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Evaluation of Groundwater Quality in Rewari City, Haryana: Implications for Drinking and Agricultural Purposes

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Abstract-The present study evaluates groundwater suitability for irrigation in the Rewari industrial area of Haryana, India, with emphasis on salinity, sodium hazards, and hydrochemical characteristics. Groundwater samples from 11 borewells and tubewells were collected during the pre-monsoon period and analyzed using standard APHA methods. Key irrigation water quality parameters, including Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Sodium Percentage (Na%), and Residual Sodium Carbonate (RSC), were calculated to assess water quality. Hydrochemical facies were identified using the Piper trilinear diagram, and irrigation suitability was evaluated using Wilcox classification and the US Salinity Laboratory (USSL) approach. Results indicate moderate to high salinity levels (EC: 1210–1780 µS/cm) and moderate mineralization (TDS: 680–828 mg/L), reflecting combined influence of geogenic processes and anthropogenic activities such as industrial discharge and urban wastewater infiltration. Hydrochemical analysis revealed dominant Ca–Mg–Cl and Na–Cl water types, indicating ion exchange and secondary salinization processes. Irrigation suitability classification showed that most samples fall under moderate to permissible categories, while some locations exhibit high salinity and sodium hazards, limiting their use to salt-tolerant crops. The study concludes that although groundwater is relatively suitable for irrigation compared to surface water, long-term use may lead to soil degradation. Therefore, sustainable groundwater management, crop planning, and regular monitoring are essential for agricultural sustainability in the region.

Keywords-Groundwater quality, Rewari city, irrigation suitability, drinking water, salinity hazard, sodium adsorption ratio, hydrochemical analysis, Piper diagram, Water Quality Index, agricultural sustainability.

1. Introduction

Groundwater is a fundamental component of the hydrological cycle and serves as the primary source of freshwater for drinking, domestic, agricultural, and industrial needs in many parts of India, especially in semi-arid and rapidly urbanizing regions. The present study titled "Evaluation of Groundwater Quality in Rewari City, Haryana: Implications for Drinking and Agricultural Purposes" is undertaken to assess the current status of groundwater quality and to evaluate its suitability for human consumption as well as agricultural activities. Rewari city, located in the southern part of Haryana, is a rapidly developing urban and industrial hub that has witnessed substantial population growth, infrastructural expansion, and industrialization over the past few decades(Hoalst-pullen, 2026; Mukherjee et al., 2025; Rani et al., 2025). This rapid development has placed immense pressure on local groundwater resources, which are the major source of water supply in the absence of adequate surface water availability. The overdependence on groundwater, coupled with uncontrolled extraction, has resulted in declining water levels and potential deterioration in water quality. Additionally, various anthropogenic activities such as industrial effluent discharge, agricultural runoff containing fertilizers and pesticides, improper sewage disposal, and solid waste accumulation have further contributed to the contamination of groundwater systems in the region(Nagal et al., 2025; Raghav & Rastogi, 2025; Rao et al., 2025). The natural geological composition of the area also influences the hydrochemical characteristics of groundwater, making it essential to analyze both natural and human-induced factors affecting water quality. In this context, a systematic evaluation of groundwater quality becomes crucial for ensuring sustainable water resource management and safeguarding public health. The study involves the collection of groundwater samples from different representative locations across Rewari city, including residential, agricultural, and industrial zones, to capture spatial variations in water quality.

