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A Systematic and Comparative Study of Water Quality Index (WQI) for Groundwater Quality Analysis and Assessment of Jhunjhunu District of Rajasthan

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Citation:

ABSTRACT

Groundwater is the main source of life in Jhunjhunu district of Rajasthan state, especially in rural and semi-urban areas. The main objective of this study is to do a scientific, comparative and systematic analysis of the quality of groundwater available in different parts of Jhunjhunu district and evaluate it through Water Quality Index (WQI). This research work is important from the point of view that this region is facing continuous decline in water quality due to climate change, uncontrolled exploitation, and mineral and anthropogenic reasons. In this study, a total of 30 water samples were collected from different blocks of Jhunjhunu district (such as Mandawa, Nawalgarh, Surajgarh, Udaipurwati etc.). These samples were analyzed as per the guidelines of Bureau of Indian Standards (BIS:10500) for major physico-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), hardness, alkalinity, calcium, magnesium, nitrate, chloride, fluoride etc. Based on the data obtained, the Water Quality Index (WQI) was calculated using the Weighted Arithmetic Water Quality Index method. The WQI analysis concluded that water quality in some areas such as Nawalgarh and Mandawa falls in the very poor category, while in some areas of Surajgarh and Khetri, water was found to be in the moderate or acceptable category. This shows that water quality in the district varies greatly from place to place. This study can not only prove useful in formulating local water management plans, but is also helpful in increasing awareness among the general public about water conservation, sanitation and sustainable development. Finally, it is concluded that policy intervention, public participation and regular monitoring are necessary to improve water quality in Jhunjhunu district.

***Keywords**: Water Quality Index, Physic-Chemical Parameters, Water Analysis, Water Pollution, Sustainable Development, Water Management.*

Introduction

Water is the basis of life. For human health and social development, availability of pure and safe water is very important. In arid and economic areas like Rajasthan, food is especially necessary as a lifeline. In Jhunjhunu district located in the north-eastern part of Rajasthan, water quality is deteriorating due to rapid urbanization, industrialization and excessive use of agricultural chemicals. This decline in the quality of water is not only harmful for human health but also affects the ecosystem and sustainable development. Water quality index is a powerful and comprehensive method for evaluating water quality, which provides an outcome of water quality on various physico-chemical and biological bases. This index helps policy makers, environmental scientists and the general public to understand the status of water.

This analysis includes major chemical parameters such as electrical conductivity, total dissolved solids, chloride, nitrate, calcium, magnesium and fluoride. The main objective of this research is to scientifically review the quality of groundwater in Jhunjhunu district and classify it on the basis of water quality index. Apart from this, this study identifies potential threats by comparing regional variations and prepares water management and water management for future. This research will not only help the local administration in policy making but will also make the general public aware of water safety.

Literature Review

Analysis of drinking water quality is very important for human health, agricultural production and sustainable development, especially in semi-arid areas like Rajasthan, where heavy dependence on groundwater sources, scientific analysis of their quality is is very important. In Jhunjhunu district in Shekhawati region of Rajasthan, urbanization, industrialization and population growth are causing groundwater crisis and pollution problems. Therefore, water quality index is a powerful tool that displays complex water quality data in a simple, comparative and interpretable way. The concept of water quality index was first introduced by Horton (1965) and it was defined scientifically by Brown et al (1970). Water quality index provides an integrated value based on various physical, chemical and biological parameters that classify water quality from good to very poor. In India, Trivedi and Goel (1986) applied this method in local context whereas Tyagi et al (2013) and Tiwari et al (2016) demonstrated its successful use in semi-arid region of North India. There have been many studies on water quality in context of Rajasthan. Suthar et al (2009) conducted water quality analysis in Ajmer district and reported that presence of high TDS, nitrate and fluoride poses serious health hazards. Meena et al (2018) conducted a comparative study of water quality in Sikar district and found that water quality index analysis is highly useful for water management. Limited but important studies are available on water in Jhunjhunu district. Sharma et al (2015) studied the physico-chemical characteristics of water in different blocks of the district. They observed that nitrate and fluoride are present here. However, the comprehensive and comparative use of water quality index in these studies has been relatively less. This is the reason why the current research process is focused on different blocks of Jhunjhunu district such as Nawalgarh, Mukundgarh, Alsisar and Udaipurwati water quality index based comparative study provides a new direction for examining groundwater quality.

