343 | 387 | 309 |
| **TDS (mg/l)** | 887 | 1731 | 2448 | 1285 | 1287 | 1245 | 887 | 889 | 647 | 483 | 615 | 362 | 483 | 781 | 759 |
| **EC (µS/Cm)** | 1.348 | 1.721 | 2.740 | 1.358 | 1.289 | 1.037 | 0.745 | 0.847 | 0.889 | 1.229 | 0.364 | 0.171 | 0.331 | 0.374 | 0.326 |
| **pH** | 6.5 | 7.8 | 7.3 | 7.5 | 7.3 | 7.6 | 7.7 | 7.8 | 8.1 | 8.2 | 7.8 | 7.5 | 7.3 | 7.4 | 7.1 |
| **Village/ Town** | **Krishna colony** | **Circular road** | **Hansi gate** | **Naya bazaar** | **Ghanta Ghar** | **Adarsh Nagar** | **Old housing board** | **HUDA sector 13** | **Agrasen Chowk** | **Patel Nagar** | **Baptist school** | **Vijay Nagar** | **BTM mill** | **Anaj mandi** | **TIT colony** |

**Table 3: Physio-chemical analysis of groundwater collected in different locations of Bhiwani city**

**Table 4: Physio-chemical analysis of groundwater collected in different locations of Hisar City**

| Village/Town | pH | EC (μS/Cm) | TDS (mg/l) | TH (mg/l) | $Ca^{2+}$(mg/l) | $Mg^{2+}$(mg/l) | TA (mg/l) | $CO_3^{2-}$(mg/l) | $HCO_3^{2-}$(mg/l) | $Cl^-$(mg/l) | $PO_4^{3-}$(mg/l) | $Na^+$(mg/l) | $K^+$(mg/l) | $F^-$(mg/l) | $SO_4^{2-}$(mg/l) | $NO_3$(mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lahoria chowk | 7.6 | 1.90 | 560 | 800 | 188.8 | 372.83 | 324 | ND | 395.28 | 392.44 | 0.197 | 64.4 | 85.8 | 2.8 | 121.3 | 8.41 |
| Housing Board | 7.6 | 1.44 | 320 | 460 | 51.2 | 249.3 | 312 | ND | 380.64 | 142.0 | 0.365 | 128.8 | 78 | 0.59 | 95.7 | 8.43 |
| HUDA Sector 14 | 7.5 | 1.23 | 320 | 532 | 99.3 | 264 | 390 | ND | 475.8 | 116.44 | 0.869 | 89.7 | 54.9 | 1.8 | 75.1 | 7.7 |
| Barwala road | 6.5 | 2.66 | 1560 | 840 | 216 | 380.64 | 456 | ND | 556.32 | 360.68 | 0.525 | 209.3 | 141.8 | 2.4 | 83.1 | 6.14 |
| Auto market | 7.8 | 1.60 | 720 | 800 | 176 | 380.64 | 480 | ND | 585.64 | 241.4 | 0.663 | 46 | 107.6 | 2.1 | 72.4 | 4.12 |
| Tilak market | 7.6 | 2.54 | 1560 | 960 | 320 | 390.40 | 396 | ND | 637 | 471.44 | 0.966 | 193.4 | 159.4 | 1.4 | 254.2 | 5.22 |
| Bus Stand | 8.6 | 2.35 | 1480 | 980 | 275.3 | 429.40 | 462 | ND | 629 | 418.9 | 0.953 | 193.4 | 190.2 | 1.6 | 197.6 | 3.21 |
| Rishi Nagar | 7.3 | 5.32 | 3400 | 1380 | 528 | 519.72 | 414 | ND | 505.08 | 149.10 | 0.324 | 326.6 | 46.8 | 2.1 | 354.3 | 2.96 |
| Nagori gate | 7.6 | 5.26 | 3790 | 1488 | 507.2 | 598.28 | 378 | ND | 461.16 | 1408 | 0.292 | 296.7 | 198.5 | 10 | 187.9 | 4.61 |
| DN college road | 7.7 | 4.96 | 3240 | 1320 | 496 | 502.64 | 690 | ND | 641.8 | 923.0 | 0.332 | 181.9 | 62.4 | 1.4 | 157.9 | 5.12 |
| Parijat Chowk | 7.7 | 5.45 | 3880 | 1240 | 456 | 478.24 | 372 | ND | 453.84 | 995.42 | 0.177 | 308.2 | 105.3 | 2.5 | 249.5 | 12.2 |
| Bishnoi market | 7.8 | 5.58 | 3850 | 1280 | 456 | 502.64 | 516 | ND | 629.52 | 1008.2 | 0.173 | 197.8 | 117 | 2.5 | 215.7 | 7.98 |
| Pandav chowk | 7.8 | 3.30 | 2560 | 1288 | 472 | 497.76 | 390 | ND | 475.8 | 525.4 | 0.900 | 92 | 72.4 | 3.1 | 214.1 | 8.55 |

