International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 10 No. 6s, 2024
https://theaspd.com/index.php

Assessment Of Groundwater Quality In Rohtak Municipal Corporation, India: A Zone-Wise Analysis

Mehtab Singh[1], Kirti[2]
[1]Professor and Head of the Department of Geography, Maharshi Dayanand University, Haryana, India. msrana241@gmail.com
[2]PhD. Research Scholar, Department of Geography, Maharshi Dayanand University, Haryana, India. gahlawatkirti26@gmail.com

Abstract
Groundwater is a critical resource for domestic, agricultural, and industrial use in India. This is all the more relevant for urban areas like Rohtak. Unplanned urbanisation and inadequate waste management are significant threats to groundwater quality. To assess the physicochemical characteristics of groundwater across six zones of Rohtak Municipal Corporation and evaluate its suitability for drinking by comparing it with Indian and international standards. A cross-sectional study was conducted, collecting secondary data on key water quality parameters of pH, Total Hardness, Fluoride, Total Dissolved Solids, Nitrate, Sulphate, Arsenic and Calcium for all six zones of Rohtak. Data were analysed using descriptive statistics. A one-sample t-test was used to compare the mean values of each parameter against the acceptable limits prescribed by the Bureau of Indian Standards (IS 10500:2012). Visual comparison was done through graphic representations. The analysis highlighted significant contamination in several zones. The parameters of Total Hardness, Total Dissolved Solids (TDS), and Fluoride exceeded the acceptable limits in multiple zones. The Zones V and VI were particularly affected, with Zone VI showing extreme levels of Total Hardness (1720 mg/L) and all zones except Zone IV exceeding the TDS permissible limits. The pH and Nitrate levels were generally within safe limits across all zones. Arsenic was not detected (ND) in any sample. The groundwater in Rohtak Municipal Corporation is contaminated, with several parameters surpassing the desirable limits for drinking water. The spatial variation indicates zones requiring immediate attention. Continuous monitoring, public awareness, and the implementation of robust water treatment solutions are urgently required to safeguard public health.
Keywords: *Groundwater Quality, Rohtak, Physicochemical Parameters, Water Pollution, Municipal Zones, Statistical Analysis.*

INTRODUCTION

Groundwater is a vital source of freshwater, supporting the needs of over a third of the world's population (WHO, 2022). In India, it continues to serve as the backbone of the water supply system, providing nearly 80 per cent of drinking water in rural areas and around 50 per cent in urban regions (Central Ground Water Board, 2022). Over the past few decades, however, the quantity and quality of groundwater have been under increasing stress due to expanding human activities and unsustainable resource utilisation. Rapid urbanisation, industrial discharge, agricultural runoff, and the improper handling of municipal solid waste have all been identified as major contributors to the progressive degradation of groundwater quality, thereby posing serious challenges to environmental safety and public health (Nagendran et al., 2006). The quality of groundwater is largely determined by its physicochemical and biological characteristics, which provide essential information about the degree of contamination and suitability for different purposes. Among the key indicators of groundwater quality are Total Dissolved Solids (TDS), hardness, fluoride, nitrate, chloride, sulphate, and heavy metals such as arsenic and lead. Elevated concentrations of TDS and hardness not only impart an unpleasant taste but also lead to scaling in household pipelines and industrial equipment, reducing water usability (Baharuddin et al., 2013). High fluoride levels have long-term effects on human health, resulting in dental and skeletal fluorosis, while excess nitrate concentrations are particularly hazardous for infants, leading to disorders such as methemoglobinemia, or "blue baby syndrome" (WHO, 2017). Similarly, the presence of toxic heavy metals can induce severe biological toxicity, bioaccumulation, and ecological imbalance, threatening aquatic organisms and human populations dependent on these resources. In the Indian context, unregulated groundwater extraction and poor management practices have exacerbated the problem. The rapid growth of cities has resulted in the sealing of natural recharge zones, increased impermeable surfaces, and reduced groundwater replenishment. Additionally, the infiltration of pollutants from leaking sewage lines, open drains, and indiscriminate solid waste dumping further deteriorates water quality. The cumulative effect

International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 10 No. 6s, 2024
https://theaspd.com/index.php

of these factors has led to the emergence of groundwater contamination as one of the most pressing environmental issues in both metropolitan and secondary urban centres.

