# International Journal of Engineering Research and Science & Technology

IJERST

www.ijerst.org

ISSN : 2319-5991

Vol. 22 No. 1 (2026)

ijerst.editor@gmail.com
editor@ijerst.com

*ISSN 2319-5991* www.ijerst.com
*Vol. 22, No. 1, 2026*

*Peer Reviewed, Referred & Indexed Journal*

**Research Paper**

# PHYSIOCHEMICAL ASSESSMENT OF SEWAGE AND GROUNDWATER AND ITS IMPACT ON SOIL QUALITY IN RATANGARH TEHSIL, CHURU DISTRICT

***Tarun Vijay Chotia[1], Dr. Sangeeta Sharma[2]***

1. *Research Scholar, Department of Chemistry, MGS University, Bikaner (Raj.)*
2. *Professor (Rtd.), Department of Chemistry, Govt. Dungar College, Bikaner (Raj.)*

**Abstract:** Owing to increasing water scarcity and dependence on untreated sewage water for irrigation in the Ratangarh (Churu) region, a systematic analysis was undertaken to understand the extent of environmental degradation and potential risks to agriculture and human health. The present study evaluates the physicochemical characteristics of sewage water, groundwater, and soil in Ratangarh tehsil of Churu district, Rajasthan. The results revealed notable variations in water and soil quality, with sewage water exhibiting elevated levels of dissolved solids, nutrients, and contaminants compared to groundwater. Continuous use of sewage water for irrigation was found to influence soil properties, particularly salinity, nutrient imbalance, and accumulation of trace metals, leading to gradual degradation of soil quality. Sewage water analysis showed high electrical conductivity (2.64–4.45 mS/m), organic carbon (812–942 mg $l^{-1}$), nitrogen (116–188 mg $l^{-1}$), sulphur (44.8–66.7 mg $l^{-1}$), and phosphate (0.61–4.10 mg $l^{-1}$). Trace metal assessment revealed iron (1.49–2.86 mg $l^{-1}$), copper (0.12–0.79 mg $l^{-1}$), zinc (0.13–1.35 mg $l^{-1}$), manganese (0.28–0.70 mg $l^{-1}$), chromium (0.12–0.19 mg $l^{-1}$), nickel (0.17–0.27 mg $l^{-1}$), lead (0.02–0.09 mg $l^{-1}$), and critically elevated cadmium (4.23–9.30 mg $l^{-1}$), exceeding CPHEEO limits. Soil samples from sewage-irrigated areas showed pH values of 7.03–7.23, EC of 1.01–1.99 dS/m, organic carbon of 0.39–0.97%, and excessive accumulation of nitrogen (35–196 mg $kg^{-1}$), phosphorus (27–35 mg $kg^{-1}$), and potassium (31–96 mg $kg^{-1}$). Groundwater samples exhibited high EC (2.45–5.20 dS/m), TDS (1214–2286 mg $l^{-1}$), hardness (274–808 mg $l^{-1}$), and magnesium (47–104 mg $l^{-1}$), resulting in moderate to poor water quality (WQI: 46.9–123.9). The findings indicate that while sewage irrigation provides short-term nutrient benefits, its prolonged use leads to soil degradation, roundwater deterioration, and potential risks to crop safety and human health.

**Keywords:** Physicochemical analysis; Sewage; Groundwater; Soil; Water Quality Index (WQI); Soil salinity; Human health.

Received: 10-01-2026 Accepted: 18-02-2026 Published: 25-02-2026

## 1. Introduction: -

Water is essential for the survival of all living organisms on the planet. Naturally, it is found in oceans, ice and glaciers, underground, and on land. Nevertheless, freshwater is continually replenished during the hydrological cycle. It regulates the timing and location of water movement through processes such as evapotranspiration, precipitation, and runoff (Kundzewicz, 2008). The quantity and rate of groundwater recharge are inherently dependent on effective groundwater resource management. Water is a crucial resource for industrial and economic advancement. It serves multiple purposes like as consumption, leisure, industrial applications, and irrigation. Furthermore, it plays a crucial function in maintaining the integrity of natural systems (Bierkens and Wada, 2019; Moniruzzaman et al., 2025; Gebreslassie et al., 2025). Water is the most crucial resource on Earth of all the many resources available. It is a crucial component for all social, economic, and developmental endeavors. The condition of the water supply is influenced by factors such as soil type, vegetation cover, human activities, and usage patterns. Water is the sole chemical compound on this planet that exists in solid, liquid, and gaseous states. Precipitation is the primary means by which groundwater is replenished. Additional sources encompass replenishment from rivers, streams, and irrigation water, among others. Groundwater is an inconspicuous and concealed resource (Shaker et al., 2023). Once, the purity and availability of it were assumed without question. Currently, pollution and accessibility pose significant concerns. Scientists approximate that groundwater constitutes about 95% of the total fresh water accessible for utilization. Roughly 50% of cultivated land that is watered utilizes underground water sources. Groundwater satisfies approximately 33% of the water requirements in the industrial sector. Approximately 40% of the total river flow across the country, on average, is contingent upon groundwater. Groundwater is an essential element in the management plans created by a growing number of Watershed partnerships.