These samples are analyzed using standard laboratory methods for various physicochemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), chloride (Cl^-), nitrate (NO_3^-), sulfate (SO_4^{2-}), and fluoride (F^-). These parameters provide a comprehensive understanding of the chemical nature of groundwater and its suitability for different uses. The results obtained from laboratory analysis are compared with the permissible limits set by international and national standards such as the World Health Organization (WHO), Bureau of Indian Standards (BIS), and Indian Council of Medical Research (ICMR) to determine whether the groundwater is safe for drinking purposes. Any deviation from these standards indicates potential health risks, including waterborne diseases and long-term health hazards such as fluorosis, kidney disorders, and methemoglobinemia caused by excessive nitrate concentration. In addition to drinking water quality assessment, the study also evaluates the suitability of groundwater for irrigation purposes, which is particularly important for the agrarian economy of Haryana. Irrigation water quality is assessed using important indices such as Sodium Adsorption Ratio (SAR), Residual Sodium Carbonate (RSC), percentage sodium (%Na), Kelly's Ratio (KR), and salinity hazard classification based on EC values. These parameters help in understanding the impact of groundwater on soil permeability, structure, and crop productivity. High salinity or sodium levels in irrigation water can lead to soil degradation, reduced agricultural yield, and long-term loss of soil fertility, thereby affecting the sustainability of agricultural practices in the region. The findings of this study are expected to reveal significant spatial variations in groundwater quality across different locations in Rewari city, highlighting areas that are relatively safe as well as those that are highly contaminated. It is also anticipated that regions located near industrial zones may exhibit higher levels of contamination due to untreated effluents and chemical discharge, while agricultural areas may show elevated nitrate and salinity levels due to fertilizer application and irrigation practices. The interpretation of these results will provide valuable insights into the relationship between land use patterns and groundwater quality deterioration(Chahal et al., 2022; Haryana, 2022;

Yadav & Pandey, 2022). The study emphasizes the importance of continuous monitoring and periodic assessment of groundwater quality to prevent further degradation and to ensure the availability of safe water resources for future generations. The research findings will be highly beneficial for policymakers, environmental planners, public health authorities, and local governing bodies in formulating effective strategies for groundwater management, pollution control, and sustainable development. Measures such as rainwater harvesting, wastewater treatment, regulated groundwater extraction, and public awareness campaigns are recommended to mitigate the adverse impacts on groundwater resources. Overall, this study aims to provide a comprehensive and scientific evaluation of groundwater quality in Rewari city, Haryana, and to highlight its implications for drinking water safety and agricultural sustainability, thereby contributing to the broader goal of environmental protection and sustainable resource management in the region(Ige et al., 2022; Ishaq et al., 2022; Jain, 2021).

2. Literature Review

(Arveti et al., 2026) evaluates groundwater quality in the Kolar Gold Fields (KGF), Karnataka, using hydrogeochemical analysis of 40 samples. Parameters such as pH, EC, TDS, and major ions (Na, Ca, Mg, HCO_3) were analyzed along with irrigation indices including SAR, adjusted SAR, permeability index, and WQI. Results indicate poor water quality, mainly due to high TDS and hardness, making it unsuitable for drinking without treatment. Irrigation assessment shows low sodium hazard but high salinity in many samples. Piper and geochemical analyses reveal Ca–HCO_3 and Ca–Mg–Cl water types, controlled by evaporation, ion exchange, and mineral dissolution influenced by mining activities.

(Deep et al., 2025) monitored spatio-temporal changes in groundwater depth in Kurukshetra district, Haryana, using GIS-based analysis of 97 observation wells (1985–2020). IDW interpolation was used to map water level depth and fluctuations, while VES surveys assessed subsurface conditions. Results show a significant decline in groundwater levels over time, with most of the area shifting from 10–20 m bgl in 1990 to 40–45 m bgl in 2020. The decline is mainly due to intensive wheat–paddy cultivation and overextraction of groundwater. The study recommends efficient irrigation practices, crop diversification, rainwater harvesting, and government initiatives like "Mera Pani–Meri Virasat" to restore groundwater sustainability.

(Mboudou & Yiika, 2025) assesses the physicochemical characteristics of surface and groundwater in the Logbadjeck quarrying area, Southern Cameroon, for domestic and agricultural use. Chemical parameters were analyzed using titration, spectrometry, and colorimetric methods. Results show low temperature, electrical conductivity, and total dissolved solids, indicating fresh, low-mineralized water within WHO permissible limits. Major ions followed the order $Ca^{2+} > Mg^{2+} > Na^{+} > K^{+}$ and $HCO_3^{-} > NO_3^{-} > SO_4^{2-} > Cl^{-} > F^{-}$. Hydrogeochemical facies reflect rock weathering, ion exchange, and precipitation influence. Irrigation indices confirm suitability for agriculture, with no significant pollution or health risks, indicating overall good water quality.

