https://doi.org/10.30799/jespr.250.25110102 J. Environ. Sci. Pollut. Res. - Volume 11 Issue 1 (2025) 507–510

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Journal of Environmental Science and Pollution Research

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ISSN: 2455-0272

Second Phase Study of Groundwater Quality in Kushalgarh Block Villages, Banswara District, Rajasthan

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ARTICLEDETAILS

Article history:
Received 22 December 2024
Accepted 06 January 2024
Available online 17 February 2025

Keywords:
Groundwaters
Groundwater Quality
Physico-Chemicals Analysis
Banswara

ABSTRACT

Water is crucial as it profoundly affects humans, wildlife, and aquatic life. The quality of water hinges on its composition, physical properties, and organic attributes. The rapid expansion of industrialization and increased use of chemical pesticides in agriculture have significantly contributed to the deterioration of water quality through contamination. The consumption of this polluted water has led to waterborne infections in the human population. In the current study, the quality parameters of water in the Kushalgarh block have been assessed. The assessment of water quality parameters in the Kushalgarh block indicates that all measured parameters remain within permissible limits. Despite concerns over industrialization and agricultural pesticide use, the study found no significant deviation in physical, chemical, or organic attributes of the water. These findings suggest that, while regular monitoring is essential, the current water quality poses no immediate health risks to humans or aquatic life.

1. Introduction

Water that is intended for drinking and other uses must be extremely pure, and devoid of contaminants and chemical microbes. The rapid industrialization and increasing population increase have caused the quality of water to deteriorate. One of the most important and vital requirements for life on Earth is groundwater. Water needs to be assessed and mapped because it is an essential part of our ecology. The usefulness of groundwater samples for industrial, agricultural, and residential uses is largely determined by their physical and chemical properties.

Birajdar et al. [1] Assessed how seasonal fluctuation affected the physicochemical characteristics of tubewell groundwater from several sites in Maharashtra State's Latur district. Eleven distinct stations collected the samples during the summer, monsoon, and winter seasons [1]. Standard analytical techniques were used to determine the major physicochemical parameters, including temperature, pH, electric conductivity (EC), total hardness (TH), total dissolved solids (TDS), total alkalinity (TA), Ca^{2+}, Mg^{2+}, and Clby. According to the investigation, the study area's drinking water quality is logically good and free of harmful pollution levels. However, because the concentration of the parameters exceeds the acceptable limits for drinking water, it requires a moderate amount of treatment before use.

An attempt has been made to determine the hydrochemical characteristics of groundwater in Nanded Tehsil and to develop a water quality index model (WQI) by Birajdar et al. [2]. Fifty representative groundwater samples were extracted from wells drilled or excavated following the 2012 monsoon and analysed for important cations and anions. The quality of the groundwater was assessed using physicochemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), bicarbonate (HCO_3^-), magnesium (Mg^{2+}), calcium (Ca^{2+}), potassium (K^+), sodium (Na^+), carbonate (CO_3^{2-}), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), etc.,.

The Water Quality Index (WQI) categorise water quality into four groups: excellent, good, terrible, and improper. The hydrochemical results reveal that TDS (16%) and TH (22%). This is in contrast to Indian guidelines (BIS). 6% of samples are inappropriate for human consumption, 60% are decent, and 34% are exceptional, according to WQI. Unfit drinking water is found in groundwater samples 12, 40, and 44 from an urbanised and industrialised area. Clutching hydrochemical analysis was used to illustrate the regional fluctuation of WQI in Nanded Tehsil using a GIS-based IDW approach.

Sivakumar et al. analysed how the Amaravathi River basin in the Karur region's groundwater quality is affected by industrial activities generally and the textile sector specifically. Physicochemical parameters were used to assess the quality [3]. During the pre-monsoon and monsoon seasons, groundwater samples were taken from five (05) open and underground borewells in the study area. Physicochemical parameters such as pH, electrical conductivity, TDS, total hardness, calcium and magnesium hardness, chloride and sulphate, etc., were examined to ascertain the present state of the open and groundwater borewell quality as per APHA, 1998. The drinking water quality (IS: 10500) was better during the monsoon season than it was before.