The primary sources of soil, water, and plant pollution are sewage sludge, industrial factory leftovers, and intensive fertilization (Bahuguna et al., 2022; Katoch and Dahiya, 2024; Antil, 2012; Dwivedi et al., 2019; Ghazaryan et al., 2024). The utilization of industrial or municipal wastewater is a prevalent method in various regions worldwide, including India, particularly in suburban areas. Utilizing sewage effluents for irrigating agricultural land is a common technique globally. Consequently, the nutrient levels in soils are anticipated to rise through the ongoing irrigation with sewage water (Obijianya et al., 2025; Chojnacka et al., 2020; Al Hamedi et al., 2023; Moradinejad, 2022; Amahmid et al., 2022). The issue of contamination and the quality of irrigation water is a primary concern, particularly in Rajasthan with scarce water resources. Water resources in this region should be both efficiently exploited and protected against contamination. It is particularly prevalent in western region of Rajasthan, where the expense of water treatment is significant. In order to understand the extent of pollution, it is required to conduct thorough research. Therefore, the objective of this study is to do a thorough physicochemical examination of soil, sewage, and groundwater samples obtained from the sewage areas and village panchayats of Ratangarh, Churu District, Rajasthan.

## 2. Research Methodology: -

The study was designed to comprehensively assess the quality of sewage, groundwater and soil in the Ratangarh area and understand their impact on agricultural practices. The primary objectives of the research include the collection of sewage, groundwater and soil samples from various locations in the area, followed by a detailed physicochemical analysis of these samples under controlled laboratory conditions. The aim was to analyze parameters and specific contaminants in water and soil samples. The sample size includes 62 sewage and groundwater samples and 62 soil samples, which will be collected from 4 sewage areas in Ratangarh and 5 village Panchayats in the district. Specific sites for sewage sampling include areas near NH-11, the Power House on the Mega Highway to Sardarshahar, Ward No. 9 in Bika Bass, and near the BSNL office in Ratangarh. Additionally, groundwater and soil samples were obtained from the villages of Loonch, Ladhasar, Jaleu, Loha, and Derajsar, with 10 sites selected from each of these Panchayats.

**Study Area:** The study is based in the Ratangarh tehsil of Churu District. Ratangarh is situated at coordinates 28.08°N 74.6°E. The average elevation is 312 meters (1023 feet). Ratangarh is located in the Thar Desert, namely on the dhoras, which are enormous sand dunes. Several neighbourhoods in the town are named after these landmarks.

**Fig 1: Study Area**

**Procedure for Collection of Sewage and Groundwater Samples:** Water and Sewage samples were collected from various locations using a glass or plastic bottle that had undergone a washing and rinsing process. Sample collection was conducted in close proximity to floating debris or any other potential pollutants.

- **Tools and Accessories:**
    - **Sampling Containers:** Clean and pre-washed glass plastic bottles were utilized to prevent contamination.
    - **Protective Gear:** Hand gloves and face masks were worn during sample collection to maintain safety and sample purity.
- **Collection Procedure:**
    - **Sewage Samples:** Samples were collected from designated sites near NH-11, the Power House on the Mega Highway to Sardarshahar, Ward No. 9 in Bika Bass, and near the BSNL office in Ratangarh.
    - **Groundwater Samples:** Samples were obtained from wells or boreholes in the five selected village Panchayats: Loonch, Ladhasar, Jaleu, Loha, and Derajsar.
    - **Volume:** A minimum of 1 liter was collected for each sample to ensure sufficient volume for all required analyses.
    - **Handling:** Care was taken to prevent contact between the interior of the bottles and external surfaces during collection to avoid contamination.
- **Storage and Transport:**
    - **Preservation:** Samples were immediately refrigerated at 4°C (40°F) to prevent microbial growth and chemical changes.
    - **Transport:** Insulated coolers with ice packs were used to maintain the required temperature during transit to the laboratory.

**Collection of Soil Samples:** Soil samples were collected from various locations using following technique:

- **Tools and Accessories:**
    - **Sampling Tools:** Augers, post hole diggers, or screw augers were employed to extract soil samples.
    - **Containers:** Clean plastic containers or bags were used for combining soil samples.
    - **Protective Gear:** Hand gloves and face masks were worn to ensure safety and sample purity.
- **Collection Procedure:**
    - **Sampling Sites:** Samples were collected from various locations within the four sewage areas and five village Panchayats.
    - **Depth and Quantity:** Soil was extracted from the top 15 cm layer, combining samples from multiple spots to form a composite sample.
    - **Volume:** The composite sample volume was approximately 1 kg.
    - **Handling:** The combined soil sample was placed into a clean plastic container or bag, ensuring it was free from contamination.
- **Storage and Transport:**
    - **Drying:** Soil samples were air-dried at ambient temperature, avoiding direct sunlight and excessive heat.
    - **Sieving:** After drying, the soil was sieved through a 2 mm mesh to remove debris and homogenize the sample.

- **Storage:** The sieved soil was stored in clean, labeled plastic or glass containers, kept away from direct sunlight and moisture.
- **Transport:** Samples were securely packaged to prevent contamination or loss during transit to the laboratory.

**Fig 2: (a) and (b) Collection of Water and Sewage Samples**


**Analysis:** Collected samples were subjected to analysis. Following methods were used for assessing different parameters:

**Table 1: Parameters and Method Used**

| S. No. | Parameters | Method |
|---|---|---|
| 1 | pH | Digital pH Meter |
| 2 | EC | Digital Conductivity Meter |
| 3 | TDS | Evaporation method |
| 4 | Turbidity | Nephlometer. |
| 5 | Total Hardness | EDTA method |
| 6 | Alkalinity | Potentiometer method |
| 7 | Magnesium and Calcium | Titration method |
| 8 | Chloride | Titration with standard $AgNO_3$ |
| 9 | Sulphate | By EDTA method |
| 10 | Organic Carbon | Rapid titration |
| 11 | Available Nitrogen | Alkaline potassium Permanganate |
| 12 | K | By flame photometer |
| 13 | Sulphur | Turbidimetric |
| 14 | Manganese, Copper, Iron, Zinc | Extract with DTPA and determined by AAS. |
| 15 | Cadmium and Lead | AAS |
| 16 | Chromium | Spectrophotometric method |
| 17 | Nickel | ICP-OES |

**Standards for Parameters:** Following standards were used for analysing observations of the physicochemical analysis of different samples.