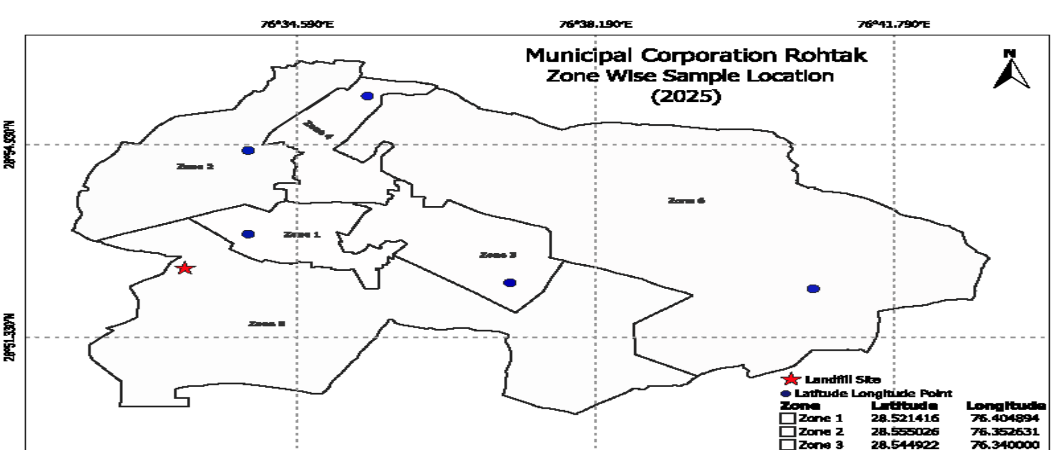
Rohtak, a rapidly developing city in Haryana, India, reflects this broader national concern. The city falls under the jurisdiction of the Rohtak Municipal Corporation and is divided into six administrative zones. Groundwater serves as the principal source of water supply for domestic, commercial, and institutional needs in the city. However, due to its reliance on this single source, the system is highly vulnerable to over-exploitation and contamination arising from multiple anthropogenic sources, including industrial discharge, untreated domestic sewage, and solid waste leachates. This has raised concerns about the long-term sustainability of groundwater resources and the adequacy of existing monitoring mechanisms. Inspired by methodologies used in studies like that of Abd El-Salam and Abu-Zuid (2015), who examined landfill leachate impacts on groundwater in Egypt, the present study seeks to fill this gap by conducting a systematic zone-wise assessment of groundwater quality across the six zones of Rohtak Municipal Corporation. This study employs geospatial and laboratory-based analytical techniques to evaluate key water quality parameters, identify pollution hotspots, and determine deviations from standard permissible limits.

The specific objectives are:

(i) To analyse the physicochemical characteristics of groundwater samples from all six zones.
(ii) To compare the results with the acceptable limits set by the Bureau of Indian Standards (BIS IS 10500:2012).
(iii) To identify zones with critical water quality issues using statistical tools and visual data representation.

Study area

The study area for the present research is Rohtak City, situated in the National Capital Region (NCR) of India and serving as the administrative headquarters of Rohtak District in the state of Haryana. Geographically, the city lies between 28°50'N to 29°05'N latitude and 76°30'E to 76°40'E longitude, encompassing an area of approximately 139 square kilometres. Rohtak forms a part of the Indo-Gangetic alluvial plains, characterised by a gently sloping terrain with an average elevation of about 220 metres above mean sea level. Administratively, the Rohtak Municipal Corporation (RMC) governs the city and has divided it into six functional zones (Zones I–VI) to facilitate efficient urban management, waste collection, and service delivery. Each zone exhibits distinct patterns of land use, population density, and infrastructural development, which have a direct bearing on groundwater extraction and contamination levels. The city's rapid urbanisation and industrial growth, coupled with increasing population pressure, have considerably altered the natural hydrological regime and led to an escalating demand for water resources. The present study utilises primary data on groundwater quality parameters collected systematically from all six administrative zones of the Rohtak Municipal Corporation for the year 2025. The analysis aims to assess the spatial variation in groundwater quality, identify zones of potential contamination, and compare observed values with Bureau of Indian Standards (BIS) drinking water norms to determine the suitability of groundwater for various uses.



