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Physicochemical Characteristics and Irrigation Quality of Water in Faya and Surrounding Areas Plateau State, Nigeria

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Abstract

This study evaluates the physicochemical properties and irrigation suitability of various water sources in Faya and its surrounding environs within Plateau State, Nigeria. A total of 25 water samples were systematically collected during the dry season from both surface water bodies (including rivers, streams, ponds, dams, and mining ponds) and groundwater sources (wells and boreholes). These samples were analyzed for key physical parameters—pH, electrical conductivity (EC), total dissolved solids (TDS), turbidity, salinity, and total hardness—as well as major chemical constituents such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), chloride (Cl^{-}), sulfate (SO_4^{2-}), bicarbonate (HCO_3^{-}), nitrate (NO_3^{-}), nitrite (NO_2^{-}), phosphate (PO_4^{3-}), and fluoride (F^{-}). In addition, irrigation water quality indices were computed, including the Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), and Kelley's Ratio (KR). The results show that most water samples had pH values within the acceptable limits prescribed by the World Health Organization (WHO). However, elevated levels of TDS, turbidity, and hardness were observed in several samples. Notably, both groundwater and surface water sources exhibited fluoride and nitrate concentrations exceeding WHO guidelines, indicating potential health risks, particularly for long-term consumption. While SAR values remained below 10 in most cases—suggesting a low sodium hazard to soil permeability—MAR values exceeded 50% in the majority of samples, pointing to a significant magnesium dominance. Furthermore, elevated KR values in select locations suggest a risk of sodium-induced degradation of soil structure. These findings underscore the combined effects of geogenic processes (such as mineral weathering) and anthropogenic activities (including agricultural runoff and artisanal mining) on water quality. The study highlights the critical need for regular monitoring, effective water treatment strategies, and integrated water resource management to ensure the suitability of water for both irrigation and human use in the region.

Keywords
Irrigation suitability; Physicochemical analysis; Sodium Adsorption Ratio (SAR); Magnesium Hazard (MAR); Kelley's Ratio (KR); Total Dissolved Solids (TDS); Fluoride contamination; Middle Benue Trough; Hydrogeochemical assessment; Agricultural runoff;

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INTRODUCTION

Water is a fundamental natural resource critical to both ecological systems and human livelihoods. It serves domestic, and industrial purposes, especially in rural communities where reliance on surface and groundwater is high. Water is also a raw material for photosynthesis and therefore is important for crop production. Increased food demand and rising population, combined with an extended dry season in parts of the Middle Benue Trough Nigeria, have prompted many farmers to adopt dry season farming using irrigation. To achieve this, they rely on water sourced from shallow aquifers. Irrigation involves supplying water to crops to compensate for the lack of rainfall, particularly during the dry season. In Faya, Plateau State, residents depend entirely on local water sources for drinking, domestic, and agricultural needs. Research in the Middle Benue Trough (MBT) and surrounding areas has highlighted the impact of both anthropogenic activities (such as mining and agriculture) and geogenic factors on water quality. For instance, Obiefuna and Sheriff (2011) and Solomon et al. (2020) reported that water quality in these regions is often compromised by high levels of dissolved solids and hardness, which can be attributed to both natural mineralization and human-induced contamination.

Water quality indices (WQI) and irrigation suitability indices, such as Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), and Kelly's Ratio (KR), are widely used to interpret the implications of these parameters for human health and agricultural productivity. Studies in Plateau State and the Niger Delta have shown that while some water sources meet the standards for irrigation, others exceed critical thresholds for TDS, nitrates, and hardness, posing risks for both drinking and agricultural use.

However, increasing anthropogenic activities and potential geogenic sources in the region, especially due to barite mining within the Middle Benue Trough (MBT), may be affecting water quality. Previous studies have indicated that water quality directly influences public health and agricultural productivity (Algaon-odot et al., 2012; Hogan, 2014). This study aims to evaluate the physicochemical characteristics of local water sources and assess their suitability for irrigation purposes.