**Table 2: BIS Standards for Groundwater Parameters**

| S. No. | Groundwater Parameters | BIS Standards (in mg/l where unspecified except pH) |
|---|---|---|
| 1 | Turbidity | 10 % |
| 2 | EC | 750 dS/m |
| 3 | pH | 6.5-8.5 |
| 4 | Total Hardness ($CaCO_3$) | 200-600 |
| 5 | Sulphate | 150-400 |
| 6 | Chlorides | 250-1000 |
| 7 | Calcium Hardness | 75-200 |
| 8 | TDS | 500 |
| 9 | Mg | 30 |
| 10 | Alkalinity | 200-600 |

**Table 3: BIS Standards for Soil Parameters**

| S. No. | Soil Parameters | BIS Standards |
|---|---|---|
| 1 | E.C. | **0.07-6 dS/m** |
| 2 | pH | **6.8-8.0** |
| 3 | Organic Carbon | **0.5-7.5 %** |
| 4 | Available Phosphorus | **<2.5 mg/kg** |
| 5 | Available K | **<60 mg/kg** |
| 6 | Nitrogen | **<50 mg/kg** |
| 7 | Calcium | - |
| 8 | Magnesium | - |
| 9 | Sulphur | - |

**Table 4: CPHEEO Standards for Wastewater Parameters**

| S. No. | Parameters | CPHEEO Standards |
|---|---|---|
| 1 | EC | - |
| 2 | Organic Caron | - |

| | | |
|---|---|---|
| **3** | **Nitrogen** | - |
| **4** | **Phosphorus** | - |
| **5** | **Sulphur** | - |
| **6** | **Iron** | 3.0 |
| **7** | **Copper** | 3.0 |
| **8** | **Zinc** | 15.0 |
| **9** | **Manganese** | |
| **10** | **Cadmium** | 1.0 |
| **11** | **Chromium** | 2.0 |
| **12** | **Nickel** | 3.0 |
| **13** | **Lead** | 1.0 |

### 3. Result and Discussion: -

**Sewage Samples:**

Samples were collected from four different sites namely, Near NH-11, Near Power house on Mega highway to Sardarshahar, Ward no. 9, Bika Bass, Ratangarh and Near BSNL office, Ratangarh. The parameters selected for analysis of sewage samples encapsulate a broad spectrum of chemical constituents and contaminants commonly associated with sewage effluents. These include Electrical Conductivity (EC), Organic Carbon content, and concentrations of essential nutrients such as Nitrogen and Phosphorus, which can influence soil fertility and aquatic ecosystems. Additionally, the presence of Sulphur, Iron, Copper, Zinc, Manganese, Cadmium, Chromium, Nickel, and Lead is examined, as these elements are known to have significant implications for environmental quality and human health when present in sewage effluents.

**Table 5: Mean value for parameters for sewage samples from sewage area**

| Parameter | Site-1 (Near NH-11) | Site-2 (Near Power House, Mega High way) | Site-3 (Ward No. 9, Bika Bass) | Site-4 (Near BSNL Office) |
|---|---|---|---|---|
| **EC (mS/m)** | 2.7157 | 2.638 | 4.4533 | 3.152 |
| **Organic Carbon (mg $l^{-1}$)** | 941.8533 | 845.9067 | 891.56 | 812.55 |
| **Nitrogen (mg $l^{-1}$)** | 115.9067 | 170.5367 | 188.2233 | 159.85 |
| **Total Phosphate (mg $l^{-1}$)** | 4.1 | 4.03 | 0.61 | 3.2133 |
| **Sulphur (mg $l^{-1}$)** | 49.83 | 52.63 | 44.85 | 66.6967 |
| **Iron (mg $l^{-1}$)** | 1.52 | 1.4933 | 2.86 | 1.98 |
| **Copper (mg $l^{-1}$)** | 0.79 | 0.7767 | 0.116 | 0.52 |
| **Zinc (mg $l^{-1}$)** | 1.35 | 1.33 | 0.1327 | 0.5643 |
| **Manganese (mg $l^{-1}$)** | 0.7 | 0.69 | 0.28 | 0.54 |
| **Cadmium (mg $l^{-1}$)** | 4.2267 | 4.2867 | 9.3 | 5.3567 |
| **Chromium (mg $l^{-1}$)** | 0.19 | 0.14 | 0.15 | 0.12 |
| **Nickel (mg $l^{-1}$)** | 0.27 | 0.22 | 0.17 | 0.21 |
| **Lead (mg $l^{-1}$)** | 0.07 | 0.0233 | 0.088 | 0.0333 |
| **WQI** | 1049.719 | 949.521 | 1049.94 | 927.357 |