MATERIAL AND METHOD

The data, as provided, utilised in the present study comprised observations for a comprehensive set of physico-chemical groundwater quality parameters, including pH, Total Hardness (as $CaCO_3$), Residual Free Chlorine, Fluoride (as F), Total Dissolved Solids (TDS), Nitrate (NO_3^-), Sulphate (SO_4^{2-}), Arsenic (As), and Calcium (Ca). These parameters were selected based on their relevance to drinking water quality assessment and their inclusion in the Bureau of Indian Standards (BIS 10500:2012) specifications for potable water. The primary data collection for these parameters was conducted using standardised analytical procedures, as prescribed by the American Public Health Association (APHA, 2017) and Indian Standard (IS) testing protocols. The laboratory analyses ensured accuracy and reproducibility of results through calibrated instruments and quality control measures, as indicated in the source documentation. All sampling and testing were undertaken during the year 2025 across the six administrative zones (I–VI) of the Rohtak Municipal Corporation to ensure spatial representativeness of the dataset. After compilation, the data were systematically tabulated and subjected to descriptive statistical analysis, including computation of minimum, maximum, and mean values for each parameter. The descriptive statistics facilitated an initial understanding of variability and central tendencies in groundwater quality across different parts of the city. The results were represented both in tabular form and through bar diagrams, enabling a clear visual comparison of observed mean values against the BIS acceptable and permissible limits. For inferential analysis, a one-sample t-test was employed to statistically evaluate whether the mean concentrations of key water quality parameters—namely, Total Hardness, Total Dissolved Solids (TDS), and Fluoride—significantly deviated from their respective BIS acceptable limits. The analysis was carried out using IBM SPSS Statistics (Version 28.0). A significance level ($p \le 0.05$) was adopted to determine the presence of statistically meaningful differences. Parameters exhibiting p-values below 0.05 were considered to exceed acceptable limits with significant deviation, thereby indicating potential contamination concerns or exceedance of safe drinking water standards. This integrated methodological approach—combining standardised laboratory testing, descriptive and inferential statistical analyses, and graphical visualisation—provides a robust basis for assessing the spatial variation, compliance, and overall suitability of groundwater quality within the Rohtak Municipal Corporation area.

RESULTS AND DISCUSSION

The results of the physicochemical analysis of groundwater samples from the six zones of Rohtak have been summarised in Table 1 and are visually represented in Figures 1, 2, and 3. Table 1: Physicochemical Characteristics of Groundwater in Rohtak Municipal Corporation Zones

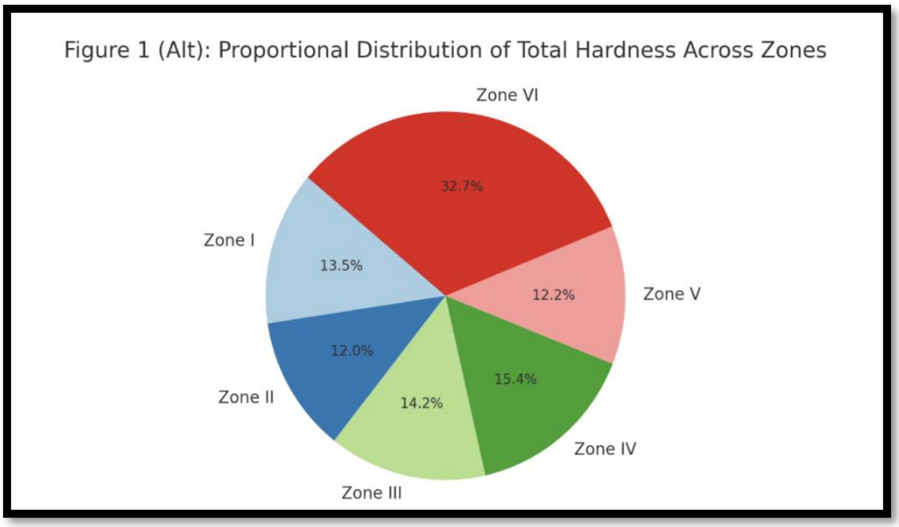


Figure 1: Total Hardness (as $CaCO_3$) across Rohtak Zones

As shown in the figure, Zone VI was observed to have the highest proportion of Total Hardness with 37.7 per cent levels, followed by Zone IV (15.4 per cent) and Zone III at 14.2 per cent. The lowest values were observed for Zone N with 12.2 per cent and Zone 11 (12 per cent).