2. Materials and Methods

Numerous studies have assessed the physicochemical characteristics and suitability of water sources for various uses across Nigeria, particularly in regions with significant agricultural and mining activities. Water quality is commonly evaluated using parameters such as pH, total dissolved solids (TDS), electrical conductivity (EC), hardness, and concentrations of major ions (e.g., nitrates, chlorides, sulfates, and fluorides). These parameters are critical for determining the suitability of water for drinking, domestic, and agricultural purposes.

2.1 Study Area

The study area is part of the Middle Benue Trough, North Central Nigeria. Faya and surrounding areas (such as Shendam, Langtang, and Wase) lie within southern Plateau State (Fig. 1 and 2), which is geographically part of Nigeria's Middle Belt region, typically dominated by the Guinea Savanna. It is characterized by moderate to high elevations and is known for its mineral deposits, particularly barite. The area is characterised by mixture of tall grasses and scattered medium-to-large deciduous trees. Typically, rainfall is moderate, about 1,000–1,500 mm annually, with a distinct wet and dry season. The study area supports both agriculture as the main occupation (especially cereals like maize, sorghum, and millet) and grazing. This ecological setting influences soil development, erosion patterns, and weathering processes, which in turn affect rock exposure, hydrology, and groundwater availability, factors that are important in geological and hydrogeological studies. Major settlements within the area include Faya, Langtang South, Batkilang, Dadinkowa and Walmin. These settlements are interconnected by a network of roads and are often situated along river valleys or near outcrops of particular geological units, influencing their development and accessibility.

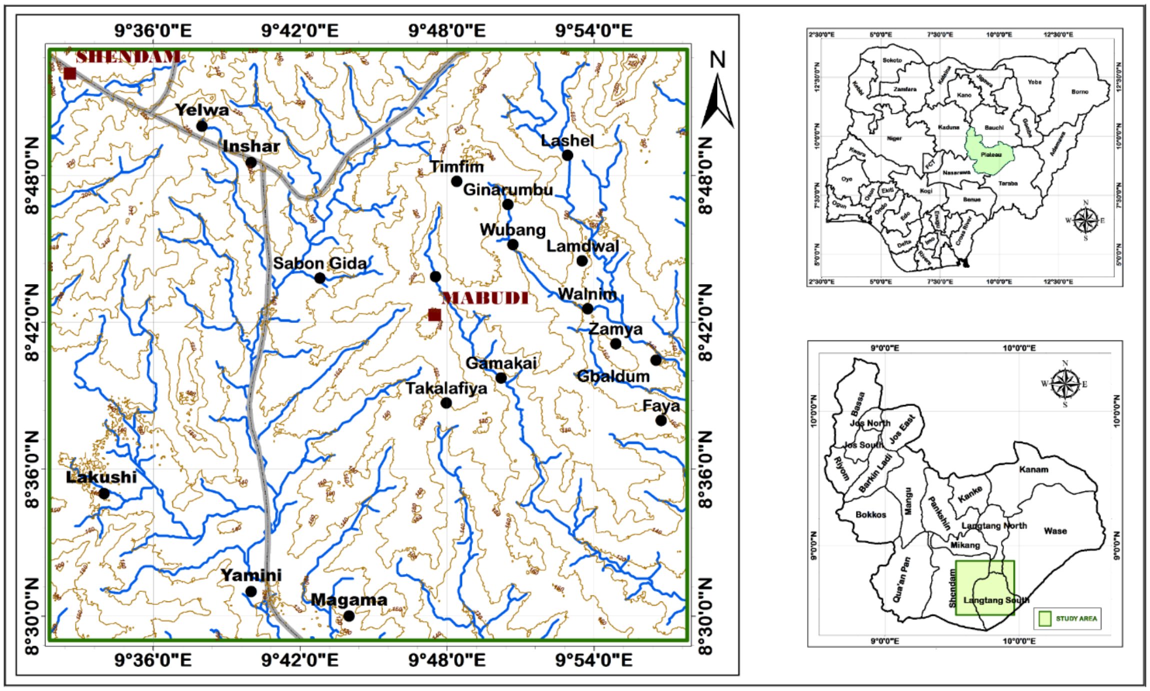

Figure 1: Location Map of the Study Area

2.2 Geology of the Study Area

The area is generally underlain by the Precambrian Basement Complex (Migmatite) shows evidence of Pan-African orogeny (550–600 Ma), with foliations and lineations oriented NW-SE, The Migmatite (M) is of Precambrian (Early–Mid Proterozoic, >1000 Ma) age and are high-grade metamorphic rocks formed during ancient orogenic events, representing the oldest crustal components in the region. The western portion of the study area has the Feldspathic-Calcareous-Shelly Sandstone (Bss), likely Upper Cretaceous in age part of the Cretaceous sedimentary rocks of the Middle BenueTrough according to Macleod et al and possibly part of the Gombe or Yolde Formations, representing high-energy shallow marine environments (Figure 3).