The physicochemical analysis of sewage samples collected from four locations in Ratangarh tehsil reveals substantial spatial variation in pollution load and provides clear evidence of severe wastewater contamination. The results have been evaluated in light of the CPHEEO standards for wastewater parameters to assess their suitability for discharge or reuse. Electrical conductivity (EC), organic carbon, nitrogen, phosphorus, and sulphur do not have prescribed CPHEEO limits; however, their very high values across all sites indicate excessive dissolved salts, organic load, and nutrient enrichment. EC values ranged from 2.64 to 4.45 mS/m, reflecting a high ionic concentration in sewage water, which can adversely affect soil salinity when used for irrigation. Organic carbon concentrations were extremely high at all sites (812.55–941.85 mg $l^{-1}$), signifying a heavy organic load typical of untreated domestic sewage. Similarly, elevated nitrogen (115.9–188.2 mg $l^{-1}$) and phosphate levels (0.61–4.10 mg $l^{-1}$) indicate strong eutrophication potential and pose risks of nutrient imbalance in soils and contamination of groundwater. Sulphur concentrations ranged from 44.85 to 66.70 mg $l^{-1}$, suggesting contributions from detergents, organic waste, and possibly industrial effluents. Although no CPHEEO limit is specified for sulphur, such levels may contribute to soil sulphate accumulation and long-term degradation. Among the regulated heavy metals, iron concentrations (1.49–2.86 mg $l^{-1}$) at all sites remained within the CPHEEO permissible limit of 3.0 mg $l^{-1}$, though Site-3 approached the upper threshold, indicating a potential future risk if loading continues. Copper (0.12–0.79 mg $l^{-1}$) and zinc (0.13–1.35 mg $l^{-1}$) concentrations were well below their respective limits of 3.0 mg $l^{-1}$ and 15.0 mg $l^{-1}$, suggesting limited contamination from these metals. In contrast, cadmium levels were alarmingly high at all sites, ranging from 4.23 to 9.30 mg $l^{-1}$, far exceeding the CPHEEO permissible limit of 1.0 mg $l^{-1}$. This indicates serious cadmium contamination and represents a major environmental and public health concern due to its high toxicity, persistence, and tendency to accumulate in soils and crops. Chromium (0.12–0.19 mg $l^{-1}$), nickel (0.17–0.27 mg $l^{-1}$), and lead (0.02–0.09 mg $l^{-1}$) were found to be within the CPHEEO limits of 2.0, 3.0, and 1.0 mg $l^{-1}$, respectively, though their continuous input through sewage irrigation may still lead to gradual buildup in soil.

The Water Quality Index (WQI) values for all sewage samples were extremely high, ranging from 927.36 to 1049.94, clearly categorizing the sewage water as severely polluted. Site-1 and Site-3 recorded the highest WQI values, indicating the poorest water quality, which aligns with their higher organic load, nutrient concentrations, and cadmium levels. Overall, comparison with CPHEEO standards reveals that while most metals such as iron, copper, zinc, chromium, nickel, and lead are presently within permissible limits, cadmium contamination is far beyond acceptable levels, and the excessive organic and nutrient load makes the sewage water unsuitable for direct agricultural use. The findings strongly emphasize the need for effective wastewater treatment, continuous monitoring, and strict regulation before reuse of sewage water for irrigation, in order to prevent soil degradation, crop contamination, and associated human health risks.

**Soil Samples:**

The selected parameters for analysis of soil samples encompass various aspects of soil physicochemical properties and nutrient availability, offering insights into the current state of soil quality and potential impacts of sewage contamination. These parameters include pH, Electrical Conductivity (EC), Organic Carbon and Organic Matter content, as well as concentrations of key nutrients such as Available Nitrogen, Phosphorus, Calcium, Magnesium, Potassium, and Sulphur.

**Table 6: Mean value for parameters for soil samples from sewage area**

| Parameter | Site-1 (Near NH-11) | Site-2 (Near Power House, Mega Highway) | Site-3 (Ward No. 9, Bika Bass) | Site-4 (Near BSNL Office) |
|---|---|---|---|---|
| **pH** | 7.2267 | 7.12 | 7.0333 | 7.16 |
| **Electrical Conductivity (mS/m)** | 1.86 | 1.9933 | 1.01 | 1.5533 |
| **Organic Carbon (%)** | 0.9667 | 0.9567 | 0.96 | 0.39 |
| **Organic** | 108.2 | 102.23 | 96.23 | 88.5 |

| | | | | |
|---|---|---|---|---|
| **Matter (mg/l)** | 667 | 33 | 33 | |
| **Available Nitrogen (mg/l)** | 35.2667 | 82.25 | 195.5533 | 54.55 |
| **Phosphorus (mg/l)** | 27.1667 | 28.24 | 32.1367 | 35.45 |
| **Calcium (mg/l)** | 46.5667 | 65.2333 | 88.3 | 56.2333 |
| **Magnesium (mg/l)** | 53.2667 | 40.5 | 35 | 48.5 |
| **Potassium (mg/l)** | 31 | 53.6 | 96.01 | 65.5 |
| **Sulphate (mg/l)** | 61.6 | 60.5 | 61.3133 | 65.5667 |

The physicochemical characteristics of soil samples collected from sewage-affected areas of Ratangarh tehsil were evaluated and compared with the BIS standards to assess the influence of continuous sewage irrigation on soil quality. The results indicate notable variations among sites, reflecting localized impacts of wastewater application and associated anthropogenic activities. Soil pH values across all sites ranged from 7.03 to 7.23, which fall well within the BIS permissible range of 6.8–8.0. This indicates that the soils are slightly alkaline to near neutral and suitable for crop growth. The relatively stable pH suggests that sewage irrigation has not caused extreme acidification or alkalization of soils in the study area. Electrical conductivity (EC) values varied between 1.01 and 1.99 dS/m, remaining within the BIS acceptable range of 0.07–6 dS/m. These values indicate low to moderate salinity levels. Although current EC levels do not pose an immediate threat to soil health, continued sewage irrigation may gradually increase salinity, particularly in arid regions such as Ratangarh where leaching is limited.