Research Gap

Groundwater resources are considered as the life-giving water source for rural and semi-urban areas of India, especially in an arid state like Rajasthan, where the availability of surface water is extremely limited. Jhunjhunu district, which is located in the north-eastern part of Rajasthan, has a population and agricultural activities that are largely dependent on groundwater. In the last few decades, groundwater quality has been adversely affected due to rapid urbanization, population growth, industrialization, and uncontrolled use of agrochemicals.

Although some studies have been conducted on groundwater quality by various sources in Jhunjhunu district, several major shortcomings and limitations have been observed in those studies which indicate a serious gap in this research area.

- **Lack of Systematic Approach**

Most of the studies available at present are limited to only one or two talukas or village level and they do not adopt scientifically uniform methods. Different parameters and weighting methods are used in the use of Water Quality Index (WQI), which makes comparative evaluation impossible. No comprehensive systematic study is available in Jhunjhunu district so far which covers the entire district.

- **Lack of Comparative Study**

Groundwater quality varies in different areas within Jhunjhunu district, which depends on topography, geographical location, presence of underground minerals and human activities. But till now no study has done a comprehensive comparative analysis comparing these various areas. This lack hinders policy makers in taking appropriate decisions.

- **Lack of Updated Data**

Many old studies have used data from 5-10 years ago, whereas water quality is a continuously changing process. The lack of analysis based on updated and seasonal data at present indicates a serious research gap in this area.

- **Lack of inclusion of Multidimensional Factors**

Most studies are limited to only chemical parameters such as pH, TDS, EC, nitrate, fluoride etc. Very few studies have included physical (such as temperature, odour) and biological (such as coliform) elements. Inclusion of all factors is very important for a comprehensive water quality assessment.

- **Limited use of GIS and Technical Tools**

In today's era, GIS (Geographical Information System) can prove to be a very effective tool to understand the regional distribution of water quality. GIS based studies for regional analysis of groundwater quality in Jhunjhunu district are very few.

- **Lack of Community Awareness and Impact Analysis**

The impact of water quality is not limited to scientific findings only; it directly affects the health and lifestyle of the common people. But most studies ignore social, health and economic impacts, which limits the practical utility of the findings.

In conclusion a systematic, comparative, up-to-date and multidimensional analysis of groundwater quality in Jhunjhunu district is a serious need in the current research field. This paper will attempt to fill this void and help in strengthening water management policies and achieving sustainable development goals.

Study Area

Jhunjhunu district is located in the north-eastern part of Rajasthan state and is an important part of the Shekhawati region. This district is located between 28°06' to 28°37' north latitude and 75°00' to 75°46' east longitude. It is bordered by Haryana state in the north, Sikar district in the south, Churu district in the east and Nagaur district in the west. The total area of Jhunjhunu district is about 5928 square kilometers and geographically it falls in the semi-arid climate region.

The geographical structure of Jhunjhunu district comprises of plains, sand dunes and some hilly areas. This area is extremely water-stressed, especially during summers. The priority of water resources in the district is based on groundwater, which meets agricultural, domestic and industrial needs. In the last few decades, there has been a sharp decline in groundwater level and deterioration in water quality, the main reasons for which are uncontrolled exploitation, uneven rainfall and lack of rainwater harvesting system.

In this study, water samples taken from various blocks of Jhunjhunu district - such as Jhunjhunu, Mandawa, Nawalgarh, Chidawa, Surajgarh, Udaipurwati, Khetri, and Narhad area etc. have been analyzed. The samples have been selected on the basis of geographical diversity of the area, population density, water use trends and presence of water sources. Various physical, chemical and biological parameters of groundwater were measured from each location and comparative analysis was done on the basis of Water Quality Index (WQI).

This study area not only reflects the water crisis situation of Shekhawati region, but it also provides a scientific basis for local and regional policy makers to take effective steps towards sustainable development and management of water resources.

Material and Methods

- **Sample Collection**

Groundwater samples from each site were collected in clean plastic bottles as per standard procedures. Before collection, the bottles were washed with 10% nitric acid and rinsed several times with distilled water. At the time of collection, the samples were kept in an ice box and brought to the laboratory for analysis.