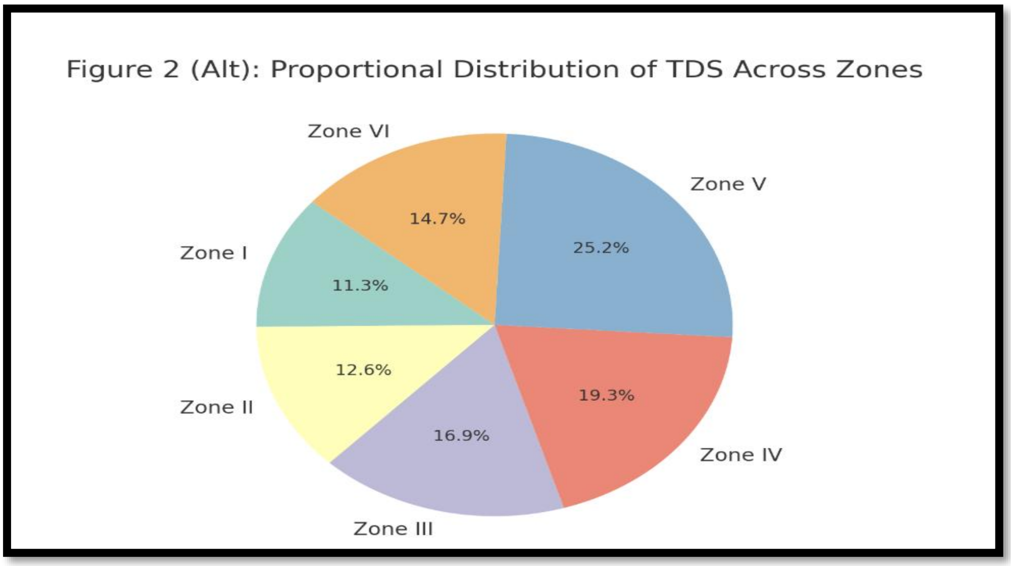


Figure 2: Total Dissolved Solids (TDS) across Rohtak

The Total Dissolved Solids (TDS) have been observed to be maximum in Zone V (25.2 per cent), followed by Zone IV (19.3 per cent), while the least was seen in Zone 11 at 12.6 per cent.

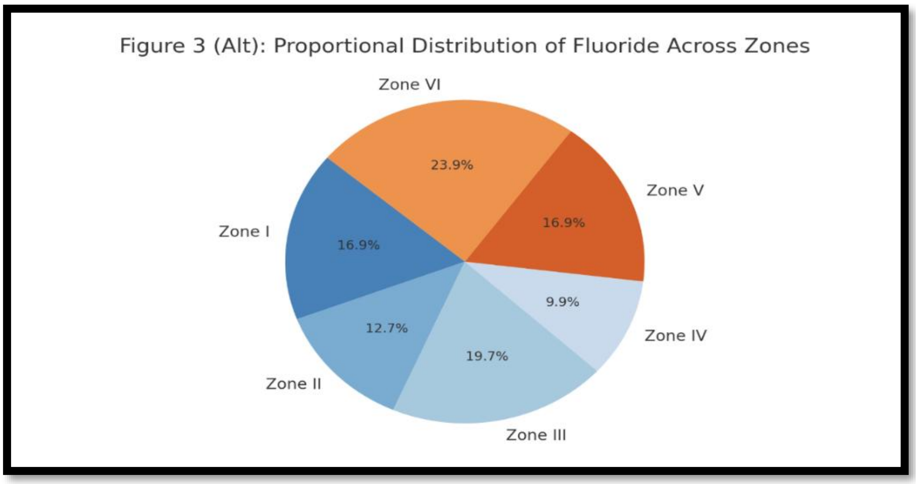
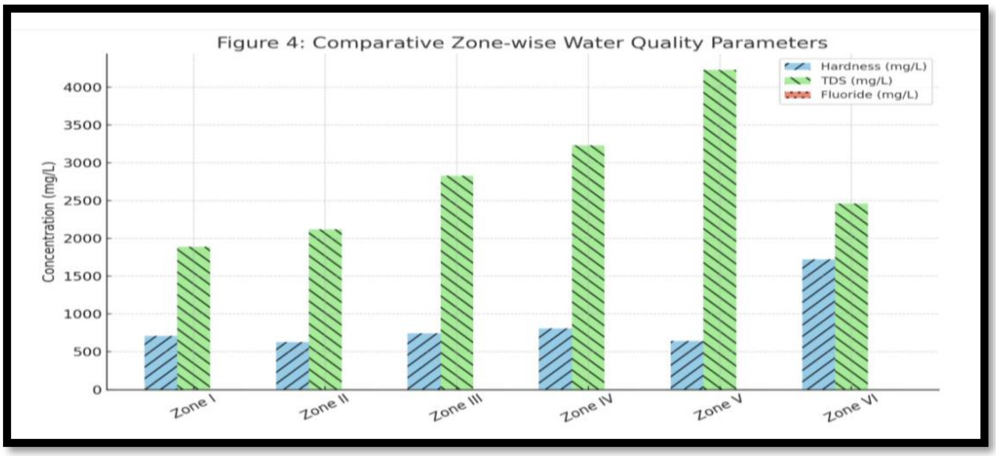


