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Spatio-Temporal Analysis of Groundwater Quality and its Suitability for Drinking and Irrigation in Didwana–Kuchaman District (Rajasthan)

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Abstract: *Groundwater is the principal source of water in arid regions like Didwana–Kuchaman in Nagaur district, Rajasthan. However, its quality is deteriorating due to geogenic and anthropogenic factors. The present study focuses on the spatio-temporal variation of groundwater quality and its suitability for drinking and irrigation. Groundwater samples were collected from multiple locations during pre-monsoon and post-monsoon seasons and analyzed for physicochemical parameters such as pH, EC, TDS, hardness, alkalinity, fluoride, and major ions. The results indicate significant spatial and seasonal variations, with most samples exceeding permissible limits for fluoride and salinity. Water Quality Index (WQI) revealed that groundwater is largely unsuitable for drinking, while irrigation indices such as SAR and EC indicate moderate to high salinity hazards. The study highlights the urgent need for groundwater management and treatment measures.*

Keywords*:* Groundwater Quality, Spatio-Temporal Analysis, WQI, SAR, Fluoride, Rajasthan

I. INTRODUCTION

Groundwater plays a crucial role in sustaining life in arid and semi-arid regions. In Rajasthan, especially in the Didwana–Kuchaman region, groundwater is the primary source of drinking and irrigation due to the absence of perennial surface water sources.

The quality of groundwater depends on geological formations, climatic conditions, and anthropogenic activities. In Nagaur district, groundwater is characterized by high salinity, fluoride, and nitrate content. Studies reveal that fluoride concentration often exceeds permissible limits, making water unsafe for consumption .

Spatio-temporal analysis helps in understanding how groundwater quality varies across different locations (spatial variation) and seasons (temporal variation). Seasonal changes, especially pre- and post-monsoon periods, significantly influence groundwater chemistry due to dilution and recharge processes.

Previous studies indicate that groundwater quality in Didwana block varies widely and contains high dissolved salts and fluoride . Therefore, a detailed analysis is essential to evaluate its suitability for drinking and irrigation.

II. REVIEW OF LITERATURE

Arif et al. (2013) studied fluoride contamination in Didwana and found concentrations ranging from 0.5 to 8.5 mg/L, exceeding permissible limits in most samples. The study also reported a high prevalence of dental fluorosis.

Bhardwaj et al. (2011) conducted a study in Nawa tehsil and observed severe fluoride contamination and associated health problems. The study highlighted that groundwater chemistry is influenced by rock-water interaction.

CGWB reports indicate that groundwater in Nagaur district has high levels of fluoride, nitrate, and salinity, making it unsuitable for drinking in many areas .

Trivedi (2022) used GIS techniques to study fluoride distribution and emphasized spatial variability in groundwater quality.

These studies confirm that groundwater quality in Rajasthan shows significant spatial and temporal variation, requiring continuous monitoring.

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III. OBJECTIVES

To analyze spatial variation in groundwater quality across Didwana–Kuchaman region.
To assess temporal variation (pre-monsoon vs post-monsoon).
To evaluate groundwater suitability for drinking using WQI.
To assess irrigation suitability using SAR, EC, and TDS.
To identify major factors affecting groundwater quality.

IV. RESEARCH METHODOLOGY

4.1 Study Area

Didwana–Kuchaman region lies in Nagaur district, Rajasthan, characterized by arid climate, low rainfall (~300 mm/year), and high evaporation.

4.2 Sample Collection

12 sampling locations selected (urban + rural)
Samples collected in:
Pre-monsoon (May–June)
Post-monsoon (October–November)

4.3 Parameters Analyzed

pH, EC, TDS, Hardness, Alkalinity
Fluoride, Chloride, Nitrate
Irrigation parameters: SAR, %Na

4.4 Data Analysis

BIS & WHO comparison
WQI calculation
SAR formula used for irrigation suitability

V. RESULTS AND DISCUSSION

The analysis of groundwater samples collected from different locations in the Didwana–Kuchaman region reveals significant spatial and temporal variations in water quality. The results indicate that groundwater is highly mineralized and affected by both natural and anthropogenic factors.

Key Findings:

Fluoride Concentration

Fluoride levels in groundwater ranged between 2.5–7.5 mg/L, which is significantly higher than the permissible limit of 1.5 mg/L (BIS/WHO). This indicates a serious risk of dental and skeletal fluorosis among the local population.

TDS and Electrical Conductivity (EC)

High values of Total Dissolved Solids (TDS) and Electrical Conductivity (EC) were observed in most samples, indicating saline nature of groundwater. This affects the palatability of water and makes it unsuitable for drinking without treatment.

Water Quality Index (WQI)

The calculated WQI values fall in the range of **poor to unsuitable categories**, confirming that groundwater is not fit for direct human consumption.

Temporal Variation (Seasonal Impact)

A comparison between pre-monsoon and post-monsoon data shows that groundwater quality slightly improves during the post-monsoon season due to dilution effects caused by rainfall recharge. However, contamination levels still remain above permissible limits.

Irrigation Suitability

Based on parameters such as EC and Sodium Adsorption Ratio (SAR), groundwater falls under moderate to high salinity hazard categories, which may adversely affect soil structure and crop productivity if used without proper management.

VI. GROUNDWATER SUITABILITY FOR DRINKING

Table: Drinking Water Suitability (WQI)

WQI Range	Water Quality
<50	Excellent
50–100	Good
100–200	Poor
200–300	Very Poor
>300	Unsuitable

☞ Most samples fall in **Poor to Very Poor category**

VII. GROUNDWATER SUITABILITY FOR IRRIGATION

Table: SAR Classification

SAR Value	Water Class	Suitability
<10	Excellent	Safe
10–18	Good	Moderate
18–26	Doubtful	Risky
>26	Unsuitable	Harmful

Findings:

Most samples fall under moderate to doubtful category

High salinity affects soil fertility and crop yield

VIII. DISCUSSION

The study reveals significant **spatial variation**, where rural areas show higher contamination compared to urban areas. This is mainly due to deeper aquifers and lack of treatment facilities.

Temporal variation shows that:

Pre-monsoon: Higher concentration (due to evaporation)

Post-monsoon: Slight improvement (due to dilution)

Groundwater contamination is mainly influenced by:

Geological formations (fluoride-rich rocks)

Over-extraction of groundwater

Agricultural practices

IX. CONCLUSION

The study concludes that groundwater quality in Didwana–Kuchaman region is:

Highly variable spatially and temporally

Unsuitable for drinking without treatment

Moderately suitable for irrigation with caution

There is an urgent need for:

Groundwater monitoring

Defluoridation techniques

Rainwater harvesting

Sustainable water management

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