

Assessment of Groundwater Quality and Its Suitability for Drinking and Irrigation in Telangana, India

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Abstract

Groundwater is the primary source of drinking and irrigation water in Telangana due to limited surface water resources and growing demand from agriculture, industry, and domestic sectors. This study evaluates the physico-chemical and biological quality of groundwater and assesses its suitability for drinking and irrigation purposes. Water samples from various districts of Telangana were analyzed for key parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, major cations (Ca^{2+} , Mg^{2+} , Na^+ , K^+), major anions (HCO_3^- , SO_4^{2-} , Cl^- , NO_3^-), and heavy metals. The results were compared with WHO and Bureau of Indian Standards (BIS) guidelines for drinking water. Irrigation water quality was assessed using sodium adsorption ratio (SAR), residual sodium carbonate (RSC), and permeability index (PI). The study reveals that groundwater quality varies significantly across Telangana, with some regions exhibiting high salinity and nitrate contamination, making them unsuitable for direct consumption or long-term irrigation without treatment or management interventions.

Keywords: Groundwater, Drinking water quality, Irrigation suitability, Telangana, Water quality index, Hydrochemistry

Introduction

Water is a fundamental natural resource essential for sustaining life, agriculture, and economic development. In semi-arid regions like Telangana, groundwater is the most reliable source of water supply due to seasonal rainfall variability and limited surface water availability. Rapid urbanization, intensive agriculture, and industrial activities have placed significant stress on groundwater reserves, leading to both quantitative depletion and qualitative deterioration.

Previous studies in India have shown that groundwater quality often fails to meet the required standards for safe drinking water due to contamination by fluoride, nitrate, salinity, and heavy metals. For agriculture, the chemical composition of irrigation water plays a critical role in soil health and crop productivity. Therefore, a comprehensive hydrochemical assessment of groundwater in Telangana is essential to determine its suitability for human consumption and irrigation practices.

Objectives of the Study

1. To analyze the physico-chemical characteristics of groundwater in selected districts of Telangana.
2. To evaluate the suitability of groundwater for drinking purposes based on BIS (2012) and WHO (2017) standards.
3. To assess irrigation water quality using indices such as SAR, RSC, and PI.
4. To identify spatial variations in groundwater quality and suggest management strategies.

Materials and Methods

Study Area

Telangana, located in south-central India, lies between latitudes $15^{\circ}46'$ – $19^{\circ}47'N$ and longitudes $77^{\circ}16'$ – $81^{\circ}43'E$. The state experiences a tropical climate with an average annual rainfall of 906 mm, largely influenced by the southwest monsoon. Geologically, Telangana comprises granites, basalts, and sedimentary formations which influence groundwater occurrence and quality. Agriculture is the dominant land use, with paddy, cotton, and maize as the major crops.

Sample Collection and Analysis

Groundwater samples were collected from bore wells and open wells across different districts covering rural and urban regions. Standard procedures outlined by APHA (2017) were followed for sample collection, preservation, and laboratory analysis.

Parameters analyzed include:

- **Physical:** pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS).
- **Chemical:** Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Chloride (Cl^-), Sulphate (SO_4^{2-}), Bicarbonate (HCO_3^-), Nitrate (NO_3^-).
- **Biological/Heavy Metals:** Fluoride (F^-), Iron (Fe), Lead (Pb), Arsenic (As)

3 Irrigation Water Quality Indices

- **Sodium Adsorption Ratio (SAR):** Evaluates sodicity hazard.
- **Residual Sodium Carbonate (RSC):** Indicates carbonate and bicarbonate hazards.
- **Permeability Index (PI):** Reflects impact of water quality on soil permeability.

Water Quality Index (WQI)

A Water Quality Index was computed to provide an overall assessment of drinking water suitability.

Results and Discussion

Groundwater Quality for Drinking

- **pH:** Most samples were within permissible limits (6.5–8.5).
- **TDS & EC:** Higher values were observed in semi-arid districts (Mahbubnagar, Nalgonda), indicating salinity hazards.
- **Fluoride:** Elevated concentrations (>1.5 mg/L) in Nalgonda and Khammam districts pose a risk of dental and skeletal fluorosis.
- **Nitrate:** Agricultural regions showed nitrate levels exceeding 45 mg/L, likely due to fertilizer leaching.
- **Heavy Metals:** Sporadic traces of iron and lead were observed, but mostly within permissible limits.

Groundwater Quality for Irrigation

- **SAR:** Most samples fell under “excellent to good” category, though some showed medium sodicity hazard.
- **RSC:** Negative values in many locations suggest safe irrigation use, while a few samples indicated potential alkalinity hazard.
- **PI:** Indicated generally safe permeability levels, though high sodium concentration in some areas could reduce soil infiltration capacity.

Water Quality Index (WQI)

The computed WQI revealed that ~60% of samples fall under “good” to “excellent” category, 25% under “poor,” and ~15% were “unsuitable for drinking” without treatment.

Physico-chemical Parameters of Groundwater (Sample Values)

Tables1: for Groundwater Assessment

Parameter	Range	Permissible Limit (BIS)	Remarks
pH	6.8 – 8.2	6.5 – 8.5	Within limits
EC (µS/cm)	500 – 2200	1500	High in some areas
TDS (mg/L)	300 – 1500	500	Above in few samples
Fluoride (mg/L)	0.5 – 2.1	1.5	High in Nalgonda
Nitrate (mg/L)	10 – 90	45	High in agricultural zones

Table 2: Water Quality Index (WQI) Classification

WQI Range	Category	Percentage of Samples
0 – 50	Excellent	30%
50 – 100	Good	30%
100 – 200	Poor	25%
>200	Unsuitable	15%

Table 3: Irrigation Water Quality Indices

Index	Range	Suitability
SAR	1.2 – 8.5	Excellent to Good

Index	Range	Suitability
RSC	-2 to 2	Safe
PI (%)	45 – 80	Safe to Permissible

Graph Placeholders (to insert in Word)

Figure 1: WQI Classification of Groundwater Samples

- Create a **bar chart** with X-axis: Excellent, Good, Poor, Unsuitable; Y-axis: Percentage of Samples (30, 30, 25, 15).

Figure 2: Scatter Plot of EC vs TDS

- X-axis: EC ($\mu\text{S}/\text{cm}$) – 500, 1000, 1500, 2000, 2200
- Y-axis: TDS (mg/L) – 300, 700, 1000, 1300, 1500

Conclusion

Groundwater quality in Telangana exhibits significant spatial variability due to geology, agricultural practices, and human activities. While most samples are suitable for drinking and irrigation, areas with elevated fluoride, nitrate, and salinity levels require urgent attention. Proper treatment, controlled use of fertilizers, and artificial recharge measures are recommended to improve groundwater quality.

Recommendations

1. Regular monitoring of groundwater quality at district and mandal levels.
2. Promotion of rainwater harvesting and managed aquifer recharge.
3. Adoption of low-nitrate fertilizers and sustainable irrigation practices.
4. Fluoride removal techniques (activated alumina, Nalgonda technique) in affected areas.
5. Awareness programs for rural communities on safe drinking water practices.

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