| | |
|---|---|
| 10.4 | 7.16 |
| 259.6 | 314.5 |
| 3.5 | 2.6 |
| 101.4 | 198.7 |
| 273.7 | 248.4 |
| 0.933 | 0.650 |
| 306.7 | 468.6 |
| 468.5 | 549.2 |
| ND | ND |
| 384 | 338 |
| 331.84 | 495.32 |
| 136 | 512 |
| 680 | 1324 |
| 880 | 1480 |
| 2,46 | 2.86 |
| 7.7 | 7.6 |
| **Railway station** | **Sabji mandi Chowk** |

**Table 5: Physio-chemical analysis of groundwater collected in different locations of in Mahendergarh**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **$NO_3$(mg/l)** | 4.4 | 2.4 | 6.3 | 8.6 | 4.7 | 6.9 | 7 | 11.2 | 8.8 |
| **$SO_4^{2-}$(mg/l)** | 74.17 | 59.61 | 59.80 | 48.15 | 78.44 | 66.40 | 314.7 | 41.55 | 65.63 |
| **$F^-$(mg/l)** | 8.2 | 9.28 | 10 | 8.5 | 10 | 8.2 | 10 | 10 | 10 |
| **$K^+$(mg/l)** | 113.1 | 73.1 | 58.5 | 93.6 | 59 | 120.9 | 144.3 | 109.2 | 241.8 |
| **$Na^+$(mg/l)** | 271.4 | 170.2 | 147.2 | 45 | 131.1 | 250.7 | 213.9 | 138 | 292 |
| **$PO_4^{3-}$(mg/l)** | 0.635 | 0.255 | 0.729 | 0.515 | 0.985 | 0.148 | 0.319 | 0.669 | 0.316 |
| **$Cl^-$(mg/l)** | 227.2 | 127.8 | 103.66 | 34 | 52.54 | 193.12 | 360.68 | 65.32 | 102.24 |
| **$HCO_3^{2-}$(mg/l)** | 112.3 | 100 | 168.7 | 110.9 | 151.6 | 138.1 | 167.8 | 119.2 | 158.4 |
| **$CO_3^{2-}$(mg/l)** | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| **TA (mg/l)** | 68 | 60 | 112 | 68 | 104 | 92 | 112 | 84 | 128 |
| **$Mg^{2+}$(mg/l)** | 220.08 | 116.63 | 51.24 | 65.88 | 41.96 | 100 | 523.13 | 43.43 | 84.91 |
| **$Ca^{2+}$(mg/l)** | 107.2 | 100.8 | 80 | 56 | 59.2 | 56 | 78.4 | 60.8 | 108.8 |
| **TH (mg/l)** | 468 | 292 | 164 | 177 | 210 | 220 | 936 | 132 | 248 |
| **TDS (mg/l)** | 920 | 120 | 1360 | 200 | 880 | 1400 | 2880 | 1080 | 160 |
| **EC (µS/Cm)** | 1.095 | 0.895 | 1.635 | 0.198 | 1.338 | 1.834 | 4.383 | 1.438 | 1.584 |
| **pH** | 8.4 | 8.1 | 8.7 | 7.2 | 7.3 | 8.8 | 7.9 | 8.7 | 7.3 |
| **Village/Town** | **Raghunath Pura** | **Rewari road** | **Keshav Nagar** | **Adarsh Nagar** | **Kojinda** | **Bus Stand** | **Moti Nagar** | **Daya Nagar** | **Singhana road** |