Organic carbon (OC) content ranged from 0.39% to 0.97%. Sites 1, 2, and 3 showed OC values within the BIS recommended range (0.5–7.5%), reflecting enrichment of organic matter due to sewage inputs. However, Site-4 recorded a lower OC value (0.39%), slightly below the BIS threshold, indicating reduced organic matter accumulation and potential decline in soil fertility at this location. Available nitrogen exhibited substantial variation across sites. Site-1 recorded nitrogen levels below the BIS limit of <50 mg/kg, while Sites-2, 3, and 4 exceeded this limit significantly, with Site-3 showing exceptionally high nitrogen concentration (195.55 mg/l). Elevated nitrogen levels indicate excessive nutrient loading from sewage, which may enhance short-term crop growth but increases the risk of nitrate leaching, groundwater contamination, and nutrient imbalance in the long term. Phosphorus concentrations at all sites (27.17–35.45 mg/l) were far above the BIS guideline of <2.5 mg/kg. This excessive phosphorus enrichment is characteristic of sewage-irrigated soils and poses a risk of eutrophication of nearby water bodies, as well as nutrient antagonism affecting plant uptake of other essential elements. Potassium levels varied widely, ranging from 31 mg/l at Site-1 to 96.01 mg/l at Site-3. While Site-1 and Site-2 remained within or near the BIS guideline of <60 mg/kg, Sites-3 and 4 exceeded this limit, indicating potassium accumulation due to prolonged sewage application. Excess potassium may interfere with calcium and magnesium uptake by plants, potentially affecting crop quality. Furthermore, elevated calcium and magnesium levels suggest increased base saturation, while sulphate concentrations (60.5–65.57 mg/l) reflect continuous sulphur input from sewage sources, detergents, and organic waste. Overall, comparison with BIS standards reveals that while soil pH and EC remain within acceptable limits, excessive accumulation of nitrogen, phosphorus, and potassium at certain sites indicates nutrient imbalance and emerging risks of soil degradation. The findings demonstrate that sewage irrigation has a dual effect—temporarily improving organic matter and nutrient availability while simultaneously increasing the risk of long-term soil fertility decline and environmental contamination. These results highlight the need for controlled sewage application, periodic soil monitoring, and integrated nutrient management strategies to maintain sustainable soil health in sewage-affected agricultural areas.

**Samples Collection from Village panchayats of Ratangarh:**

This part focused on conducting an analysis of soil and groundwater samples collected from select village panchayats in Ratangarh namely, Loonch, Ladhasar, Jaleu, Loha and Derajsar.

**Soil Samples:**

The parameters selected for analysis of soil samples represent fundamental aspects of soil physicochemical properties and nutrient availability, offering valuable insights into the current state of soil quality and agricultural potential. These parameters include pH, Electrical Conductivity (EC), Organic Carbon and Organic Matter content, as well as concentrations of key nutrients such as Available Nitrogen, Phosphorus, Calcium, Magnesium, Potassium, and Sulphur.

**Table 7: Mean value for parameters for soil samples from different village panchayat**

| Parameter | Site-1 (Loonch) | Site-2 (Ladhasar) | Site-3 (Jaleu) | Site-4 (Loha) | Site-5 (Derajsar) |
|---|---|---|---|---|---|
| **pH** | 7.24 | 6.34 | 7.22 | 8.44 | 7.23 |
| **Electrical Conductivity (dS/m)** | 0.56 | 0.37 | 0.67 | 0.73 | 0.45 |
| **Organic Carbon (%)** | 0.55 | 0.45 | 0.55 | 0.36 | 0.25 |
| **Organic Matter** | 0.92 | 0.86 | 0.94 | 0.74 | 0.65 |
| **Available Nitrogen (mg/kg)** | 273.74 | 241.86 | 159.84 | 190.94 | 265.61 |
| **Phosphorus (mg/kg)** | 11.71 | 17.65 | 20.34 | 25.94 | 15.66 |
| **Calcium (mg/kg)** | 6.23 | 6.55 | 8.23 | 7.63 | 5.36 |
| **Magnesium (mg/kg)** | 3.35 | 8.27 | 4.24 | 5.54 | 2.34 |
| **Potassium (mg/kg)** | 462.92 | 455.93 | 399.57 | 416.65 | 482.84 |
| **Sulphur (mg/kg)** | 15.21 | 20.26 | 30.26 | 48.34 | 16.19 |

The physicochemical analysis of soil samples collected from five village panchayats of Ratangarh tehsil provides valuable insights into soil health and fertility status when compared with the Bureau of Indian Standards (BIS) guidelines for soil parameters. The pH of the soils ranged from 6.34 to 8.44. According to BIS standards (6.8–8.0), soils from Loonch (7.24), Jaleu (7.22), and Derajsar (7.23) fall within the desirable range, indicating favorable conditions for most crops. However, Ladhasar (6.34) exhibited slightly acidic soil, while Loha (8.44) showed alkaline conditions, exceeding the BIS upper limit. Such deviations in pH can influence nutrient availability and microbial activity, potentially affecting crop productivity. The electrical conductivity (EC) values varied between 0.37 and 0.73 dS/m, which are well within the BIS permissible range of 0.07–6 dS/m. This indicates that the soils are non-saline in nature and currently suitable for agricultural cultivation without immediate salinity stress.