During the dry, semi-dry, and wet seasons in 2015, spring water samples were taken from the Ankober district in low-, middle-, and high-altitude regions. To determine its suitability for domestic use, a variety of physicochemical and bacteriological parameters were examined. The study's findings demonstrated that, except for a few values at the lowest attitude area, the majority of the parameters were found to be within the safe limit values of the WHO and Ethiopian standards for drinking water: TC/FC (147/1 per 100 mL) and F^- (1.68 mg/L) in the dry season, Mg^{2+} (52.1 mg/L) in the semi-dry season, and K^+ (1.59–51.15 mg/L) in all three seasons. Additionally, in the majority of the samples, the Fe^{2+} values (0.448–1.005 mg/L) were higher than the limit. With only minor variations in the low-altitude region, spring water in the evaluated areas is generally acceptable for residential use. Vulnerability mapping and raising awareness are highly advised for long-term use [4].

Ojekunle et al. analysed the impacts of industrial activity in Ogun State, Nigeria, was the aim of this study. For the study of physicochemical quality indicators, 96 samples were gathered during the wet and dry seasons. Piper Trilinear software was used to examine the hydrochemical facies of groundwater samples and the hydrochemical evaluation adhered to APHA guidelines. The relationship between the two variables was evaluated using Pearson correlation. In Sagamu (wet season), the pH values range from 6.01 ± 0.04 to 6.67 ± 0.06 and from 5.15 ± 0.07 to 6.55 ± 0.07, whereas at Otta, they range from 6.67 ± 0.06 to 9.42 ± 0.11 in the wet season and from 4.35 ± 0.21 to 5.70 ± 0.14 in the dry season [5].

In other work, thirteen groundwater samples were taken during the pre- and post-monsoon seasons from shallow wells along the riverside to evaluate the quality of the groundwater. All groundwater samples were examined for physicochemical parameters, including pH between 6.9 and 8.1, total dissolved solids between 320 and 4011 mg/L, total hardness between 120 and 1320 mg/L, chloride between 160 and 2260 mg/L, and sulphate between 61 and 777 mg/L [6].

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https://doi.org/10.30799/jespr.250.25110102
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Cite this Article as: D. Mukesh Kumar, P. Dushyant Kumar, V. Shubang, G. Jaya, Second phase study of groundwater quality in Kushalgarh block villages, Banswara district, Rajasthan, J. Env. Sci. Pollut. Res. 11(1) (2025) 507–510.

AlSuhaimi et al examined the quality of the groundwater used for irrigation and domestic purposes in the Odqus region of Saudi Arabia. Water samples from 51 wells were collected in July and August of 2013 and tested for pH, total dissolved solids (TDS), total hardness (TH), and the presence of major anions and cations. The findings showed that while a small percentage of samples (7.14%) had higher than allowed TDS content, and the pH, NO_3^-, NO_2^-, Br^-, and F^- in all samples were below the local drinking water guideline: SASO (Saudi Standards, Metrology, and Quality Organization) values. By this, very few samples failed the K, Na, Cl, and SO_4^{2-} ion tests (1.96 %, 5.88 %, 7.84 %, and 5.88 %, respectively). Even still, 98 % of the samples fell short of the highest level suggested by the SASO [7]. The physicochemical properties of groundwater collected from multiple locations in the Bichi Local Government Area of Kano State were examined using standard methods by Bernard and Ayeni [8]. The study area has a mean of Turbidity of 2.0 NTU, Color 2.5 TCU, Temperature of 25 °C, pH 6.8, total alkalinity 85.0 mg/L, total hardness 71.83 mg/L, and calcium 25.24 mg/L, magnesium 2.19 mg/L, iron 0.05, chloride 7.89 mg/L, nitrate 0.79 mg/L, total dissolved solids 81.0 mg/L, and conductivity 135 µS/cm. According to the samples collected from 20 different locations. The purpose of the study was to determine the quality of the groundwater in the area, and it was found that the water samples were within the groundwater safety limits set by the World Health Organization and the Standard Organization of Nigeria for use in domestic, agricultural, and industrial applications. To prevent contamination of the groundwater, it was advised that regular monitoring and control of human activity be implemented [8].

