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Study of Physicochemical Parameters of Groundwater in the Shekhawati Region of Rajasthan

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ABSTRACT

The Shekhawati region in Rajasthan, India, is known for its arid climate and scarce water resources, especially groundwater. Groundwater is the main source of water for drinking, irrigation, and industrial purposes in this region. However, the quality of groundwater has been compromised due to several anthropogenic and natural factors. This study aims to assess the physicochemical parameters of groundwater in the Shekhawati region, focusing on its suitability for drinking, agriculture, and industrial use. The study evaluates parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), alkalinity, hardness, chloride, nitrate, fluoride, and heavy metals. The results are compared with the drinking water standards prescribed by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO) to understand the potential health implications for the local population. Additionally, the research explores the impacts of land use, agriculture practices, and mining activities on groundwater quality.

***Keywords**: Anthropogenic, pH, BIS, WHO, EC, Groundwater.*

Introduction

Groundwater is a critical resource in arid and semi-arid regions like Shekhawati, which spans parts of Rajasthan in northern India. The region's climate is characterized by low rainfall and high evaporation rates, making surface water resources inadequate for the growing population. As a result, groundwater has become the primary source of water for both drinking and irrigation. However, the rapid urbanization, agricultural expansion, and industrial development in the region have placed immense pressure on the groundwater system. Groundwater contamination, particularly with salts, heavy metals, and other pollutants, poses serious risks to both public health and the environment.

The Shekhawati region is characterized by its unique socio-economic and environmental conditions. The agricultural activities primarily rely on groundwater for irrigation, leading to over-extraction of water and degradation of its quality. The region also has mining activities, especially for minerals like marble and gypsum, which can contribute to groundwater contamination. The goal of this research is to evaluate the physicochemical properties of groundwater in Shekhawati, identify potential contaminants, and assess the implications for water quality and public health.

Review of Literature

Groundwater quality assessment using physicochemical parameters has garnered significant attention, particularly in arid and semi-arid regions like Rajasthan, where groundwater serves as the primary source for domestic and agricultural needs. Several studies have emphasized the importance of analyzing these parameters to evaluate water quality, identify potential health risks, and propose sustainable water management practices.

Karanth (1987) provided a foundational understanding of hydrogeology and highlighted the geochemical processes influencing groundwater composition in Indian aquifers. Trivedy and Goel (1986) developed standardized methods for water quality analysis, which have been extensively adopted in subsequent studies across various regions.

In the context of Rajasthan, Gupta et al. (2015) conducted an assessment of groundwater in Jhunjhunu district and found that key parameters like total dissolved solids (TDS), nitrate, and chloride often exceeded permissible limits due to agricultural runoff and poor wastewater management. Similarly, Sharma and Jain (2011) examined groundwater samples in Sikar district and reported high levels of fluoride and nitrate, linking them to both natural lithological conditions and anthropogenic activities.

The Shekhawati region—which includes Jhunjhunu, Sikar, and Churu districts—faces growing challenges related to groundwater contamination and depletion. Yadav et al. (2017) carried out a seasonal analysis in parts of the region and documented considerable variation in pH, electrical conductivity (EC), and hardness. Their findings indicated contamination from fertilizers and unregulated groundwater extraction.

Meena et al. (2020) further observed a progressive increase in salinity levels in groundwater across the Shekhawati region, rendering it unsuitable for drinking and posing risks to soil fertility. Industrial activities in adjacent areas were also found to influence groundwater quality, as noted by Rao and Rao (2018), who reported elevated concentrations of heavy metals in aquifers near industrial clusters.

Despite these efforts, a comprehensive and up-to-date study focused specifically on the physicochemical characteristics of groundwater in the Shekhawati region remains limited. The present research aims to address this gap by systematically evaluating key water quality parameters and comparing them with the standards set by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO).

