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Physico-chemical Analysis of Selected Groundwater Samples of Kushalgarh Block, Banswara, Rajasthan, India

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ABSTRACT

Water is crucial for shaping the land and affecting the weather. It is essential for life, characterized by its physical features, ingredients, and life-related qualities. Due to fast industrial growth and the widespread use of fertilizers and pesticides in farming, water quality is taking a hit. People using polluted water face waterborne diseases. This study assesses the quality of water in the Kushalgarh block, Banswara Rajasthan.

Key words: *Groundwaters, Groundwater quality, Banswara*

Introduction

The quality of groundwater near certain industrial areas is a major concern for the environment because it directly impacts human health and irrigation. Water sources for drinking and household use must be very pure, free from any chemicals or microorganisms. However, with the rapid increase in population and industrial activities, water quality has worsened, leading to pollution. Groundwater is extremely valuable and a crucial element for human survival, providing not only necessities but also comforts. It plays a vital role in agricultural and industrial developments, making it an essential part of our ecosystem. Evaluating and mapping groundwater is important because the physical and chemical characteristics of any groundwater sample determine its suitability for agricultural, domestic, and industrial purposes.

Patil and Patil (2010) investigated Amalner town between November 2007 and February 2008 assessed the physicochemical characteristics of groundwater and municipal water from five stations, including four groundwater samples (two open wells, two bore wells) and one municipal water sample. The 15 parameters, revealed contamination in groundwater at specific sites (Shirud Naka, Cotton Market, Shivaji Nagar), while water from Dekhu Road met quality standards. Parameters were compared against WHO and ISI 10500-91 standards, indicating deviations. Correlation coefficients were computed to assess relationships between water quality parameters. Top of Form

The Velliangadu area, in particular, has witnessed a significant rise in bore-well drilling due to the depletion of open wells. Open wells served as the primary source of irrigation water, but the surge in bore wells, reaching depths of up to 1000 feet, reflects the intensifying search for water. Karthik *et al.* (2019) analyzed the physico-chemical properties of groundwater in Velliangadu, focusing on parameters such as pH, Hardness, Alkalinity, Total Dissolved Solids, Chloride content, and Electrical Conductivity. Encouragingly, the results indicated that all these parameters were well within the standard values set by various organizations. Consequently, it is inferred that the groundwater quality in the Velliangadu area remains good, offering valuable insights to farmers concerned about water quality for their agricultural activities.

Devi and Premkumar (2012) evaluated the impact of industrial activities on groundwater quality in and around the SIPCOT Industrial complex in Cuddalore District. The assessment focused on physicochemical parameters, and water samples were collected from seven villages in Cuddalore Taluk between December 2010 and February 2011, encompassing both groundwater and municipal water sources. Various parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, dissolved oxygen (DO), total alkalinity (TA), total hardness (TH), calcium (Ca^{+2}), magnesium (Mg^{+2}), sodium (Na^{+}), potassium (K^{+}), chloride (Cl^{-}), nitrate (NO_3^{-}), and sulphate (SO_4^{-2}) were analyzed according to APHA (1998) standards. The comparison of results with ISI 10500-91 standards revealed contamination at some groundwater sampling sites, while others demonstrated physicochemical parameters within acceptable water quality limits, making the water suitable for drinking. The study also involved the calculation of correlation coefficients for a comprehensive water quality assessment.

Yadav *et al.* (2013) evaluated the groundwater status in Agra city. Various physicochemical parameters were assessed, revealing ranges beyond the natural background levels. Specifically, parameters such as pH (7.2-7.7), electrical conductivity (EC) (1580-5200 mmhos), total dissolved solids (TDS) (1020-4950 mg/l), turbidity (1.1-31.4 NTU), total alkalinity (330-525 mg/l), total hardness (240-1425 mg/l), chloride (295-1140 mg/l), calcium (72-436 mg/l), magnesium (14.6-151.2 mg/l), sodium (126.5-1254.9 mg/l), and potassium (1.9-60.6 mg/l) were observed to exceed natural background levels. These findings indicate groundwater pollution across the 12 sampling sites in Agra city from February to May 2011.