In addition to surface water, groundwater is a valuable natural resource for drinking water. Like other natural resources, it should be regularly inspected and the quality of the drinking water should be communicated to the local population. Utilized groundwater samples that were collected and analysed for their physicochemical properties, such as temperature, colour, turbidity, electrical conductance (EC), pH, total dissolved solids (TDS), total alkalinity, chemical oxygen demand (COD), and ion concentrations, such as calcium, magnesium, fluoride, and chloride, from different locations in Gujarat state, India's Vadgam taluka. Its quality was assessed about EU drinking water standards and ICMR guidelines (1998). Data on mean, standard deviation, and correlation coefficient (r) were also calculated for the statistical study of these water quality features [9]. In February 2019, primary data on groundwater samples from five distinct zones in Erbil, Iraq, were collected to determine the physicochemical characteristics of the groundwater and the levels of radon activity by Qadir et al. [10].

The collection of 24 water samples was necessary for the physicochemical examination and radon determination. The level of dissolved Radon 222Rn in a groundwater sample has been measured using the electronic Radon detector RAD 7. Groundwater has been measured for a variety of parameters, such as pH, total dissolved solids, total hardness, sulphate, and magnesium. Regression analysis revealed that there is no correlation between the concentration of radon and pH, TDS, hardness, sulphate, and magnesium since these variables are not significant at the 95 % confidence level. Otherwise, the correlation of definite (R2) values indicates the relationship between Sulfate and Magnesium Radon Concentration because both are significant at the 95 % confidence level [10].

This study aims to evaluate the impact of agricultural and industrial activities on water characteristics by analyzing the water quality metrics in the Kushalgarh block. The study looks at physical, chemical, and biological factors in order to assess any possible threats to aquatic ecosystems and public health as well as compliance with acceptable criteria. The results will help maintain sustainable resource management and continuous water quality monitoring.

2. Experimental Methods

About 500 mL plastic sample collection bottles that had been previously cleaned were used to collect the samples. During Summer, Winter and Monsoon season at 2023, water samples were gathered from ten villages in the Kushalgarh block (Table 1). Physical-chemical characteristics were measured, including pH, TDS, total hardness, electrical conductivity, calcium, magnesium, fluoride, and chloride using standard procedures.

Table 1 Sites of sample collections

Sample Name	Villages	Sample Name	Villages
S1	Bhiladhi	S6	Devdasath
S2	Mohkampura	S7	Ramgarh
S3	Churada	S8	Potaliya
S4	Bakaner	S9	Bhagatpura
S5	Badwas Badi	S10	Lohariya Kalan

3. Results and Discussion

3.1 pH Level in the Ground Water Samples

The pH of groundwater typically falls between 7.1 and 8.6. The water is classified as acidic, soft, and corrosive if the pH falls below 6.5. Elevated quantities of hazardous metals are also indicated by an acidic pH. pH monitoring is essential. Water with a low pH can cause aesthetic issues including a sour or metallic taste and hasten the degradation of metal pipes. Table 2 lists the precise pH values for each sample.

Table 2 Variations of pH in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	8.2	7.3	8.0
S 2	7.2	7.1	8.1
S 3	7.7	7.6	7.5
S 4	8.3	8.6	8.6
S 5	7.8	7.4	7.1
S 6	8.3	8.1	7.8
S 7	7.4	7.8	7.9
S 8	8.5	8.4	8.1
S 9	8.1	8.2	8.4
S 10	8.1	8.1	7.5

3.2 Total Dissolved Solids (TDS)

Minerals, salts, metals, cations, and anions that dissolve in water are all included in total dissolved solids or TDS. In addition to trace amounts of dissolved organic matter, it is mostly composed of inorganic salts such as calcium, magnesium, potassium, sodium, bicarbonates, chlorides, sulphates, and phosphate. Without identifying the types or connections of dissolved ions, TDS analysis provides a qualitative assessment of water quality. According to Indian Standards, the maximum allowable level for TDS is 2000 mg/L, whereas the acceptable value is 500 mg/L. The TDS values for the several samples are shown in Table 3 and range from 132 to 415 mg/L, suggesting an overall concentration that is within allowable bounds.