Research Gap

Despite the critical importance of groundwater as a primary source of drinking and irrigation water in the arid Shekhawati region of Rajasthan, comprehensive and region-specific studies on its physicochemical quality remain limited. Several prior studies on groundwater in Rajasthan have focused broadly on hydrogeology or specific contaminants such as fluoride and nitrate. However, there exists a lack of systematic and integrated assessment of key physicochemical parameters (such as pH, TDS, EC, hardness, chloride, sulfate, and heavy metals) in the Shekhawati belt, which includes districts like Jhunjhunu, Sikar, and Churu.

Moreover, existing data are often fragmented, outdated, or limited in spatial and seasonal coverage, making it difficult to draw conclusive insights on the current status and trends of groundwater quality. There is also a deficiency in correlating these parameters with anthropogenic influences such as agricultural runoff, over-extraction, industrial activity, and climate variability, all of which are increasingly impacting the region.

This study aims to bridge these gaps by providing a comprehensive, updated, and location-specific analysis of the physicochemical characteristics of groundwater in the Shekhawati region, with implications for public health, sustainable water management, and environmental policy-making.

Materials and Methods

Study Area

Shekhawati is located in the northern part of Rajasthan, India, covering the districts of Sikar, Jhunjhunu, Churu. The region is semi-arid, with limited rainfall and high temperatures, making water scarcity a significant issue. The groundwater table is generally deep, and its quality varies depending on the proximity to urban centers, agricultural activities, and industrial zones.

Sample Collection

A total of 30 groundwater samples were collected from different locations within the Shekhawati region, representing both rural and urban areas, agricultural zones, and regions affected by mining activities. The samples were collected from hand pumps, wells, and boreholes during the summer and winter seasons to account for seasonal variations in water quality. The samples were preserved in clean plastic bottles, and immediately analyzed for various physicochemical parameters.

Parameters Analyzed

The following physicochemical parameters were measured in the groundwater samples:

- **pH:** The acidity or alkalinity of the water was measured using a digital pH meter.
- **Electrical Conductivity (EC):** EC was measured using a conductivity meter, which indicates the ionic content of water.

- **Total Dissolved Solids (TDS):** TDS, representing the concentration of dissolved solids, was measured using a TDS meter.
- **Alkalinity:** Alkalinity was determined by titration with a standard acid solution.
- **Hardness:** Hardness, expressed in mg/L of $CaCO_3$, was determined using the EDTA titration method.
- **Chlorides:** Chloride content was measured using a silver nitrate titration method.
- **Nitrates:** Nitrate concentration was determined using the UV-Vis spectrophotometric method.
- **Fluoride:** Fluoride concentration was measured using the ion-selective electrode method.
- **Heavy Metals:** Concentrations of heavy metals such as lead (Pb), arsenic (As), and cadmium (Cd) were measured using atomic absorption spectrophotometry (AAS).

Data Analysis

The data obtained from the physicochemical analysis were compared with the drinking water quality standards provided by the Bureau of Indian Standards (BIS) and the World Health Organization (WHO). Statistical analysis was performed to identify correlations between different parameters and to determine the suitability of groundwater for various uses.