| | | | | | |
|---|---|---|---|---|---|
| 8.6 | 8.3 | 14.2 | 6.7 | 7.3 | 10.9 |
| 53.59 | 136.8 | 329.7 | 67.57 | 106 | 291 |
| 11 | 7.97 | 10 | 3.6 | 10 | 10 |
| 217.1 | 242.5 | 253 | 117.6 | 205.1 | 250.9 |
| 257.6 | 363.4 | 394.5 | 87.4 | 255 | 358.4 |
| 0.283 | 0.572 | 0.257 | 0.957 | 0.565 | 0.287 |
| 130.64 | 312.4 | 286.84 | 228.62 | 539.6 | 45.44 |
| 139.5 | 103.6 | 158.8 | 269.3 | 143.2 | 267.8 |
| ND | ND | ND | ND | ND | ND |
| 72 | 53.5 | 108.7 | 173.7 | 74.3 | 175 |
| 117.6 | 82.96 | 456.28 | 36.11 | 473.8 | 139.65 |
| 139.2 | 272 | 232 | 68.8 | 312 | 179.2 |
| 332 | 408 | 980 | 137 | 1088 | 408 |
| 1040 | 1080 | 352 | 880 | 1920 | 4080 |
| 1.412 | 1.509 | 5.075 | 1.265 | 2.042 | 5.046 |
| 8.7 | 8.5 | 8.1 | 7.5 | 8.3 | 8.1 |
| **Nasibpur road** | **Purani mandi** | **Jal Mahal** | **Mandi road** | **Ieedgah colony** | **Stadium** |

**Table 6: Showing physio-chemical results of different locations in Rewari City**

| | | | | | |
|---|---|---|---|---|---|
| **$NO_3$ (mg/l)** | 6.1 | 8.4 | 7.2 | 8.8 | 8.1 |
| **$SO_4^{2-}$ mg/l)** | 52.62 | 213.2 | 198.8 | 279.4 | 160.3 |
| **$F^-$(mg/l)** | 1.8 | 1 | 2.2 | 4.2 | 2.1 |
| **$K^+$ (mg/l)** | 93.6 | 136.8 | 136.5 | 144.3 | 136.5 |
| **$Na^+$ (mg/l)** | 66.7 | 193.2 | 266.8 | 218.7 | 207 |
| **$PO_4^{3-}$(mg/l)** | 0.969 | 0.257 | 0.871 | 0.117 | 0.662 |
| **$Cl^-$(mg/l)** | 183.4 | 287.5 | 171.9 | 323.6 | 233.6 |
| **$HCO_3^{2-}$(mg/l)** | 175.2 | 140.7 | 165.8 | 129.6 | 187.8 |
| **$CO_3^{2-}$(mg/l)** | ND | ND | ND | ND | ND |
| **TA (mg/l)** | 160.8 | 122.3 | 153.2 | 112.8 | 170.3 |
| **$Mg^{2+}$(mg/l)** | 60.51 | 185.92 | 129.32 | 608.04 | 100.04 |
| **$Ca^{2+}$(mg/l)** | 740.8 | 375.2 | 768 | 755.2 | 656 |
| **TH (mg/l)** | 840 | 680 | 980 | 1767 | 820 |
| **TDS mg/l)** | 1640 | 4760 | 1800 | 4940 | 3300 |
| **EC μS/Cm)** | 0.652 | 1.616 | 3.012 | 6.677 | 2.230 |
| **pH** | 7.7 | 7.8 | 7.2 | 7.4 | 7.6 |
| **Village/Town** | **Bawal road** | **HUDA Sector 14** | **Bus Stand** | **Railway station** | **Naiwali chowk** |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Brass market** | 7.7 | 0.998 | 4480 | 968 | 691.2 | 168.84 | 110.7 | ND | 123.5 | 218.8 | 0.388 | 163.3 | 136.5 | 4.9 | 56.3 | 2.7 |
| **Kirti Nagar** | 7.2 | 6.155 | 2000 | 1620 | 723.2 | 547.04 | 128.6 | ND | 138.5 | 188.9 | 0.989 | 98.9 | 81.9 | 10 | 362 | 3.8 |
| **Delhi road** | 7.7 | 2.852 | 1460 | 1040 | 789 | 153.3 | 70.3 | ND | 92.4 | 342.1 | 0.628 | 310.5 | 236.5 | 4.6 | 195.1 | 4.2 |
| **Patel Nagar** | 7.6 | 7.538 | 1280 | 928 | 791 | 84.91 | 181.5 | ND | 203.5 | 356.9 | 0.414 | 140.3 | 144.3 | 5.8 | 243.6 | 3.2 |
| **HUDA Sector 1** | 7.3 | 6.880 | 1520 | 1384 | 680 | 429.44 | 330.1 | ND | 376.8 | 292.5 | 0.829 | 64.4 | 113.1 | 10 | 261.7 | 8.9 |