Table 3 Variations of total dissolved solids (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	238	327	331
S 2	364	330	345
S 3	165	196	214
S 4	243	278	298
S 5	166	261	305
S 6	132	279	351
S 7	284	310	422
S 8	234	360	415
S 9	241	312	392
S 10	184	263	339

3.3 Total Hardness (TH)

The total hardness, expressed in mg/L equivalent to $CaCO_3$, is the sum of the concentrations of Ca^{2+} and Mg^{2+}. It is mostly caused by the weathering of sedimentary rock, limestone, and minerals that contain calcium. Local sources could include excessive fertilizer use in agricultural areas or groundwater affected by chemical and mining industrial emissions. According to Indian Standards, a total hardness (TH) level of 200–600 mg/L is considered acceptable and allowed. According to Table 4, the total TH concentration ranged from 205 to maximum of 625 mg/L.

Table 4 Variations in total hardness (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	220	268	298
S 2	395	418	458
S 3	235	308	482
S 4	405	520	363
S 5	275	344	386
S 6	205	263	256
S 7	420	535	472
S 8	560	590	602
S 9	500	545	625
S 10	440	470	495

3.4 Calcium

By supporting bone mass, assisting in the absorption of heavy metals, and possibly avoiding some types of cancer, calcium is essential for maintaining human health. Water hardness is directly correlated with its

https://doi.org/10.30799/jespr.250.25110102

presence. According to Table 5, the water samples' calcium concentrations ranged from 44 to 178 mg/L. Notably, calcium levels in groundwater samples from locations S2, S4, S6, and S8 exceeded 100 mg/L WHO's allowable limit. Site S8 had the highest calcium content measured.

Table 5 Variations in calcium (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	72.9	70.2	68.4
S 2	117.5	115.6	112.4
S 3	84.3	82.2	81.3
S 4	160.2	155.8	148.2
S 5	45.6	48.3	44.1
S 6	178.7	172.3	168.9
S 7	67.3	65.4	62.7
S 8	124.6	131.9	121.5
S 9	72.8	70.8	71.6
S 10	46.1	44.9	42.8

3.5 Chloride

Since sodium chloride is a prevalent ingredient in many water sources, particularly groundwater and subterranean water, chloride and sodium are frequently linked. Table 6 shows that the chloride concentrations in the water samples ranged from 51.3 to 111.6 mg/L. Thankfully, every chloride value for the groundwater samples fell within the 250- mg/L allowable range set by the BIS and WHO.

Table 6 Variations in chloride (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	92.4	97.7	105
S 2	111.1	108.6	115.4
S 3	66.5	112.4	119.2
S 4	86.2	82.9	92.1
S 5	88.2	83.7	90.2
S 6	56.3	58.1	63.5
S 7	106.4	109.2	112.4
S 8	111.6	108.8	118.3
S 9	99.2	92.2	124
S 10	54.9	51.3	62.5

3.6 Electrical Conductivity (EC)

The ionic content of water is measured by electrical conductivity (EC), which is expressed in units of µs/cm. Higher dissolved salts result in stronger current flow and improved electrical conductivity; this attribute is related to the overall concentration of ionised chemicals in water. Total alkalinity, which represents the concentration of hydroxide ions (alkalinity) in the water, is intimately related to the mobility of ions in solution.

Higher EC values in densely inhabited places, such as where these water points are located, could be explained by concentrated dissolved salts brought on by human activity. Table 7 shows that the water samples' EC values varied from 570 to 1450 mg/L. By BIS guidelines, 2250 mg/L is the acceptable level.