Organic carbon (OC) content ranged from 0.25% to 0.55%. As per BIS standards (0.5–7.5%), soils from Loonch and Jaleu (0.55%) marginally meet the minimum requirement, whereas Ladhasar (0.45%), Loha (0.36%), and Derajsar (0.25%) fall below the recommended threshold. Low organic carbon levels suggest poor soil structure, reduced microbial activity, and limited nutrient retention capacity, highlighting the need for organic amendments. The available nitrogen content was exceptionally high across all sites, ranging from 159.84 to 273.74 mg/kg, far exceeding the BIS guideline value of <50 mg/kg. Such elevated nitrogen levels may be attributed to anthropogenic inputs, including fertilizer application and organic waste incorporation. While nitrogen is essential for plant growth, excessive concentrations can lead to nutrient imbalance, groundwater contamination through leaching, and environmental pollution. Similarly, available phosphorus concentrations (11.71–25.94 mg/kg) at all sites were significantly higher than the BIS recommended limit of <2.5 mg/kg. This excessive phosphorus accumulation indicates a high risk of nutrient runoff and eutrophication of nearby water bodies, and it may also interfere with the uptake of micronutrients by plants. Potassium levels were extremely high across all village panchayats, ranging from 399.57 to 482.84 mg/kg, substantially exceeding the BIS guideline value of <60 mg/kg. Although potassium enhances crop yield and stress tolerance, excessive potassium can disrupt nutrient balance and reduce the availability of calcium and magnesium to plants. Furthermore, elevated sulphur levels, particularly at Loha (48.34 mg/kg), may influence soil acidity and long-term fertility if accumulation continues. Overall, the comparison with BIS standards indicates that while salinity levels are within safe limits, nutrient concentrations—especially nitrogen, phosphorus, and potassium—are excessively high, reflecting nutrient enrichment likely caused by intensive fertilizer use or organic waste inputs. Additionally, low organic carbon content in several locations points to declining soil quality. These findings emphasize the need for balanced nutrient management, incorporation of organic matter, and site-specific soil fertility practices to ensure sustainable agricultural productivity in the Ratangarh tehsil.

**Groundwater Samples:**

The parameters selected for analysis of groundwater samples include pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Turbidity, Total Hardness, Alkalinity, as well as concentrations of Calcium, Magnesium, Chloride, and Sulphate.

**Table 8: Mean value for parameters for groundwater samples from different village panchayat**

| Parameter | Site-1 (Loonch) | Site-2 (Ladhasar) | Site-3 (Jaleu) | Site-4 (Loha) | Site-5 (Derajsar) |
|---|---|---|---|---|---|
| **pH** | 7.89 | 7.154 | 7.56 | 9.038 | 7.311 |
| **Electrical Conductivity (dS/m)** | 2.9787 | 2.4474 | 2.6108 | 5.1987 | 4.6066 |
| **Total Dissolved Solids (mg/l)** | 1542.7 | 1214.2 | 1259.7 | 2223.7 | 2285.5 |
| **Turbidity (%)** | 0 | 0.541 | 10.11 | 0.0303 | 0.205 |
| **Total Hardness (mg/l)** | 483.3 | 273.6 | 375.1 | 660 | 808.1 |
| **Alkalinity (mg/l)** | 143.9 | 152.5 | 121.1 | 132.2 | 124.9 |
| **Calcium (mg/l)** | 78.8 | 51.5 | 58.5 | 84.2 | 161.6 |
| **Magnesium (mg/l)** | 72.2 | 47.2 | 60.9 | 103.7 | 99.3 |
| **Chloride (mg/l)** | 246.7 | 214.1 | 177.9 | 191 | 200.8 |
| **Sulphate (mg/l)** | 121.7 | 135.7 | 107.1 | 119.8 | 115.2 |
| **WQI** | 77.1136 | 46.9937 | 73.7644 | 123.8693 | 90.9374 |

The physicochemical characteristics of groundwater samples collected from five village panchayats of Ratangarh tehsil were evaluated and compared with the Bureau of Indian Standards (BIS) guidelines to assess their suitability for domestic and agricultural use. The pH of groundwater ranged from 7.15 to 9.04. According to BIS standards (6.5–8.5), groundwater from Loonch, Ladhasar, Jaleu, and Derajsar falls within the acceptable range, indicating slightly alkaline but generally suitable water. However, Loha (pH 9.04) exceeds the upper permissible limit, reflecting strong alkalinity, which may affect taste, scaling, and the solubility of minerals. Electrical conductivity (EC) values varied from 2.45 to 5.20 dS/m. Although the BIS limit for EC is indicated as 750 (units unspecified), the observed EC values suggest elevated ionic concentration, particularly at Loha and Derajsar, indicating saline tendencies and potential restrictions for irrigation and domestic use.

The Total Dissolved Solids (TDS) concentrations were markedly high at all sites (1214.2–2285.5 mg/l), far exceeding the BIS desirable limit of 500 mg/l. Such high TDS values indicate mineral-rich groundwater, which can lead to unpleasant taste, scaling of pipes, and potential health effects upon prolonged consumption. Turbidity values were generally low across most sites and remained within the BIS permissible limit of 10%, except Jaleu (10.11%), which slightly exceeded the standard, suggesting localized suspended particulate contamination. Total hardness values ranged from 273.6 to 808.1 mg/l. BIS recommends a range of 200–600 mg/l; thus, groundwater from Loonch, Ladhasar, and Jaleu falls within acceptable limits, while Loha (660 mg/l) and Derajsar (808.1 mg/l) exceed the upper limit, classifying the water as very hard and potentially unsuitable for domestic use without treatment. Alkalinity values (121.1–152.5 mg/l) were below the BIS desirable range of 200–600 mg/l at all sites, indicating low buffering capacity, which may make the water more susceptible to pH fluctuations. Calcium hardness values ranged from 51.5 to 161.6 mg/l. Most sites fall within the BIS acceptable range (75–200 mg/l), except Ladhasar (51.5 mg/l) and Jaleu (58.5 mg/l), which are below the lower limit, suggesting relatively soft calcium contribution to total hardness. Magnesium concentrations were significantly higher than the BIS limit of 30 mg/l at all sites, ranging from 47.2 to 103.7 mg/l. Elevated magnesium contributes to excessive hardness and may cause laxative effects when present in high concentrations. Chloride levels (177.9–246.7 mg/l) were within the BIS permissible range of 250–1000 mg/l at all sites, indicating limited chloride contamination and minimal influence from saline intrusion or sewage sources. Similarly, sulphate concentrations (107.1–135.7 mg/l) were well below the BIS permissible limit of 150–400 mg/l, suggesting that sulphate does not currently pose a major concern in the study area. The Water Quality Index (WQI) values indicate spatial variability in overall groundwater quality. Ladhasar (WQI 46.99) falls in the good water quality category, while Loonch and Jaleu exhibit moderate water quality. In contrast, Loha (WQI 123.87) and Derajsar (WQI 90.94) fall under poor water quality categories, reflecting cumulative impacts of high TDS, hardness, magnesium, and alkalinity deviations. Therefore, comparison with BIS standards reveals that groundwater quality in Ratangarh tehsil is moderately to severely compromised at several locations. High TDS, magnesium, and hardness levels, along with localized pH and turbidity exceedances, limit the suitability of groundwater for drinking without treatment. These findings highlight the urgent need for groundwater quality monitoring, appropriate treatment measures, and sustainable water management practices to safeguard public health and ensure long-term water security in the region.