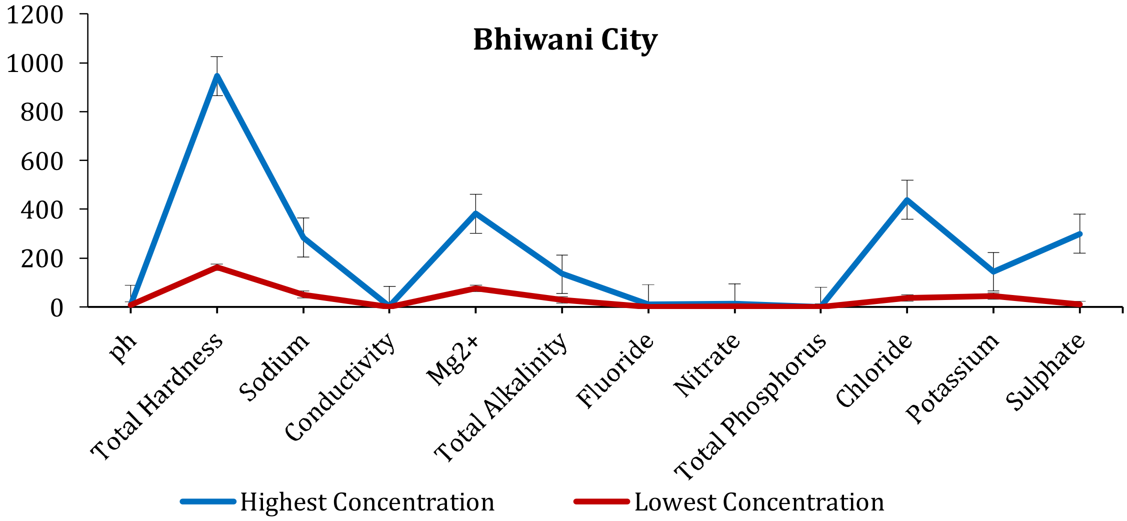


**Fig. 2 Representing Highest & Lowest concentration of different parameters in groundwater of Bhiwani**

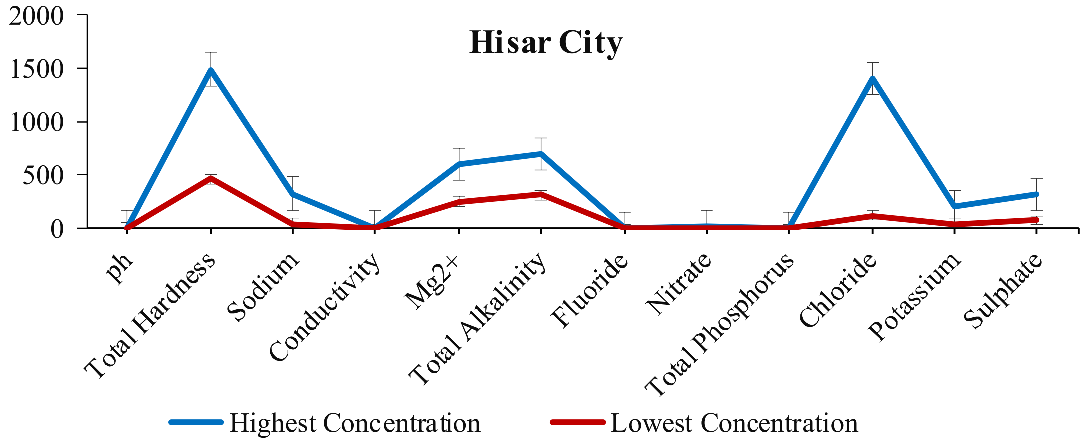


**Fig. 3 Shows Highest & Lowest concentration of different parameters in groundwater of Hisar**

 