(Jha et al., 2024) highlights groundwater stress in the NCR region due to rapid urbanization, population growth, and increased dependence on groundwater for domestic, agricultural, and industrial use. Although the region receives adequate rainfall, excessive extraction has led to declining water tables, as recharge is lower than usage. River Yamuna serves as the main surface water source only during monsoon seasons, further increasing groundwater reliance. The study emphasizes rainwater harvesting as a key solution to enhance groundwater recharge. It suggests adopting suitable urban and rural harvesting systems, rejuvenating surface water bodies, and increasing storage capacity. Prioritizing water-deficient areas and implementing mandatory rainwater harvesting can help restore depleted aquifers sustainably.

(Sangwan, 2023) examines the declining groundwater levels in India, with a focus on southern Haryana, using secondary data from the Ministry of Water Resources. Spatial analysis of groundwater depth and fluctuations was carried out using ArcGIS 9.3, while Kriging interpolation was applied to estimate groundwater elevation and generate water table maps. The results reveal severe groundwater depletion across several regions, particularly in Punjab, Haryana, Uttar Pradesh, and parts of South India, mainly due to excessive agricultural, industrial, and domestic water demand driven by population growth. In southern Haryana, Mahendergarh district and Firozpur block of Mewat were identified as critically affected zones. The study highlights the urgent need for sustainable groundwater management practices, efficient water use, and conservation strategies to mitigate further depletion and ensure long-term water security.

Table 1 Literature Review Table

Author	Methodology	Research Gap	Findings
(Srivastava et al., 2022)	One hundred nine groundwater samples collected shallow Ganga alluvial aquifer	Limited integrated assessment of trace element contamination and sewage impact	Groundwater shows Ca Mg bicarbonate facies with sewage contamination enrichment
(Ige et al., 2022)	Thirty seven groundwater samples analyzed using physico chemical methods	Limited studies on dumpsite impact on groundwater quality assessment	Groundwater generally safe, Ca HCO3 type, minimal contamination observed
(Jain, 2021)	Water quality analyzed monthly using APHA standard procedures 2014–15	Limited seasonal correlation studies of pond water quality parameters	Strong correlations observed among COD, hardness, and dissolved oxygen levels
(Roul et al., 2021)	Developed composite water sustainability index using seventeen	Lack of integrated sustainability index for groundwater assessment at district level	Haryana shows low to moderate sustainability due to overexploitation and cropping patterns

	indicators for Haryana		
(Singh et al., 2020)	Fifty groundwater samples analyzed for physicochemical parameters and irrigation indices	Limited integrated irrigation suitability assessment using multiple hydrochemical diagrams	Groundwater mostly suitable for irrigation with C2S1 type dominance and low hazard levels

3. Research Methodology

The study assessed groundwater suitability for irrigation in the Rewari industrial area, focusing on salinity, sodium hazards, and hydrochemical characteristics affecting agricultural sustainability. Groundwater samples from 11 bore wells and tube wells were collected during the pre-monsoon season and analyzed using standard APHA methods. Key parameters such as EC, TDS, SAR, Na%, and RSC were calculated to evaluate irrigation quality. Hydrochemical facies were classified using the Piper diagram, revealing Ca–Mg–Cl and Na–Cl types influenced by industrial activity. Results showed moderate to high salinity in several locations. Based on Wilcox and USSL classifications, recommendations were made for crop management, drainage improvement, and sustainable irrigation practices.

3.1 Research Objectives

a) To identify major sources of groundwater contamination associated with industrial activities.
b) To classify groundwater types using hydrochemical methods.
c) To provide scientific recommendations for groundwater management and pollution control.

3.2 Research Hypotheses

H1: Industrial activities significantly contribute to groundwater contamination in the study area.

$H0_1$: Industrial activities do not significantly contribute to groundwater contamination in the study area.

H2: Groundwater in the study area can be classified into distinct types using hydrochemical methods.

$H0_2$: There is no significant variation in groundwater hydrochemical characteristics for classification into distinct water types.

H3: Scientific groundwater management and pollution control measures are required to improve groundwater quality and sustainability.

$H0_3$: Existing groundwater conditions do not require significant changes in management and pollution control measures.