The Sedimentary units relate to Cretaceous rifting in the Benue Trough, accompanied by basaltic volcanism. Pindiga Formation – Shale and Limestone (Psh), Upper Cretaceous (Turonian–Santonian) and represents a transgressive-regressive sequence in the Middle Benue Trough; The Eze Aku Formation which is characterized by black shale and limestone, suggesting anoxic deep-water conditions with organic-rich sedimentation. Other formations in the study area are the Agwu Formation composed of shale and limestone, indicative of a marine depositional environment during the Cretaceous period and the Recent Alluvium (Al) Quaternary (Holocene–Recent), which are unconsolidated sediments, such as sand, silt, and clay, deposited by rivers and streams. Drainage patterns align with NW-SE structural trends, likely controlled by fractures or foliations.

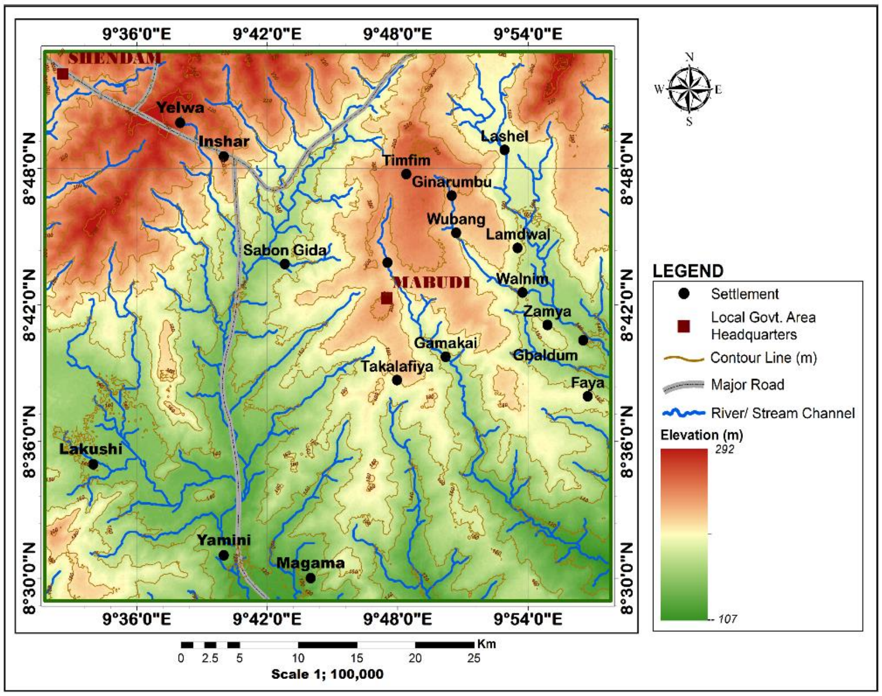

Figure 2: Elevation Map of the Study Area

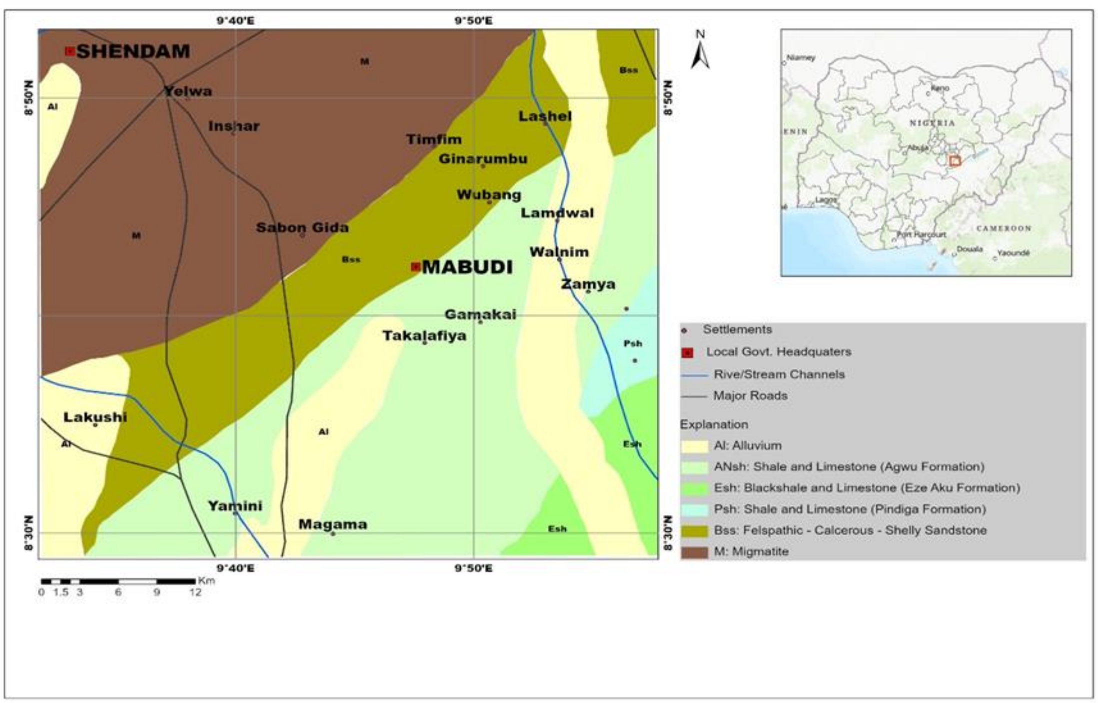

Figure 3: Geological Map of the Area (Modified from NGSA).

2.3 Sample Collection

Twenty-five water samples were collected using both random and controlled sampling methods at the peak of the dry season. Samples were obtained from surface sources (rivers, streams, ponds, dams, mining ponds) and groundwater sources (wells, boreholes), (Table 1 and Figure 4). Sampling followed standard hydrological and laboratory protocols. Each sample was preserved with nitric acid where required and stored in clean 120ml bottles at a temperature of 40 °C for analysis.