Results and Discussion

- **pH:** The pH of groundwater in Shekhawati ranged from 7.2 to 8.5, indicating that the water is generally slightly alkaline. According to BIS and WHO standards, the ideal pH for drinking water is between 6.5 and 8.5. Therefore, the groundwater in the region is generally suitable for consumption in terms of pH.
- **Electrical Conductivity (EC):** The electrical conductivity of groundwater samples ranged from 800 to 3000 µS/cm, which is higher than the acceptable limit of 1500 µS/cm for drinking water as specified by BIS. High EC values suggest that the groundwater in the region has a high ionic content, which may be attributed to the high salinity levels, especially in areas with heavy irrigation and agricultural activities. The high EC values are also indicative of the presence of dissolved salts and minerals, making the water unsuitable for drinking in many locations.
- **Total Dissolved Solids (TDS):** The TDS values ranged from 400 to 1800 mg/L, with several samples exceeding the permissible limit of 500 mg/L for drinking water, as per BIS standards. High TDS levels indicate the presence of dissolved ions like sodium, calcium, magnesium, and sulfate, which can affect the taste and palatability of water. In areas with high TDS levels, water treatment systems are often required to make the water suitable for drinking.
- **Alkalinity and Hardness:** The alkalinity of groundwater ranged from 150 to 450 mg/L, which is above the permissible limit of 200 mg/L in some areas. The high alkalinity is indicative of the presence of bicarbonates in the water, which can cause a bitter taste and may interfere with the absorption of certain nutrients.
- The hardness of groundwater varied from 250 to 800 mg/L as $CaCO_3$. Water hardness is classified into categories such as soft, moderately hard, hard, and very hard. In Shekhawati, the water was generally classified as hard to very hard, which is detrimental to household activities such as washing and can cause scaling in pipes and appliances.
- **Chloride:** Chloride concentrations in groundwater ranged from 50 to 400 mg/L. According to BIS, the permissible limit for chloride in drinking water is 250 mg/L. Higher chloride concentrations are usually associated with saline intrusion and the use of chemical fertilizers in agriculture. High chloride levels can lead to an unpleasant taste and may have a laxative effect.
- **Nitrate and Fluoride Levels:** Nitrate levels in the groundwater ranged from 20 to 90 mg/L, with several samples exceeding the permissible limit of 45 mg/L as prescribed by WHO. Elevated nitrate concentrations are a cause for concern, as they can lead to methemoglobinemia (blue baby syndrome) in infants and other health issues in adults. The high nitrate levels in Shekhawati can be attributed to the excessive use of nitrogenous fertilizers in agriculture.
- Fluoride concentrations ranged from 0.2 to 1.5 mg/L, with several areas showing fluoride levels above the recommended limit of 1.0 mg/L by WHO. Excessive fluoride intake can lead to dental and skeletal fluorosis, particularly in areas with high fluoride contamination in groundwater.

- **Heavy Metals Contamination:** The analysis of heavy metals showed that arsenic, lead, and cadmium were either absent or present in trace amounts in most of the samples. However, a few locations showed elevated levels of arsenic, which exceeded the permissible limit of 0.01 mg/L as per WHO standards. Chronic exposure to arsenic-contaminated groundwater can cause various health problems, including skin lesions, cancer, and cardiovascular diseases.

Impact of Agriculture, Mining, and Urbanization on Groundwater Quality

The results of this study suggest that the quality of groundwater in the Shekhawati region is significantly influenced by agricultural practices, mining activities, and urbanization.

- **Agricultural Practices:** The overuse of chemical fertilizers and pesticides in agriculture has led to the contamination of groundwater with high nitrate and chloride levels. The excessive withdrawal of groundwater for irrigation has also resulted in an increase in TDS and EC.
- **Mining Activities:** Mining operations, especially for minerals like gypsum and marble, have contributed to the contamination of groundwater with heavy metals and salts. In some areas, the mining of groundwater for industrial use has exacerbated the problem of over-extraction and salinization.
- **Urbanization:** The rapid growth of urban areas has increased the demand for water, leading to over-extraction of groundwater. The expansion of sewage systems and improper disposal of industrial waste have also contributed to the contamination of groundwater.

Conclusion

The physicochemical analysis of groundwater in the Shekhawati region of Rajasthan reveals significant variations in water quality across different locations. While the pH levels of groundwater are within the acceptable range, other parameters such as TDS, EC, nitrate, fluoride, and hardness exceed the permissible limits in many areas. The contamination of groundwater is primarily driven by agricultural practices, mining activities, and urbanization. There is an urgent need for effective water management strategies, including the regulation of fertilizer use, the implementation of water conservation measures, and the treatment of wastewater, to ensure the sustainability of groundwater resources in Shekhawati. Additionally, public awareness campaigns on the risks of drinking contaminated water and the importance of water conservation are essential for protecting public health and improving water quality in the region.

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