Table 7 Variations in EC (µS/cm) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	625.8	628	610.3
S 2	1290.2	1296.8	1298.3
S 3	840.3	840	835
S 4	1450.6	1442.9	1448.4
S 5	570.4	560	556.1
S 6	620.7	631.3	651.5
S 7	635.2	618	630.3
S 8	710.6	740.6	762.4
S 9	950.3	958.7	927
S 10	865.2	886	862

3.7 Fluoride

Groundwater frequently contains higher levels of fluoride than surface water. The acceptable and allowable fluoride levels, according to the Indian Standards, are 1.6 and 0.5 mg/L, respectively. Fluoride levels in drinking water that are between roughly less than 0.5 and 2.1 mg/L are thought to be good for human health. However going above the allowed limit might result in problems including bone fractures, dental fluorosis, and, worse, skeletal fluorosis. As seen in Table 8, the fluoride levels were within the allowable limits even though the concentration range was the same for both seasonal samples.

Table 8 Variations in fluoride (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	0.7	1.3	1.2
S 2	1.6	1.9	1.3
S 3	0.5	1.1	0.9
S 4	1.8	2.1	1.6
S 5	0.9	1.1	0.8
S 6	0.4	0.7	0.5
S 7	1.1	1.6	1.0
S 8	1.3	1.8	1.5
S 9	1.1	1.5	1.3
S 10	0.9	1.4	1..2

3.8 Magnesium

Drinking water with magnesium may benefit heart and vascular health. But high doses that have a laxative effect can be harmful to your health. Magnesium is essential for chlorophyll and serves as a growth-limiting element for phytoplankton. It is correlated with water hardness and frequently associated with calcium, although in lesser proportions. Although magnesium is necessary for these processes, Indian guidelines limit the amount of magnesium that can be present in water to 100 mg/L. All samples' magnesium ions are found to be within the allowable limit, according to the results shown in Table 9.

Table 9 Variations in magnesium (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	64.7	72.9	62.6
S 2	43.9	42.9	41.3
S 3	35.6	41.0	39.4
S 4	29.1	31.2	34.8
S 5	54.2	65.3	62.0
S 6	37.7	39.6	42.5
S 7	81.6	89.7	86.3
S 8	93.2	98.6	90.4
S 9	78.6	82.9	80.1
S 10	28.5	30	27.8

3.9 Nitrate

Rainfall and groundwater aquifers naturally contain nitrates, typically in trace amounts (less than 10 mg/L NO_3^-). However, human activities such as industry, home wastewater, combustion engine emissions, and agriculture can raise nitrate levels. While the natural background quantity of nitrate is roughly 7.2 mg/L, the Bureau of Indian Standards (BIS) sets the acceptable amount of nitrate in drinking water at 45 mg/L. In most samples, nitrate ions are within the permissible limit, as indicated by the results.

Table 10 Variations in nitrate (mg/L) in Kushalgarh block

Sample	Summer	Winter	Monsoon
S 1	0.7	2.9	2.6
S 2	1.0	2.3	1.3
S 3	1.4	1.0	1.6
S 4	3.2	3.6	3.4
S 5	1.6	1.9	1.4
S 6	0.2	0.8	1.1
S 7	3.6	3.4	3.2
S 8	5.3	5.6	5.1
S 9	2.9	3.1	2.8
S 10	0.8	1.3	1.1

4. Conclusion

Ten locations provided water samples for the investigation, which was carried out in the Kushalgarh block of Banswara, Rajasthan. According to the research, most sites had pH, TDS, total hardness, calcium, chloride, electrical conductivity, fluoride, and magnesium within allowable bounds. Since every evaluated parameter satisfies legal requirements, the study verifies that the water quality in the Kushalgarh block stays within safe bounds for aquatic life and human consumption.

There were no significant changes in the water's composition despite the region's industrial and agricultural activity. To guarantee the long-term sustainability of water resources and to identify any new contaminants that can compromise water safety in the future, routine monitoring is advised.

https://doi.org/10.30799/jespr.250.25110102

Cite this Article as: D. Mukesh Kumar, P. Dushyant Kumar, V. Shubang, G. Jaya, Second phase study of groundwater quality in Kushalgarh block villages, Banswara district, Rajasthan, J. Env. Sci. Pollut. Res. 11(1) (2025) 507–510.

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https://doi.org/10.30799/jespr.250.25110102

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