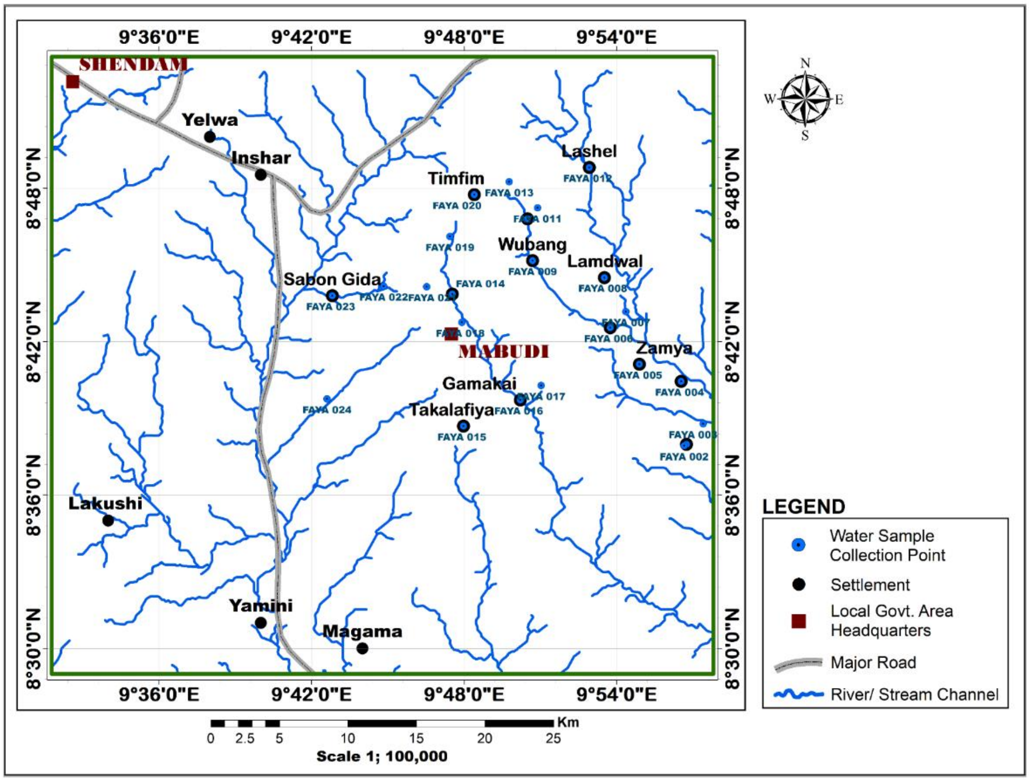

Figure 4: Map showing sample collection points

Table 1: Water samples source and number of samples

SURFACE SOURCES	No.Sampling Points
River	4
Stream	1
Pond	3
Dam	5
Mining Pond	3
GROUND WATER SOURCES	
Well	4
Borehole	5
Total	**25**

2.4 Analytical Methods

The following parameters were analyzed using standard laboratory techniques:- Physical Parameters: pH, temperature, turbidity, salinity, electrical conductivity (EC), total dissolved solids (TDS), and total hardness.- Chemical Parameters: HCO_3^-, NO_3^-, NO_2^-, PO_4^{3-}, SO_4^{2-}, F^-, Cl^-, Ca^{2+}, Mg^{2+}, Na^+.- Irrigation Quality Indices: Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), and Kelly Ratio (KR).

3. Results and Discussion

Physical and chemical parameters measured for both ground and surface water samples in the study area, as shown in Table 2 and 3, are pH, EC, TDS, Turbidity, Salinity and Total Hardness for physical parameters; ph for Groundwater with mean: 7.0 and range of 5.73(acidic)–7.94(slightly alkaline); Surface water with mean of 6.90 and range: 6.14–7.98,both groundwater and surface water are mostly within the WHO acceptable range (6.5–8.5), though some groundwater samples (e.g., RMP05, RMP24) are slightly acidic, possibly due to local lithology or leachate from waste materials also probably indicating possible acid rock interaction. A study in Jos North by Ogunbode et al. (2020) reported similar pH ranges (6.5–7.6), attributing variability to underlying granitic rocks and organic matter decomposition.