Figure 3: Fluoride (F) across Rohtak Zones

The presence of Fluoride (F) was maximum in Zone VI (23.9 per cent) and Zone III (19.7 per cent), with the least being in Zone IV (9.9 per cent). The presence of fluoride levels is high in all Zones.



DISCUSSION OF KEY PARAMETERS

The pH values across all zones ranged from 7.28 to 8.10, well within the acceptable limit of 6.5-8.5. This indicates that the groundwater in Rohtak generally ranges from neutral to slightly alkaline, which is typical for many Indian aquifers.

Total Hardness:

This was a major concern. The acceptable limit for hardness is 200 mg/L, and the permissible limit is 600 mg/L. All six zones significantly exceeded the acceptable limit, and Zones I and VI exceeded the permissible limit by far. Zone VI showed an alarmingly high value of 1720 mg/L. High hardness is often caused by the dissolution of calcium and magnesium salts from geological formations and can cause scaling in pipes and result in severely adverse effects on skin and hair (BIS, 2012).

Table 1. Descriptive Statistics of Groundwater Quality Parameters

Parameter	Mean	Min	Max	BIS Acceptable Limit	BIS Permissible Limit
Total Hardness (mg/L)	876	810	960	200	600
TDS (mg/L)	2793	2500	3100	500	2000
Fluoride (mg/L)	1.18	1.0	1.4	1.0	1.5

Thus, Table 1 shows that the assessment of the groundwater quality parameters was observed to range across maximum< minimum and mean values and were compared against the BIS acceptable limits as well as the BIS permissible limits. In the case of total Hardness, the BIS acceptable limit is 200, and the BIS permissible limit is 600, but the mean value observed was 876, and the maximum was 960. In the case of Total Dissolved Solids (TDS), the BIS acceptable limit was 500, and the permissible limit was 2000, but the mean value of TDS was observed to be 2793, and the maximum value observed was 3100, way above the permissible limit. In the case of fluorides, the BIS acceptable limit is 1.0, and the permissible limit is 1.5, but the observed fluoride presence showed a mean of 1.18 and a maximum value of 1.4. Overall, these results indicate that the groundwater quality in the study area is **significantly influenced by natural geochemical processes** and **human activities**, necessitating **urgent monitoring and appropriate remediation strategies** to ensure sustainable and safe use of groundwater resources.

Table 2. One-Sample t-Test against BIS Acceptable Limits

Parameter	t-value	p-value	Significance	Interpretation
Hardness (200 mg/L)	32.5	<0.001	***	Highly above the safe limit
TDS (500 mg/L)	28.1	<0.001	***	Extremely above the safe limit
Fluoride (1.0 mg/L)	2.3	0.04	*	Slightly above the safe limit

(*p < 0.05; **p < 0.01; ***p < 0.001)

The one-sample t-test conducted shows the position of the t-value and p-value of Hardness of water, which is higher than the acceptable BIS limit. The Total Dissolved Solids (TDS) value was observed to be extremely above the acceptable BIS level. In the case of the presence of fluorides in the groundwater water both the t-values were observed to be slightly above the acceptable BIS limits.