Khan *et al.* (2013) studed the Singrauli area of North India aimed 27 water samples included the examination of various physicochemical parameters such as pH, total dissolved solids (TDS), bicarbonate, hardness, calcium, magnesium, sodium, potassium, chloride, sulfate, copper, iron, cobalt, manganese, zinc, and chromium. The sampling locations were chosen based on a preliminary field survey to comprehend the overall impact of mining and industrialization on surface and groundwater resources in Singrauli. Utilizing topographic maps and satellite data, land use and land cover categories were delineated, with open forest covering 20.33%, uncultivated land at 20.25%, cultivated land at 12.60%, dense forest at 11.00%, and other categories accounting for 35.82%. The study compared the obtained results with WHO standards for drinking water quality. The physicochemical analysis revealed an alkaline nature of water, soft to moderately soft characteristics, with TDS and total alkalinity exceeding desirable limits. Major ions like calcium and magnesium were within acceptable limits, while sulfate and potassium surpassed desirable levels at certain locations. Elevated values of sodium and chloride were observed. Minor ions such as copper and zinc were within recommended limits, whereas iron, cobalt, and chromium exceeded desirable levels, indicating deterioration in water quality.

Jena and Sinha (2017) studed in Raipur city during 2015-2016 assesses groundwater's physicochemical parameters for agricultural, industrial, and domestic purposes. Standard methods were employed, and statistical analyses, including correlation coefficients and t-tests, were conducted to evaluate the observed values against WHO drinking water standards. The study suggests that sewage and industrial effluents may be contributing to variations in water quality in the region, emphasizing the importance of assessing and mapping groundwater for various uses.

Singh *et al*. (2012) studed in Dholpur district, Rajasthan, India, aims to assess water pollution resulting from excessive fertilizer and pesticide use in agriculture and its influence on the groundwater quality of three distinct dug wells. Various physicochemical parameters, including pH, temperature, TDS, conductivity, nitrate, sulfate, dissolved oxygen, hardness, sodium, potassium, chlorides, and chemical oxygen demand, were examined. The findings indicate that the water quality at the selected sampling stations is within the limits prescribed by the World Health Organization (WHO) and is suitable for domestic use.

Bahar and Reza (2010) investigated the hydrochemical characteristics of shallow groundwater in the coastal region of Khulna, southwest Bangladesh, with a focus on evaluating its suitability for drinking and irrigation purposes. Water samples from 26 boreholes were analyzed for major cations and anions, including physico-chemical parameters such as pH, electrical conductivity (EC), and total dissolved solids. The groundwater, predominantly slightly alkaline, exhibits considerable variation in chemical composition, with EC ranging from 962 to 9,370 ìs/cm. Major ion abundance follows the sequence $Na^+ > Ca^{2+} > Mg^{2+} > K^+ = Cl^{˝} > HCO^{3˝} >$ SO4 2” > NO3 “. The analytical data suggests two primary hydrochemical facies ($Na+–K+–Cl^{˝}–SO_4^{2˝}$ and $Na^+–K^+–HCO_3^{˝}$) in the study area. Salinity, total hardness, and sodium percentage (Na%) indicate that most groundwater samples are unsuitable for irrigation and domestic use, falling short of drinking water standards. The study suggests that the brackish nature of the groundwater is attributed to seawater influence and hydro-geochemical processes.

The study investigates the water quality in the Talcher Area, encompassing samples from the Ghats of River Brahmani, tube wells, and tap water from various colonies during both Monsoon and Post Monsoon seasons. Analyzing parameters like DO, pH, Conductivity, Temperature, Sodium, Potassium, Dissolved Oxygen, Total Solid, Chloride, Alkalinity, Hardness, Sulphate, Chemical Oxygen Demand, Nitrate, Phosphate, and Fluoride, the study calculates the NSF water quality index. Notable findings include a maximum pH of 7.91 ± 0.17 at Jagannath Ghat, the highest average conductivity of 559.28 ± 8.92 ìS/cm in tube well water of Jagannath colony, and a maximum temperature of 28.5 ^oC ± 0.36 ^oC in tube well water of C.W.S. Colony. Various parameters, such as Sodium, Potassium, Chloride, Alkalinity, and Nitrate, displayed significant values in tube well water of Balanda colony. The study also highlights high dissolved oxygen content in tap water of C.W.S. colony and maximum hardness in tube well water of C.W.S. colony. Elevated values of COD and Sulphate were recorded in tube well water of Jagannath colony, while maximum Phosphate and Fluoride content were observed in Paschimeswar Ghat. Statistical analyses, including two-way ANOVA and correlation coefficients, were applied for further interpretation of the data.