**Impact of Pollution on Soil Health, Crop Productivity, and Human Health:**

Soil pollution poses a serious threat to soil fertility, food security, ecosystem stability, and human health. Fertile soils are essential for food production, water filtration, carbon storage, and nutrient cycling, but contamination from pesticides, excessive fertilizer use, industrial emissions, and waste disposal degrades these functions. Long-term soil pollution reduces crop productivity and can make food unsafe for consumption, thereby directly affecting food security. Human exposure to polluted soils occurs through direct contact, inhalation of contaminated dust, and indirectly through polluted water, food crops, and animal products. Children, the elderly, and socio-economically disadvantaged communities are particularly vulnerable due to higher exposure levels and prolonged contact. Globally, soil pollution is estimated to cause more than 500,000 premature deaths annually, with heavy metals such as arsenic, cadmium, chromium, and lead being major contributors to health risks. Industrial activities and waste sites represent significant sources of soil contamination, with millions of potentially polluted sites identified across Europe, many of which remain unregistered or unmanaged. Floodplain and urban soils often accumulate pollutants despite their agricultural importance. Soil contamination also contributes to emerging health challenges, including the spread of antimicrobial resistance. Recognizing these risks, policy initiatives such as the EU Zero Pollution Action Plan and Soil Strategy aim to significantly reduce pesticide use, nutrient losses, and soil contamination by 2030, with the long-term goal of achieving non-hazardous soil conditions by 2050. Effective identification, monitoring, and remediation of contaminated sites are essential to protect human health, ensure sustainable food systems, and preserve ecosystem services.

Soil pollution significantly reduces crop yield by disrupting soil health, plant physiology, and nutrient availability. Excessive use of chemical fertilizers, pesticides, and herbicides degrades soil structure, lowers microbial activity, and reduces nutrient cycling, ultimately decreasing soil fertility and agricultural productivity. Pollutants such as heavy metals, radioactive compounds, salinity, and pathogenic microorganisms further impair plant growth and pose risks to food safety and ecosystem stability. Soil salinity is one of the most damaging forms of pollution affecting crop yield, particularly in arid and semi-arid regions. Salt accumulation in soil causes osmotic stress, ion toxicity, nutrient imbalance, and reduced water uptake by plants, leading to wilting, poor growth, delayed reproduction, and low-quality yields. High salinity adversely affects photosynthesis, enzyme activity, and cellular processes, resulting in reduced germination, leaf area, chlorophyll content, and grain production. Large agricultural regions, including parts of India's Indo-Gangetic plains, are already affected, and saline soils are projected to cover more than half of arable land globally by 2050. Excessive application of nitrogen and phosphorus fertilizers, although essential for plant growth, contributes to soil pollution, eutrophication, altered microbial communities, and increased plant susceptibility to diseases. Imbalanced nutrient use accelerates soil degradation and reduces long-term productivity. Industrial pollutants, sewage leaks, saline irrigation, and contaminated water sources further intensify soil contamination and crop stress. Overall, pollution-driven soil degradation threatens sustainable agriculture and food security. Adopting environmentally friendly practices, balanced nutrient management, and organic soil amendments is essential to restore soil fertility, maintain biodiversity, and ensure sustainable crop production.

The use of sewage water for vegetable cultivation in the Ratangarh area of Churu district is primarily driven by the scarcity of clean irrigation water, high costs of groundwater extraction, and frequent power shortages. Farmers consider sewage water a readily available and economical alternative and report comparable crop yields, along with perceived benefits such as improved soil fertility due to its organic matter content. However, despite awareness of potential risks, economic and resource constraints compel continued reliance on untreated wastewater for irrigation. The consumption of vegetables grown with sewage water poses significant health risks to local populations. Reported health problems include fever, gastrointestinal disorders, diarrhea, and skin diseases, with children and elderly individuals being particularly vulnerable. These findings align with earlier studies indicating the accumulation of heavy metals such as cadmium, lead, and nickel in vegetables irrigated with untreated sewage, which may cause long-term organ damage, especially to the kidneys and liver. While sewage water offers short-term economic benefits, its long-term environmental and public health impacts are severe, contributing to soil contamination, crop pollution, and increased disease burden. Addressing this issue requires a combination of awareness programs, improved access to clean irrigation water, wastewater treatment facilities, strict regulatory enforcement, and continued research into low-cost, sustainable irrigation technologies. Given the sandy soils and water limitations of the Ratangarh region, adopting suitable crops such as pearl millet, cluster bean, moth bean, and salt-tolerant crops like pomegranate, along with improved soil and water management practices, can support safer and more sustainable agricultural production.