3.3 Identification of Irrigation Water Quality Problem

The second study focused on evaluating groundwater suitability for irrigation in the Rewari industrial area. Increasing industrialization, groundwater extraction, and dissolved salt accumulation have affected irrigation water quality and soil productivity in the region. The study aimed to examine salinity hazard, sodium hazard, and hydrochemical characteristics influencing agricultural sustainability. The investigation was designed to assess whether groundwater could safely be used for irrigation without adversely affecting soil permeability, crop growth, and long-term agricultural productivity.

3.4 Collection of Representative Groundwater Samples

Groundwater samples were collected from selected bore wells and tube wells distributed across industrial, agricultural, and peri-urban areas. A purposive sampling strategy ensured inclusion of locations vulnerable to salinity and industrial contamination. Sampling was carried out during the pre-monsoon period to obtain representative groundwater conditions unaffected by rainfall dilution. Eleven monitoring locations were selected to provide sufficient spatial coverage for hydrochemical evaluation and irrigation suitability analysis.

3.5 Measurement of Hydrochemical Parameters

Important irrigation-related water quality parameters such as Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Sodium Percentage (Na%), and Residual Sodium Carbonate (RSC) were evaluated. EC and TDS were measured using digital instruments, while major ionic concentrations required for hydrochemical indices were determined through laboratory analysis. These parameters are essential for identifying salinity hazards, sodium hazards, and alkalinity risks that may negatively affect soil structure and crop productivity.

3.6 Laboratory Determination of Major Ions

Laboratory analysis was conducted using APHA standard methods to determine concentrations of sodium, calcium, magnesium, bicarbonate, carbonate, chloride, and sulphate ions. Sodium and potassium concentrations were analyzed using flame photometry, while titration techniques were applied for calcium, magnesium, and bicarbonate estimation. These major ions form the basis for calculating irrigation water quality indices such as SAR, Na%, and RSC. Accurate ionic analysis was necessary to evaluate groundwater suitability for long-term agricultural use.

3.7 Calculation of Irrigation Water Quality Indices

Hydrochemical indices were calculated using standard mathematical formulas to assess irrigation suitability. SAR was calculated to determine sodium hazard and soil permeability risk, while Na% was used to estimate sodium dominance in groundwater. RSC was computed to evaluate alkalinity hazards associated with carbonate and bicarbonate ions. These indices provided a scientific basis for classifying irrigation water into suitable, moderate, or unsuitable categories according to internationally accepted irrigation water quality standards.

Sodium Adsorption Ratio (SAR):

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} Mg^{2+}}{2}}} \tag{1}$$

Sodium Percentage (Na %):

$$Na\% = \frac{(Na+k)\times 100}{(Ca+Mg+Na+K)} \tag{2}$$

3.8 Hydrochemical Classification Using Piper Diagram

The Piper Trilinear Diagram was employed as a key graphical tool to classify groundwater hydrochemical facies based on the relative abundance of major cations (Ca^{2+}, Mg^{2+}, $Na^{+} + K^{+}$)

and anions (HCO_3^-, Cl^-, SO_4^{2-}). This method enabled a systematic interpretation of groundwater chemistry and helped in identifying the dominant water types across the study area. The analysis revealed that groundwater samples predominantly fall under mixed Ca–Mg–Cl and Na–Cl facies, particularly in industrially influenced zones.

These variations indicate significant geochemical processes controlling water quality, including mineral dissolution from aquifer materials, ion exchange reactions between groundwater and host rocks, and anthropogenic inputs from industrial effluents and urban activities. The Piper diagram further highlighted spatial variations in groundwater evolution from fresh to more saline conditions. Overall, hydrochemical facies analysis provided a clear understanding of groundwater mineralization trends and demonstrated the strong influence of human activities on irrigation water quality in the Rewari industrial region.

3.9 Irrigation Suitability Classification

Groundwater suitability for irrigation in the study area was evaluated using the Wilcox classification method along with the US Salinity Laboratory (USSL) approach, both of which are widely accepted for assessing irrigation water quality. The classification was carried out by analyzing key parameters such as Electrical Conductivity (EC), Sodium Adsorption Ratio (SAR), and overall sodium hazard levels.