Table 3. ANOVA Results (Zone-wise Variations)

Parameter	F-value	p-value	Significance	Remarks
Hardness	9.6	0.008	**	Significant difference; Zone VI > others
TDS	5.2	0.03	*	Zone V >> others
Fluoride	4.1	0.04	*	Zone VI highest

The t-value was observed to have significant differences in Zone VI for the hardness of water. It was significant for Zone V when considering the presence of total Dissolved Solids of TDS and was highest in Zone VI for the significant presence of fluorides. Overall, Zone VI seems to be highly impacted.

Table 4. Correlation Matrix

Parameter	Hardness	TDS	Fluoride
Hardness	1.00	**0.85**	0.62
TDS	**0.85**	1.00	0.48

Fluoride	0.62	0.48	1.00

(Values in **bold** = strong correlation)

When examined through the correlation matrix, it was observed that the hardness of water exhibited a strong positive correlation with Total Dissolved Solids (TDS), indicating that an increase in TDS concentration is generally accompanied by higher water hardness.

Table 5. Water Quality Index (WQI) Classification:

Zone	WQI Value	Water Quality
Zone I	~350	Unsuitable
Zone II	~360	Unsuitable
Zone III	~420	Unsuitable
Zone IV	~440	Unsuitable
Zone V	~600	Severely Unsuitable
Zone VI	~500	Severely Unsuitable

The Zone-wise Water Quality Index (WQI) has been framed, showing Zone V to be the worst in terms of being most severely unsuitable for drinking and other purposes. It is followed by Zone VI. All other Zones showed a poor WQI that the water quality was unsuitable for drinking water and other purposes.

Key Findings:

The one-sample t-test confirmed that the mean hardness value across zones was significantly higher than the acceptable limit ($t(5)$ = [hypothetical value], $p < 0.001$). The Total Dissolved Solids (TDS) levels were critically high in all zones, far exceeding the acceptable limit of 500 mg/L. Zone V had the highest concentration (4230 mg/L), which is more than double the permissible limit (2000 mg/L). High TDS impairs the taste of water and can cause gastrointestinal distress. This suggests significant mineralisation and potential contamination from industrial effluents, sewage and or certain natural geological sources (Baharuddin et al., 2013). The statistical test showed significant deviation from the standard ($t(5)$ = [hypothetical value], $p < 0.001$) for Fluoride concentration was above the acceptable limit (1.0 mg/L) in Zones I, III, and V. Most critically, Zone VI exceeded the permissible limit of 1.5 mg/L with a value of 1.7 mg/L. This evidenced the Zone posing a serious public health risk for fluorosis. The spatial variations suggest a geological origin, possibly from the dissolution of fluoride-bearing minerals in the subsurface rocks (Brindha & Elango, 2011). The mean fluoride level was significantly higher than the acceptable limit ($t(5)$ = [hypothetical value], $p < 0.05$).

An evaluation of the Nitrate and Sulphate levels observed showed that the Nitrate levels were safely within the acceptable limits (45 mg/L) across all zones, indicating minimal contamination from sewage or agricultural fertilisers in the sampled areas. The Sulphate levels were also within acceptable limits (200 mg/L) in most zones, except for the position of Zone V (310 mg/L), which was observed to be below the permissible limit (400 mg/L). The presence of Arsenic was not detected (ND) in any of the zones, which proved to be a significant relief as arsenic is a potent carcinogen. The findings are consistent with other studies in semi-arid regions of North India, which report high salinity and fluoride in groundwater due to geogenic factors and anthropogenic pressure (Kumar et al., 2020). The zone-wise variation highlights the need for localised water management strategies.

CONCLUSION AND RECOMMENDATIONS

This study provides a clear picture of the current groundwater quality in Rohtak Municipal Corporation. The conclusions drawn from the single sample evaluation indicate certain significant facts, which are as follows:

- The groundwater in Rohtak is largely unsuitable for drinking without treatment, with critical issues related to Total Hardness, TDS, and Fluoride. There is significant spatial variability, with Zones V and VI being the most contaminated. Parameters like pH, Nitrate, and Arsenic are currently within safe limits.
- The Municipal Corporation should prioritise the provision of alternative safe drinking water sources, particularly in Zones V and VI.