## 4. Conclusion: -

The present study highlights the growing environmental and public health concerns associated with the use of untreated sewage water for irrigation in Ratangarh tehsil of Churu district, Rajasthan. Physicochemical analysis of sewage water revealed high organic load, nutrient enrichment, and elevated levels of contaminants, indicating severe pollution and unsuitability for direct agricultural use. Continuous irrigation with such sewage water has significantly influenced soil properties, leading to increased salinity, nutrient imbalance, and gradual degradation of soil quality. Groundwater analysis showed considerable spatial variation, with several locations exhibiting high electrical conductivity, total dissolved solids, hardness, and alkalinity, reflecting declining water quality in a region heavily dependent on groundwater resources. Soil samples from sewage-affected areas displayed temporary nutrient enrichment but also signs of long-term fertility loss and contamination risks. The study further confirms that soil and water pollution adversely affect crop productivity and pose serious health risks to local populations, particularly through the consumption of vegetables grown using sewage water. Although sewage irrigation provides short-term economic benefits, its long-term impacts on soil health, groundwater quality, agricultural sustainability, and human health are severe. Therefore, effective wastewater treatment, regular monitoring, farmer awareness, and sustainable soil and water management practices are essential to ensure safe agricultural production and environmental protection in the Ratangarh region.

## 5. Reference: -


1. Al Hamedi, F. H., Kandhan, K., Liu, Y., Ren, M., Jaleel, A., & Alyafei, M. A. M. (2023). Wastewater irrigation: A promising way for future sustainable agriculture and food security in the United Arab Emirates. *Water*, *15*(12), 2284. https://doi.org/10.3390/w15122284
2. Amahmid, O., El Guamri, Y., Rakibi, Y., Yazidi, M., Razoki, B., Kaid Rassou, K., et al. (2023). Wastewater reuse in agriculture: A review of soil and crops parasitic contamination, associated health risks and mitigation approach. *Environmental Health Engineering and Management Journal*, *10*(1), 107–119. https://doi.org/10.34172/EHEM.2023.12
3. Antil, R. S. (2012). Impact of sewage and industrial effluents on soil-plant health. In K.-Y. Show (Ed.), *Industrial waste*. InTech. http://www.intechopen.com/books/industrial-waste/impact-of-sewer-water-and-industrial-wastewaters-on-soilplant-health
4. Bahuguna, A., Singh, S., Sharma, S.,

Arvind, Pandey, A., Dadarwal, B., Yadav, B., Barthwal, A., & Khatana, R. (2022). Soil pollution due to sewage sludge and industrial effluents. In *Soil contamination and remediation* (Chapter 14). Springer. https://doi.org/10.1007/978-3-031-09270-1_14

5. Bierkens, M. F. P., & Wada, Y. (2019). Non-renewable groundwater use and groundwater depletion: A review. *Environmental Research Letters, 14*(6), 063002. https://doi.org/10.1088/1748-9326/ab1a5f
6. Chojnacka, K., Witek-Krowiak, A., Moustakas, K., Skrzypczak, D., Mikula, K., & Loizidou, M. (2020). A transition from conventional irrigation to fertigation with reclaimed wastewater: Prospects and challenges. *Renewable and Sustainable Energy Reviews, 130*, 109959. https://doi.org/10.1016/j.rser.2020.109959
7. Dwivedi, A., Mehrotra, A., & Tripathi, K. N. (2019). Comparative study of different sewage farming on soil quality: A review. *International Journal of Trend in Scientific Research and Development, 3*(3), 1849–1852. https://www.ijtsrd.com/papers/ijtsrd21594.pdf
8. Gebreslassie, H., Berhane, G., Gebreyohannes, T., Hagos, M., Hussien, A., & Walraevens, K. (2025). Water harvesting and groundwater recharge: A comprehensive review and synthesis of current practices. *Water, 17*(7), 976. https://doi.org/10.3390/w17070976
9. Ghazaryan, K., Agrawal, S., Margaryan, G., Harutyunyan, A., Rajput, P., Movsesyan, H., Rajput, V. D., Singh, R. K., Minkina, T., Elshikh, M. S., Alwahibi, M. S., Alexiou, A., Papadakis, M., Sousa, J. R., & Singh, A. (2024). Soil pollution: An agricultural and environmental problem with nanotechnological remediation opportunities and challenges. *Discover Sustainability, 5*(1). https://doi.org/10.1007/s43621-024-00666-9
10. Katoch, S., & Dahiya, S. (n.d.). Unearthing the issue: Causes and sources of soil Pollution. (2024). *International Journal of Research in Agronomy, 7*(3), 665–670.
11. Kundzewicz, Z. (2008). Hydrosphere. In *Elsevier eBooks* (pp. 1923–1930). Elsevier. https://doi.org/10.1016/B978-008045405-4.00740-0
12. Moniruzzaman, M., Dey, S., Al-Asad, H., Karjee, S., Barman, A., & Samanta, P. (2026). Nurturing the lifeline: Exploring sustainable water resource management practices. In *Advances in hydrology* (Chap. 3, pp. 37–54).
13. Moradinejad, A. (2023). *Investigating issues and problems of using sewage effluent in agriculture*. IntechOpen. https://doi.org/10.5772/intechopen.108636
14. Obijianya, C. C., Yakamercan, E., Karimi, M., Veluru, S., Simko, I., Eshkabilov, S., & Simsek, H. (2025). Agricultural irrigation using treated wastewater: Challenges and opportunities. *Water, 17*(14), 2083. https://doi.org/10.3390/w17142083
15. Shaker, S., Sayl, K., & Kamel, A. (2023). Ground water recharging methods: Review study. In *AIP Conference Proceedings* (Conference on Mathematical Sciences and Applications in Engineering: CMSAE-2021).