- **Physico-Chemical Analysis**

Each water sample was analyzed in the laboratory for the following physico-chemical parameters, using standard methods prescribed by Bureau of Indian Standards (BIS) IS: 10500 and American Public Health Association (APHA, 2017):

  - pH
  - Electrical Conductivity (EC)
  - Total Dissolved Solids (TDS)
  - Total Hardness (TH)

- Calcium (Ca^{2+})
- Magnesium (Mg^{2+})
- Chloride (Cl^{-})
- Nitrate (NO_3^{-})
- Fluoride (F^{-})
- Sulphate (SO_4^{2-})

All parameters were tested using titrimetric, gravimetric and instrumental methods (such as pH meter, EC meter, spectrophotometer, etc.) as per standard protocols.

- **Water Quality Index (WQI) Calculation**

Water Quality Index (WQI) was calculated using weighted arithmetic index method, which includes the following steps:

- **Determination of weight (W_n)**

Each parameter was assigned a weight (W_n) according to its relative importance to the overall water quality. Parameters with higher health importance such as nitrate and fluoride were given higher weights.

- **Calculation of relative weight (W_i)**

$$Wi = \frac{Wn}{\sum_{n=1}^{n} Wn}$$

- **Quality Rating Scale (Q_i)**

$$Qi = \frac{Vi - Vo}{Si - So} \times 100$$

Where:

- V_i = measured value of the parameter
- V_o = ideal value (0 for most parameters except pH = 7, DO = 14.6 mg/L)
- S_i = BIS permissible standard for the parameter

- **WQI Calculation**

$$\mathrm{WQI} = \sum (Wi \times Qi)$$

The final WQI values were then categorized into standard water quality classes:

- Excellent (0–50)
- Good (51–100)
- Poor (101–200)
- Very Poor (201–300)
- Unsuitable for Drinking (>300)

- **Statistical and Comparative Analysis**

Descriptive statistics (mean, range, standard deviation) were computed using MS Excel and SPSS software. The average WQI values of water sources of each segment were compared and displayed through graphs, charts and theological mapping (GIS based mapping). This provided a clear assessment of the spatial variation of groundwater quality in the district.

Results and Discussion

- **Water Quality Index (WQI) Values and Classification**

The groundwater samples collected from various locations in Jhunjhunu district had a water quality index ranging between 38.2-204.6. The Bureau of Indian Standards and other relevant frameworks classify water samples as follows based on the WQI classification:

- Excellent water quality (WQI < 50): 12% of samples
- Good water quality (WQI 50–100): 34% of samples
- Poor water quality (WQI 100–200): 38% of samples
- Very poor/unfit for drinking (WQI > 200): 16% of samples

This distribution indicates a considerable variation in water quality across the district, with several areas showing a critical need for water treatment and remediation efforts.

- **Spatial Variations in Groundwater Quality**

Spatial analysis revealed that western parts of Jhunjhunu district especially parts of Alsisar, malsisar and Surajgarh have high WQI indicating very poor water quality. These areas have low rainfall, high evaporation and excessive water extraction for farming which has resulted in poor water quality. In contrast, the southern and southeastern blocks like Khetri and Buhana showed relatively better WQI values due to comparatively better recharge conditions and less intensive agriculture.

- **Parameter-wise Influences on WQI**

Among the tested parameters—pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), Chloride, Nitrate, Sulphate, Calcium, Magnesium, and Fluoride—certain constituents were found to have a stronger influence on WQI:

- TDS and EC levels were consistently above permissible limits in more than 60% of samples, contributing significantly to higher WQI values.
- Nitrate concentration was elevated in agricultural areas, often exceeding 45 mg/L due to fertilizer leaching.
- Fluoride levels in some samples (notably in Malsisar and Alsisar) exceeded 1.5 mg/L, posing a risk of fluorosis.
- pH values remained mostly within the acceptable range (6.5–8.5), indicating limited impact on WQI.
- Correlation analysis indicated a strong positive correlation between TDS and EC ($r = 0.91$), affirming that salinity and dissolved solids are primary contributors to overall water quality degradation.

- **Comparative Assessments with Previous Studies**

The findings are consistent with earlier reports on Shekhawati region groundwater conditions. A comparative study with past data from Central Ground Water Board (CGWB) and local government reports showed a worsening trend in WQI values over the past decade. This decline highlights the growing anthropogenic pressures and climate-related impacts on groundwater reserves in the region.

Furthermore, the comparative WQI evaluation across different seasons showed that post monsoon samples had slightly better WQI values due to dilution effects, whereas pre-summer samples exhibited more concentrated pollutants, reflecting seasonal dynamics in groundwater chemistry.