Based on these indicators, groundwater samples were grouped into suitable, moderate, permissible, and doubtful categories for agricultural use. High EC values reflected elevated salinity levels, which can reduce soil fertility and hinder plant growth by creating osmotic stress. Similarly, increased sodium concentration and higher SAR values indicated a risk of soil permeability deterioration due to clay dispersion and reduced infiltration capacity. Areas showing severe salinity and sodium hazards were identified as unsuitable for general crops and were recommended only for salt-tolerant crop varieties, along with regulated irrigation scheduling and improved drainage management practices for sustainable agriculture.

3.10 Interpretation and Recommendation Development

The interpreted hydrochemical results were systematically compared with irrigation water quality standards provided by the Bureau of Indian Standards (BIS) and the Food and Agriculture Organization (FAO) guidelines to ensure reliable assessment of groundwater suitability. The evaluation revealed that groundwater samples collected from industrial zones exhibited moderate to high salinity and sodium hazards, making them less suitable for conventional agricultural use without proper management.

These conditions can negatively affect soil structure, reduce permeability, and limit crop productivity over time. Based on these findings, several recommendations were proposed, including the adoption of appropriate crop selection strategies, especially salt-tolerant varieties, development of efficient drainage systems, and regular monitoring of soil health. Additionally, periodic groundwater quality assessments were emphasized to track changes over time. The study also suggested the implementation of pollution control measures and sustainable groundwater extraction practices. Overall, the findings clearly demonstrate the significant impact of industrialization on groundwater quality and highlight the need for scientific irrigation management in the Rewari industrial region.

4. Results & Discussion

4.1 Evaluation of Irrigation Water Quality Parameters

Groundwater samples in the study area were systematically evaluated using key irrigation water quality parameters, including Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium Adsorption Ratio (SAR), Sodium Percentage (Na%), and Residual Sodium Carbonate (RSC). These parameters are essential for understanding the salinity, sodicity, and overall suitability of water for agricultural use. The EC values ranged from 1210 to 1780 µS/cm, indicating moderate to high salinity hazards, which can create osmotic stress in plants and reduce their ability to absorb water efficiently. Similarly, TDS values varied between 680 and 828 mg/L, reflecting moderate levels of dissolved mineral content in the groundwater. The elevated salinity and mineralization levels suggest a potential risk to soil health, particularly affecting soil permeability and aeration over long-term irrigation use. Continuous application of such water may lead to salt accumulation in the root zone, ultimately reducing soil fertility and negatively impacting crop growth and agricultural productivity in the region.

Table 4. 1 EC–TDS Relationship and Salinity Assessment

Monitoring Location	EC µS/cm	TDS mg/L	TDS/EC Ratio	Salinity Interpretation
Borewell, HSIIDC Park, Sector-1, IMT Manesar	1610	816	0.507	Moderately saline
Tubewell No. 6, HSIIDC, Sector-8, IMT Manesar	1620	828	0.511	Moderately saline
Tubewell No. 4, Haily Mandi, Pataudi	1780	784	0.440	High ionic concentration
Tubewell HSIIDC, Sector-37	1780	784	0.440	High ionic concentration
Borewell, Ansal Pioneer Industrial Park, Pathreri	1210	680	0.562	Moderate mineralization
Borewell, Water Works, Sector-35, NH-8	1350	712	0.527	Moderate mineralization
Borewell, PHED Office, Pataudi	1410	732	0.519	Moderate mineralization

The EC–TDS ratio remains mostly between 0.44 and 0.56, showing that dissolved ionic salts are the major contributors to conductivity. The highest EC values were observed at Tubewell

No. 4, Haily Mandi, Pataudi and Tubewell HSIIDC, Sector-37, both at 1780 µS/cm, suggesting stronger salinity influence, likely due to industrial and urban land-use impact.