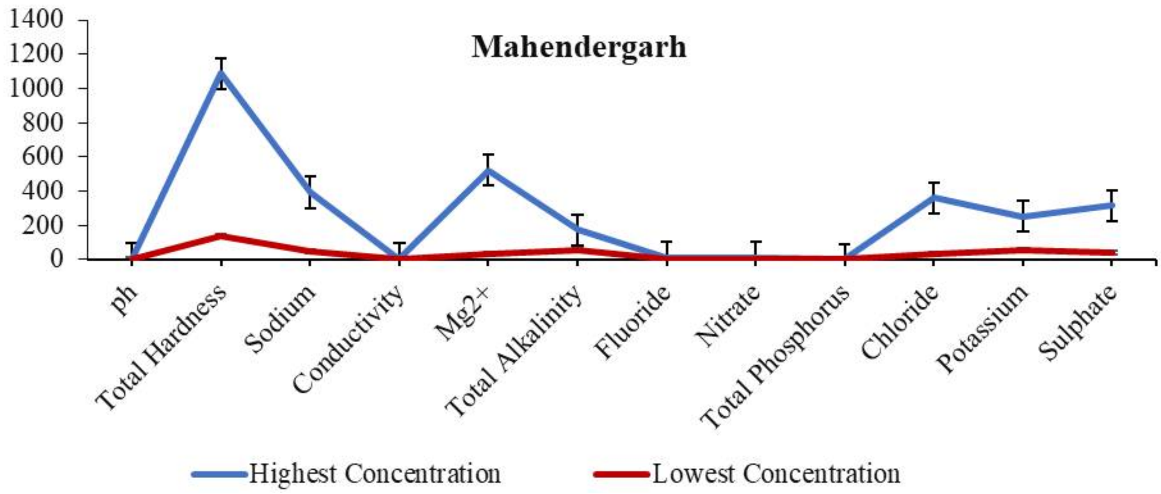


**Fig. 4 Highest and lowest concentration of different parameters in groundwater of Mahendergarh**

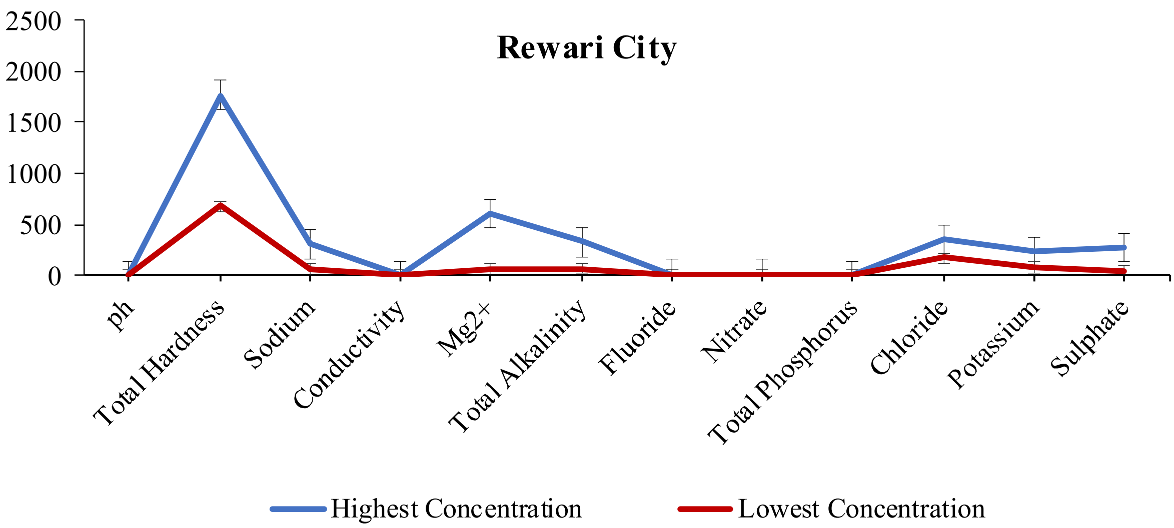


**Fig. 5 Shows Highest & Lowest concentration of different parameters in groundwater of Rewari City**

**CONCLUSION**

The pH of all groundwater samples is within the range of permissible limit except for the 4 water samples. TDS content of the analysed groundwater samples is high. It is more than 1000 ppm in 33 water samples. So, it shows that there is a need for some kind of treatment for the removal of dissolved salts before to use of water from these sources.

The Calcium content of 14 analysed groundwater samples out of a total of 55 is within the permissible limit and the rest of 41 water samples have higher Calcium content than the permissible limit.

In reality, the study found that geogenic factors were the main contributors to the salty ground fluids in the studied area. The study may thus validate and show a reliable method for evaluating the vulnerability of any area with different soils, agricultural patterns, and water management techniques to salt and trace metal contamination of groundwater. It is so abundantly clear that these regional aquifer vulnerability assessments, when correctly carried out, can enable informed management decisions in order to provide early warning of degradation and develop an efficient strategy for sustainable groundwater management. As a result, there may be a greater likelihood of bridging the gap between policy implementation and enforcement, which is frequently a barrier to achieving sustainable water usage.

 

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