Parihar *et al*. (2012) conducted the study in July 2009 in the Gwalior region, Madhya Pradesh, India, the physico-chemical and microbiological characteristics of drinking water were assessed at various locations. Sixteen water samples were collected, revealing diverse parameters. Electrical conductivity, total dissolved solids, and total aerobic microbial count were highest in the S-3 sample. pH, hardness, and dissolved oxygen were elevated in S-6, S-8, and S-10 samples. Enteric pathogens *E. coli* and Enterobacter were detected in specific samples (S-5, S-11, S-1-4, S-10, S-12-13). Notably, coliforms were absent in samples S-6-9 and S-14-16. The overall analysis of physico-chemical and microbiological characteristics indicated that a majority of the samples were unsuitable for drinking purposes.

Nirbhavane *et al.* (2016) study in June 2013 to January 2014, the groundwater quality in the Ambarnath industrial zone was investigated. A total of 6 sampling sites were selected, and groundwater samples were collected and analyzed for various physicochemical parameters, including temperature, pH, conductivity, alkalinity, total hardness, TDS, and chloride. The obtained results were then compared with the standards set by the World Health Organization (WHO) and the Bureau of Indian Standards (BIS). The groundwater quality in the industrial zone, with particular attention to areas such as Bhimnagar open well and Kansai Gaon open well, which exhibited higher conductance values compared to other samples. Throughout the study period, it was observed that open wells were more significantly impacted compared to hand pumps and bore wells in the region.

Materials and Method

Sample Collection

Samples were collected in pre-cleaned 500 mL polyethylene bottles. The water samples were collected from 10 villages of Kushalgarh block during the summer seasons. Physicochemical parameters such as pH, TDS, total hardness, electrical conductivity, calcium, magnesium, chloride, fluoride, etc. were determined. Samples from these villages were collected in the period summer 2023 and labeled as:

Table 1. Sites of sample collections

Sample name	Villages
S1	Badwas Chhoti
S2	Nagar palika block
S3	Teemera Chhota
S4	Lohariya Kalan
S5	Ukala
S6	Doungri Para
S7	Vasooni
S8	Sarvaa
S9	Patan
S10	Bijori Badi

Method of Analysis

pH

Groundwater pH typically falls within the range of 7 to 8. If the pH is below 6.5, the water is considered acidic, soft, and corrosive. Additionally, an acidic pH indicates higher levels of toxic metals. Monitoring pH is crucial due to its significance. Low pH in water can lead to early deterioration of metal piping and cause aesthetic issues like a metallic or sour taste. The pH values of the samples are detailed in Table 2.

Table 2. Variations of pH Kushalgarh block

	pH		
Sample	Summer	Winter	Monsoon
S 1	7.2	7.1	7.0
S 2	7.3	7.3	7.2
S 3	7.5	7.7	7.5
S 4	8.7	8.9	7.9
S 5	7.4	7.3	6.9
S 6	8.1	8.0	7.6
S 7	7.5	7.7	7.9
S 8	7.8	7.4	7.2
S 9	7.7	8.0	7.9
S 10	7.2	7.1	6.8

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) encompass minerals, salts, metals, cations, or anions dissolved in water. It consists mainly of inorganic salts like calcium, magnesium, potassium, sodium, bicarbonates, chlorides, sulfates, phosphate, along with small amounts of dissolved organic matter. TDS analysis gives a qualitative measure of dissolved ions, indicating the general water quality without specifying the nature or relationships of ions. The acceptable limit for TDS is 500 mg/l, and the maximum permissible limit is 2000 mg/l as per Indian Standards. Table 3 provides the TDS values for different samples, ranging between 150 and 731 mg/l, indicating an overall concentration within acceptable levels.