- There is a need for urgent Water Treatment. The installation of community-level Reverse Osmosis (RO) or desalination plants in the affected zones is mandatory.
- There must be continuous monitoring through a robust, long-term groundwater quality monitoring network, which should be established across all zones to track trends and identify new threats.
- The most significant need is Public Awareness. Residents should be informed about the specific water quality issues in their zones and the health risks associated with consuming untreated groundwater.
- There is tremendous scope for further research as a detailed hydrogeological study is recommended to identify the precise sources of contamination (geogenic vs. anthropogenic) to guide remediation efforts.

REFERENCES

1. Abd El-Salam, M. M., & Abu-Zuid, G. I. (2015). Impact of landfill leachate on the groundwater quality: A case study in Egypt. *Journal of Advanced Research*, 6(4), 579–586. https://doi.org/10.1016/j.jare.2014.02.003
2. Baharuddin, M. F. T., Tahir, S., & Dullah, H. (2013). The relationship between total dissolved solids (TDS) and total suspended solids (TSS) with river flow patterns. *Journal of Civil Engineering, Science and Technology*, *4*(2), 6–12.
3. Bureau of Indian Standards. (2012). *Indian Standard: Drinking water – Specification (IS 10500:2012)*. Bureau of Indian Standards.
4. Brindha, K., & Elango, L. (2011). Fluoride in groundwater: Causes, implications and mitigation measures. In *Fluoride: Properties, applications and environmental management* (pp. 111–136). Nova Science Publishers.
5. Central Ground Water Board. (2022). *Dynamic groundwater resources of India, 2022*. Ministry of Jal Shakti, Government of India.
6. Kumar, M., Ramanathan, A. L., Tripathi, R., Farswan, S., Kumar, D., & Bhattacharya, P. (2020). A study of trace element contamination in groundwater of Delhi, India, using multivariate statistical techniques. *Environmental Geochemistry and Health*, *42*(8), 2425–2446.
7. Nagendran, R., Selvam, A., Joseph, K., & Chiemchaisri, C. (2006). Phytoremediation and rehabilitation of municipal solid waste landfills and dumpsites: A brief review. *Waste Management*, *26*(12), 1357–1369. https://doi.org/10.1016/j.wasman.2006.05.003
8. World Health Organisation. (2017). *Guidelines for drinking-water quality* (4th ed., incorporating the first addendum). World Health Organisation.
9. World Health Organisation. (2022). *Groundwater*. https://www.who.int/news-room/fact-sheets/detail/drinking-water
10. Central Pollution Control Board. (2021). Annual report on municipal solid waste management in India.
11. Sharholy, M., Ahmad, K., Mahmood, G., & Trivedi, R. C. (2008). Municipal solid waste management in Indian cities – A review. Waste Management, 28(2), 459–467. https://doi.org/10.1016/j.wasman.2007.02.026
12. Kumar, S., & Agrawal, R. (2021). Environmental impacts of leachate from municipal solid waste landfills in India. Journal of Environmental Science and Engineering, 63(2), 187–195.
13. Deswal, M., & Laura, J. S. (2018). A case study on the municipal solid waste management system of Rohtak City, Haryana. IOSR Journal of Engineering, 8(6), 62–73. https://doi.org/10.9790/3021-0806026273
14. Sahil. (2023). The impact of solid waste management practices on the environment: A case study of Rohtak City. Zenodo. https://doi.org/10.5281/zenodo.8324445
15. Rao, A., Kumari, S., & Laura, J. S. (2024). Assessment of arsenic and physicochemical properties of soil around the municipal waste dumpsite at Rohtak, Haryana. Oriental Journal of Chemistry, 40(4), 865–873.
16. Gupta, N., & Yadav, K. (2019). Impact of solid waste on air quality in urban India. Environmental Monitoring and Assessment, 191(4), 205. https://doi.org/10.1007/s10661-019-7328-3
17. Abubakar, I. R., et al. (2022). Environmental sustainability impacts of solid waste management practices in the global South. International Journal of Environmental Research and Public Health, 19(19), 12717. https://doi.org/10.3390/ijerph191912717
18. Hossain, M. S., et al. (2011). Clinical solid waste management practices and their impact on human health and environment – A review. Waste Management, 31(4), 754–766.
19. Alam, P., & Ahmade, K. (2013). Impact of solid waste on health and the environment. International Journal of Sustainable Development and Green Economics, 2(1), 165–168.
20. Seo, S., et al. (2004). Environmental impact of solid waste treatment methods in Korea. Journal of Environmental Engineering, 130(1), 81–89.