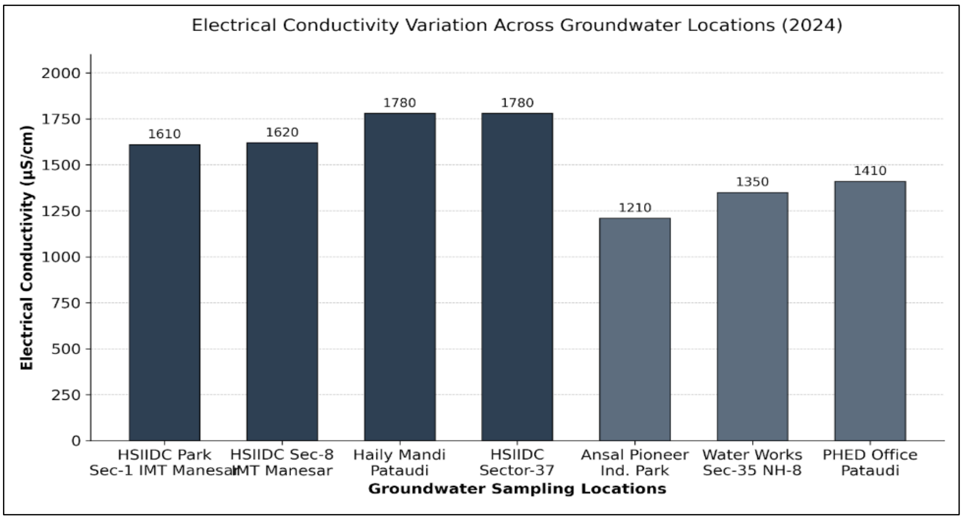

Figure 4. 1 Electrical Conductivity Variation

EC values in the study area range from 1210–1780 µS/cm, indicating moderate to high salinity conditions. Higher EC values were recorded at Haily Mandi, Pataudi, and HSIIDC Sector-37, reflecting possible industrial and urban influences, while the lowest was observed at Ansal Pioneer Industrial Park, Pathreri. Most samples exceed the BIS desirable limit of 1500 µS/cm, suggesting significant dissolved salt content. Elevated EC is attributed to rock–water interaction, longer groundwater residence time, and anthropogenic inputs such as industrial effluents and wastewater infiltration. Prolonged use may increase soil salinity and reduce agricultural productivity, requiring careful irrigation management and soil monitoring practices accordingly.

4.2 Hydrochemical Index Analysis

Hydrochemical indices revealed SAR values between 4.5 and 7.8, indicating low to moderate sodium hazards. Sodium Percentage (Na %) values ranged from 48–60%, showing increasing sodium dominance in industrial areas. RSC values remained within safe to marginal limits (0.8–1.6 meq/L). Locations such as Haily Mandi and HSIIDC Sector-37 showed higher salinity and sodium hazards, making them suitable mainly for salt-tolerant crops.

Table 4. 2 Irrigation Suitability Based on Hydrochemical Indices (2024)

Monitoring Location	EC (µS/cm)	TDS (mg/L)	SAR	Na%	RSC (meq/L)	Irrigation Suitability
HSIIDC Park Sector-1, IMT Manesar	1610	816	6.2	54	1.2	Moderate – salinity & sodium hazard
HSIIDC Sector 8,	1620	828	6.5	56	1.4	Moderate – requires management

IMT Manesar						
Haily Mandi, Pataudi	1780	784	7.8	60	1.6	High sodium hazard – salt-tolerant crops
HSIIDC Sector-37	1780	784	7.6	59	1.5	High sodium hazard
Ansal Pioneer Industrial Park	1210	680	4.5	48	0.8	Suitable
Water Works Sector-35	1350	712	5.2	50	1.0	Suitable with monitoring
PHED Office, Pataudi	1410	732	5.5	52	1.1	Moderate suitability