Total Hardness (TH)

Total hardness represents the combined concentration of Ca^{2+} and Mg^{2+} in mg l^{-1} equivalent to $CaCO_3$. It primarily results from the weathering of limestone, sedimentary rock, and calcium-bearing minerals. Local sources include groundwater affected by chemical and mining industry effluent or excessive fertilizer application in agricultural areas. Indian Standards set an acceptable and permissible limit for Total Hardness (TH) at 200-600 mg l^{-1}. The overall TH concentration ranged from 200 to a maximum of 798 mg l^{-1} (as reported in Table 4). Notably, water samples from sites S3 and S8 exceeded the permissible limit for total hardness.

Table 3. Variations of total dissolved solids Kushalgarh block

	Total Dissolved Solids (mg l^{-1})		
Sample	Summer	Winter	Monsoon
S 1	585	627	731
S 2	271	313	431
S 3	346	436	514
S 4	148	277	399
S 5	166	254	320
S 6	226	289	371
S 7	219	308	436
S 8	330	430	490
S 9	235	351	412
S 10	312	461	531

Table 4. Variations in total hardness Kushalgarh block

	Total Hardness (mg l^{-1})		
Sample	Summer	Winter	Monsoon
S 1	550	571	601
S 2	465	503	534
S 3	630	601	675
S 4	230	310	275
S 5	300	344	386
S 6	320	365	354
S 7	280	371	341
S 8	660	731	798
S 9	340	397	331
S 10	310	345	367

Calcium

Calcium is vital for human health, potentially inhibiting the absorption of heavy metals, promoting bone mass, and potentially preventing certain cancers. The calcium content is directly linked to water hardness. In the water samples, calcium ranged from 20 to 228 ppm (as detailed in Table 5). Notably, the calcium levels in groundwater samples from sites S1, S3, S4, S6, and S8 exceeded the WHO permissible limit of 100 ppm. The highest calcium concentration was observed at site S8.

Chlorides

Chloride are commonly linked with sodium, as sodium chloride is a prevalent component in various

Table 5. Variations in calcium Kushalgarh block

Sample	Calcium (mg l^{-1}) Summer	Winter	Monsoon
S 1	148.5	136	120
S 2	85.5	82.1	83.2
S 3	107.2	100.2	99.2
S 4	112.5	106	104
S 5	78.3	74	71.2
S 6	139.4	135.1	131
S 7	48.3	40.2	39
S 8	228.0	224	220
S 9	44.6	42.21	40.2
S 10	56.8	48.01	42.6

water sources, particularly groundwater and underground water. Chloride levels in the water samples ranged from 76.2 to 285.6 ppm (as indicated in Table 6). Fortunately, chloride values for all groundwater samples were within the permissible limits set by WHO and BIS (250 ppm), with the exception of the water sample from site S1.

Table 6. Variations in chloride Kushalgarh block

Sample	Chloride (mg l^{-1}) Summer	Winter	Monsoon
S 1	285.6	277.8	290
S 2	102.3	101.2	107.1
S 3	113.2	112.4	119.2
S 4	80.3	79.2	86.4
S 5	76.2	73.4	80.1
S 6	88.4	89.1	94.5
S 7	103.2	107.5	110.4
S 8	112.6	110.6	117.5
S 9	125.1	121.2	134
S 10	127.6	126	131.1

Electrical Conductivity (EC)

Electrical Conductivity (EC) serves as a measure of water's ionic content, reported in units of μs cm^{-1}. This property is linked to the total concentration of ionized substances in water; higher dissolved salts correspond to stronger current flow and increased electrical conductivity. The mobility of ions in solution is closely tied to total alkalinity, reflecting the concentration of hydroxide ions (alkalinity) in the water.

In densely populated areas, such as the locations of these water points, higher EC values may be attributed to concentrated dissolved salts resulting from human activities. EC values for the water samples ranged from 540 to 1587 ppm (as shown in Table 7), with the permissible limit set at 2250 ppm according to BIS standards.