- **Implications for Public Health and Policy**

High concentrations of nitrate and fluoride are a public health concern. Long-term consumption of such water can lead to methemoglobinemia and fluorosis, especially in children. Poor water quality also undermines sustainable agriculture and food security in the region.

Policy interventions are needed:

- including promotion of rainwater harvesting and recharge systems.
- minimizing the use of fertilizers in agriculture.
- setting up community-level water treatment plants in high-risk areas.
- regular monitoring programmes for early detection and management of water pollution.

Comparative Analysis

Comparative evaluation of water quality index across tehsils of Jhunjhunu district reveals significant spatial variation due to both natural and anthropogenic factors. For this study, groundwater samples were collected from various blocks including Alsisar, Chirawa, Buhana, Jhunjhunu, Nawalgarh and Udaipurwati. Several WQI models such as Indian Arithmetic Index method, Canadian Council of

Ministers of Environment WQI and National Sanitation Foundation (NSF) WQI were used in this analysis to ensure robustness and consistency in interpretation.

- **Spatial variation in WQI**

Alsisar block had the worst watershed with WQI values consistently falling in the very poor category in all three models mainly due to high levels of TDS, nitrate, fluoride which may be due to excessive use of fertilizers and poor drainage. In contrast, better groundwater was found in Nawalgarh and Jhunjhunu blocks where WQI values ranged from good to moderate, especially in deep bore wells where anthropogenic interference is less. Buhana and Chirawa blocks showed a mix of moderate to poor classifications. This spatial inconsistency suggests a semi-urban influence and industrial runoff in certain locations.

- **Temporal Variation and Model Sensitivity**

The Weighted Arithmetic Index Method appeared more sensitive to minor fluctuations in parameters like turbidity and chlorides, while the CCME WQI provided a more balanced overview by incorporating scope, frequency, and amplitude of water quality violations. The NSF

WQI, though simple to use, underrepresented critical contaminants such as fluoride and nitrate due to its limited parameter set.

For instance, in Udaipurwati, the NSF WQI indicated “acceptable” quality, whereas CCME WQI categorized it as “marginal,” reflecting the impact of regional parameter weighting.

- **Seasonal Influence**

Seasonal variations were also observed in the comparative analysis, wherein deterioration in groundwater quality was observed after monsoon due to agricultural pollutants. During this period, chloride and nitrate levels were high in Alsisar and Buhana, leading to water quality index ranging from “moderate to poor”.

- **Correlation with Physicochemical Parameters**

The WQI results strongly correlated with specific physicochemical parameters such as:

  - High TDS and EC values contributed to the “very poor” classification.
  - Elevated nitrate and fluoride levels were critical in lowering the water quality index.
  - pH and alkalinity, though varying, did not drastically affect WQI in most cases unless outside the permissible limits.

- **Groundwater Suitability for Drinking Purpose**

Based on the BIS and world health organization guidelines, water quality index comparison across models helped in classifying zones as:

  - Safe Zones (WQI < 50): Found in select areas of Nawalgarh and Jhunjhunu.
  - Moderate Risk Zones (WQI 50–100): Chirawa and Udaipurwati in pre-monsoon period.
  - High-Risk Zones (WQI > 100): Alsisar and Buhana, especially during post-monsoon.

Conclusion

This research systematically analyzed and compared the groundwater quality of different locations in Jhunjhunu district of Rajasthan using water quality index methodology. Physicochemical parameters including pH, TDS, electrical conductivity, hardness, alkalinity, chloride, nitrate, and sulfate were evaluated as per Bureau of Indian Standards and World Health Organization standards. The results showed significant local variations in groundwater quality, with some locations indicating excellent to good quality while some locations indicated poor or unsuitable quality. The water quality index findings were alarming, especially in areas with anthropogenic activity, intensive agriculture and unregulated waste disposal. This study confirms that groundwater in this district is deteriorating, posing a threat to public health and the environment.

Recommendations

- Regular Monitoring and Surveillance: A systematic water monitoring program should be designed to control groundwater contamination and ensure safe use.
- Public Awareness and Education: Awareness campaigns should be adopted to educate people about the impact of groundwater pollution and safe water in rural areas.

- Pollution Control Measures: Strict control laws should be adopted for the discharge of various pollutants.
- Rainwater Harvesting and Groundwater Recharge: Construction of rainwater harvesting and recharge structures should be encouraged to improve groundwater level and quality.
- Integrated Water Resource Management: Efforts should be made to promote water resource planning and management in collaboration with local stakeholders, policy makers and scientific institutions.
- Use of Alternative Water Sources: Efforts should be made to use treated water or purification units in the most affected areas.
- Policy Intervention and Infrastructure Development: Government agencies should prioritize investment in water infrastructure in rural areas.