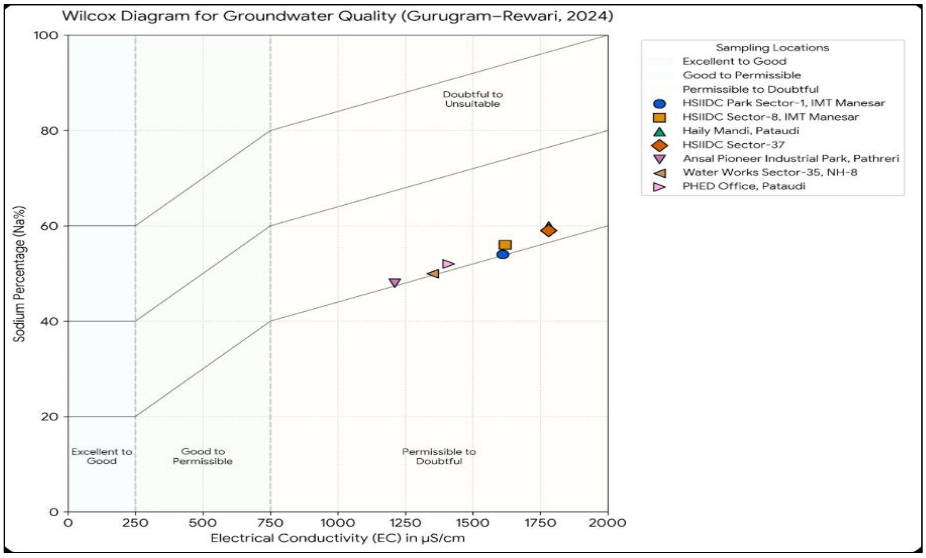

Figure 4. 2 Wilcox Diagram for Groundwater quality

Groundwater irrigation suitability was assessed using EC, TDS, SAR, Na%, and RSC. EC (1210–1780 µS/cm) indicates medium to high salinity, while TDS (680–828 mg/L) shows moderate mineralization. SAR (4.5–7.8) reflects low to moderate sodium hazard, and Na% (48–60%) indicates increasing sodium dominance in industrial areas. RSC (0.8–1.6 meq/L) suggests safe to marginal alkalinity levels. Overall, water falls in C3–S1 to C3–S2 classes, suitable for irrigation with management. Some locations show higher salinity requiring salt-

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tolerant crops. Continuous use may risk soil degradation, hence crop selection, monitoring, and proper drainage are recommended for sustainability.

4.3 Hydrochemical Facies Classification

Piper diagram analysis showed that groundwater samples predominantly belong to mixed Ca–Mg–Cl and Na–Cl hydrochemical facies. This indicates combined influence of rock-water interaction, mineral dissolution, and anthropogenic contamination from industrial discharge. Chloride-rich facies suggest secondary salinization processes associated with industrialization and urban wastewater infiltration.

Table 4. 3 EC–TDS Relationship and Salinity Assessment

Monitoring Location	EC µS/cm	TDS mg/L	TDS/EC Ratio	Salinity Interpretation
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The EC–TDS ratio remains mostly between 0.44 and 0.56, showing that dissolved ionic salts are the major contributors to conductivity. The highest EC values were observed at Tubewell No. 4, Haily Mandi, Pataudi and Tubewell HSIIDC, Sector-37, both at 1780 µS/cm, suggesting stronger salinity influence, likely due to industrial and urban land-use impact.

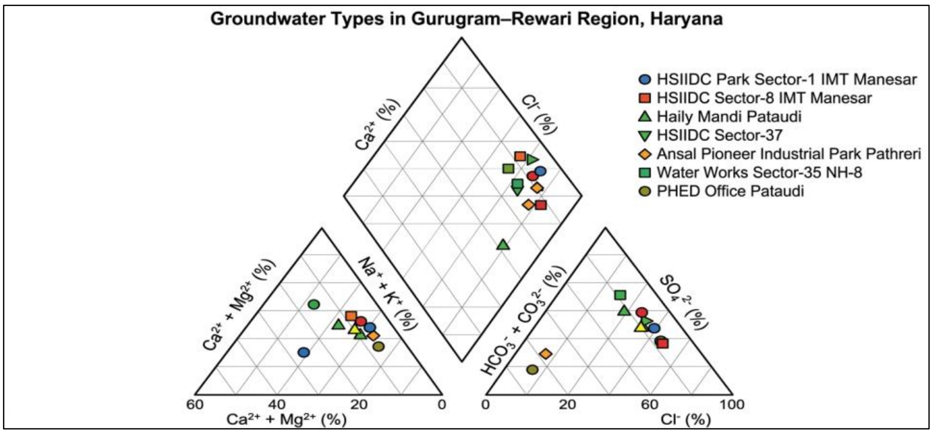

Figure 4. 3 Piper Diagram of Groundwater types

Piper diagram shows mixed Ca–Mg–Cl and Na–Cl groundwater types, indicating transitional cation and anion dominance. Results suggest ion exchange, rock–water interaction, and anthropogenic impacts from industrial and urban waste. Chloride-rich facies reflect secondary salinization, confirming moderate mineralization and combined geogenic and human influence on groundwater quality.