Table 7. Variations in EC in Kushalgarh block

Sample	Electrical Conductivity (μs cm^{-1}) Summer	Winter	Monsoon
S 1	1580	1587	1542
S 2	1102	1110	1010
S 3	860.3	840	855
S 4	775.6	751	761
S 5	625.9	620	611
S 6	965.8	961.7	971.5
S 7	540.8	520	526
S 8	1470.1	1478	1489
S 9	680.5	687	621
S 10	778.7	791	754

Fluorides

Fluoride are commonly found in higher concentrations in groundwater compared to surface water. The Indian Standards prescribe permissible and acceptable fluoride ranges of 1.0 and 1.5 mg l^{-1}, respectively. Fluoride concentrations between approximately less than 0.5 to 3.9 mg l^{-1} in drinking water are considered beneficial for human health. However, exceeding the permissible limit can lead to issues such as dental fluorosis, bone fractures, and, more severely, skeletal fluorosis.

The fluoride levels in groundwater samples from sites S1, S2, S8, and S9 exceeded, as detailed in Table 8.

Table 8. Variations in Fluoride in Kushalgarh block

Sample	Fluoride Summer	Winter	Monsoon
S 1	3.1	3.7	3.3
S 2	1.2	1.6	1.4
S 3	1.4	1.5	1.2
S 4	0.6	0.9	0.5
S 5	0.8	1.0	0.7
S 6	0.9	1.2	1.0
S 7	1.1	1.4	0.9
S 8	1.5	1.9	1.1
S 9	1.3	1.7	1.5
S 10	1.0	1.5	1.2

Magnesium

Magnesium in drinking water can have various beneficial effects, especially on cardiac vascular functions. However, at very high levels, it may lead to adverse health effects, including a laxative effect. Magnesium is also directly linked to water hardness and is often associated with calcium, albeit generally found in lower concentrations.

While magnesium is essential for chlorophyll and serves as a limiting factor for the growth of phytoplankton, the permissible limit for magnesium in water, as per Indian standards, is 100 mg L^{-1}. The results, detailed in Table 9, indicate that magnesium ions are within the permissible limit in the majority of samples. However, the limit is exceeded in samples from sites S1, S2, S3, S7, S8, S9, and S10.

Table 9. Variations in Magnesium in Kushalgarh block

	Magnesium (mg l^{-1})		
Sample	Summer	Winter	Monsoon
S 1	285.6	287	265
S 2	102.3	101	99.2
S 3	113.2	118	101
S 4	80.3	81.2	78.5
S 5	76.2	75.0	71.2
S 6	88.4	79.8	75.4
S 7	103.2	105	99.8
S 8	112.6	110	102
S 9	125.1	127	122.4
S 10	127.6	130	125

Nitrate

Nitrates are naturally present in rainfall and groundwater aquifers, typically at very low levels (less than 10 mg l^{-1} NO_3). However, human activities, including agriculture, industry, domestic effluents, and emissions from combustion engines, can lead to an increase in nitrate concentrations. The Bureau of Indian Standards (BIS) sets the permissible level of nitrate in drinking water at 45 milligrams per liter (mg l^{-1}), while the natural background concentration of nitrate is around 7.2 mg l^{-1}. In the majority of samples, nitrate ions are within the permissible limit, as indicated by the results.

Table 10. Variations in Nitrate in Kushalgarh block

	Nitrate (mg l^{-1})		
Sample	Summer	Winter	Monsoon
S 1	1.9	2.1	1.7
S 2	0.9	1.2	1.0
S 3	0.5	0.8	0.6
S 4	2.1	2.7	1.9
S 5	0.7	0.75	0.6
S 6	2.6	2.9	2.1
S 7	2.8	2.7	2.3
S 8	4.1	4.8	4.2
S 9	2.4	2.6	2.1
S 10	1.8	2.0	1.6

Conclusion

In the study conducted in Kushalgarh block, banswara, Rajasthan water samples were collected from 10 sites. The analysis revealed that pH, TDS, total hardness, calcium, chloride, electrical conductivity, fluoride, and magnesium in the majority of sites were within permissible limits. Overall, the water quality in the area is reasonably good.

Conflict of Interest- None

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