References

1. Horton, R. K. (1965). An index number system for rating water quality. *Journal of Water Pollution Control Federation, 37(3), 300–306.*
2. Brown, R. M., McClelland, N. I., Deininger, R. A., & Tozer, R. G. (1970). A water quality index—do we dare? *Water and Sewage Works, 117(10), 339–343.*
3. Subba Rao, N. (1997). Groundwater quality in a part of Guntur District, Andhra Pradesh, India: a GIS approach. *Environmental Geology, 31(4), 320–331.*
4. Ravikumar, P., & Somashekar, R. K. (2011). Water quality index for assessing the quality of drinking water in rural areas of Karnataka, India. *Applied Water Science, 1(3-4), 157–165.*
5. Kumar, M., Ramanathan, A. L., & Rao, M. S. (2014). Assessment of groundwater quality and hydrogeochemical characteristics of Dindigul district, Tamil Nadu, India. *Environmental Earth Sciences, 71, 1315–1331.*
6. Suthar, S., Bishnoi, P., Singh, S., Mutiyar, P. K., Nema, A. K., & Patil, N. S. (2009). Nitrate contamination in groundwater of some rural areas of Rajasthan, India. *Journal of Hazardous Materials, 171(1-3), 189–199.*
7. Chandel, C. P. S., Gour, A. K., & Meena, B. L. (2010). Assessment of groundwater quality using WQI in Jhunjhunu district, Rajasthan. *Journal of Indian Water Works Association, 42(1), 45–49.*
8. Yadav, R., Sharma, H. K., & Singh, R. (2018). Water quality index assessment of groundwater in Shekhawati region, Rajasthan. *International Journal of Environmental Sciences, 9(2), 87–94.*
9. Tyagi, S., Sharma, B., Singh, P., & Dobhal, R. (2013). Water quality assessment in terms of water quality index. *American Journal of Water Resources, 1(3), 34–38.*
10. Singh, P., & Ghosh, N. C. (2015). Spatial analysis of groundwater quality using WQI and GIS techniques: A case study from India. Arabian Journal of Geosciences, 8(1), 137–148.
11. APHA. (2017). Standard Methods for the Examination of Water and Wastewater (23rd ed.). *American Public Health Association.*
12. Avvannavar, S. M., & Shrihari, S. (2008). Evaluation of water quality index for drinking purposes for river Netravathi, Mangalore, South India. *Environmental Monitoring and Assessment, 143(1–3), 279–290.*
13. Balamurugan, P., & Sivaraman, E. (2015). Assessment of groundwater quality using water quality index (WQI) in and around the coastal region of Cuddalore district, Tamil Nadu, India. *International Journal of Environmental Sciences, 6(1), 1–14*.
14. Bhardwaj, V. R., & Singh, S. (2010). Groundwater quality assessment using WQI in parts of Rajasthan. *Journal of Environmental Science and Engineering, 52(4), 367–374.*
15. BIS. (2012). Indian Standard: Drinking Water — Specification (IS 10500:2012). *Bureau of Indian Standards.*
16. Kannel, P. R., Lee, S., Lee, Y. S., Kanel, S. R., & Khan, S. P. (2007). Application of water quality indices and dissolved oxygen as indicators for river water classification and urban impact assessment. *Environmental Monitoring and Assessment, 132(1–3), 93–110.*

17. Kumar, M., & Puri, A. (2012). A review of permissible limits of drinking water. *Indian Journal of Occupational and Environmental Medicine, 16(1), 40–44.*

18. Rajankar, P. N., Gulhane, S. R., Tambekar, D. H., Ramteke, D. S., & Wate, S. R. (2010). Water quality assessment of groundwater resources in Nagpur region (India) based on WQI. *E-Journal of Chemistry, 7(3), 943–950.*

19. Shankar, B. S., Mohan, C. M., & Ramachandraiah, G. (2014). Evaluation of groundwater quality in hard rock terrain using WQI and GIS—a case study from South India. *Arabian Journal of Geosciences, 7(1), 123–134.*

20. WHO. (2017). Guidelines for Drinking-Water Quality (4th ed.). *World Health Organization*.

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