4.4 Irrigation Suitability Classification

Based on Wilcox classification and the US Salinity Laboratory (USSL) approach, groundwater samples were categorized into moderate to permissible irrigation suitability classes depending on EC and SAR values. The analysis showed spatial variability in water quality across the study area. Locations such as Ansal Pioneer Industrial Park and Water Works Sector-35 demonstrated comparatively better suitability for irrigation due to lower salinity and sodium hazards. In contrast, Haily Mandi and HSIIDC Sector-37 exhibited higher salinity risks, making them less favorable for sensitive crops. These results suggest that groundwater can still be utilized for irrigation, but requires careful soil management, controlled irrigation practices, and suitable crop selection.

4.5 Comparative Analysis of Groundwater and Surface Water

Surface water bodies such as Gurgaon Canal and Sultanpur Lake showed significantly higher BOD and microbial contamination compared to groundwater, indicating strong organic and sewage pollution inputs. In contrast, groundwater was primarily affected by salinity and mineralization rather than direct biological contamination. This highlights a clear difference in pollution characteristics between the two water sources. While surface water quality is heavily degraded due to untreated domestic and wastewater discharge, groundwater remains comparatively stable but influenced by dissolved salts and geochemical processes. As a result, groundwater is relatively more suitable for irrigation than untreated surface water, provided that salinity levels are properly managed and monitored for long-term agricultural use.

Table 4. 4 Comparative Pollution Status of Water Sources

Water Source	Main Problem	Highest Reported Value	Interpretation
Groundwater monitoring locations	High TDS and EC	TDS 828 mg/L; EC 1780 µS/cm	Mineralized groundwater
Sultanpur Lake	High BOD and coliform	BOD 21 mg/L; TC 11000 MPN/100 ml	Organic and sewage pollution
Gurgaon Canal	Very high microbial load	TC 95000 MPN/100 ml	Severe sewage contamination
Water Works, Gurgaon	Raw water microbial load	TC 5600 MPN/100 ml	Treatment essential

Near HUDA/HSVP Water Works, Basai	Moderate microbial load	TC 3800 MPN/100 ml	Treatment required

The comparison of different water sources shows distinct pollution characteristics. Groundwater monitoring locations are mainly affected by high TDS (828 mg/L) and EC (1780 µS/cm), indicating mineralized water conditions. In contrast, Sultanpur Lake exhibits high organic pollution with BOD levels up to 21 mg/L and coliform counts of 11,000 MPN/100 ml, reflecting sewage contamination. Gurgaon Canal shows severe microbial pollution with extremely high total coliform values (95,000 MPN/100 ml). Water from the Water Works, Gurgaon also contains microbial load (5,600 MPN/100 ml), requiring proper treatment before use. Similarly, near HUDA/HSVP Water Works, Basai, moderate contamination (3,800 MPN/100 ml) is observed, indicating the need for treatment prior to consumption or distribution.

5. Conclusion

In conclusion, the present study evaluated the groundwater suitability for irrigation in the Rewari industrial area through detailed physicochemical and hydrochemical assessments. The analysis of 11 groundwater samples revealed moderate to high salinity conditions, with EC ranging from 1210 to 1780 µS/cm and TDS from 680 to 828 mg/L, indicating significant mineralization influenced by both natural processes and anthropogenic activities. Hydrochemical facies identified through the Piper diagram showed dominance of mixed Ca–Mg–Cl and Na–Cl types, reflecting ion exchange processes and progressive salinization due to industrial and urban impacts. Irrigation water quality assessment using Wilcox and USSL classifications categorized most samples under moderate to permissible suitability classes, while sites such as Haily Mandi and HSIIDC Sector-37 exhibited higher salinity and sodium hazards, limiting their use to salt-tolerant crops. Comparative analysis showed that groundwater is relatively more suitable for irrigation than surface water, which is severely affected by microbial and organic pollution. However, continuous use of such mineralized groundwater may lead to soil degradation, reduced permeability, and declining agricultural productivity. Therefore, the study emphasizes the need for sustainable groundwater management practices, including controlled irrigation, crop diversification, efficient drainage systems, and regular monitoring to ensure long-term agricultural sustainability in the region.

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