Electrical Conductivity (EC) and Total Dissolved Solids (TDS) for Groundwater the EC with wide range (72.1–2062 and mean 623.2 µS/cm the higher values suggest saline intrusion or mineral dissolution, TDS = mostly below WHO limit (1000 mg/L), with mean of 312.0 mg/L except RMP24; surface water EC with mean 351.6 µS/cm lower than groundwater; suggests less mineralization., TDS mean value of 174.9 mg/L which is well within WHO limits, indicating good quality. Higher EC and TDS in groundwater indicate greater mineral dissolution from the aquifer materials, possibly granitoids and weathered gneisses in the area, indicating potential risks for human consumption. Similar EC and TDS trends were observed in Awe, Middle Benue Trough, where EC values ranged up to 1200 µS/cm (Akpen et al., 2023), linked to rock-water interactions.

Turbidity values for the Groundwater with mean of 8.0 NTU and Surfacewater with mean value 8.93 NTU, both exceed WHO's 5 NTU limit, suggesting contamination from soil leaching or surface runoff, suspended particles, erosion or organic matter decomposition. Studies around Delimi River, Jos, showed turbidity values between 6.0–14.0 NTU, attributed to agricultural runoff and urban waste (Kure et al., 2021). Salinity mean value for Groundwater is 1.2 ppt low overall, except in RMP24 (4.1 ppt), suggesting mineral leaching, and for surface water mean value is 0.68 ppt which is low indicating freshwater conditions.

The slight salinity observed from sample RMP 24 has the highest at 4.1 ppt, potentially from waste leachate or mineral-rich bedrock. The total hardness of groundwater is high, with several samples exceeding WHO standards, indicating excessive Ca and Mg. However, the mean value is 571.7 mg/L, while for Surface Water, the mean value is 360.7 mg/L, making it moderately hard. Water is classified as "very hard" based on WHO standards (>300 mg/L), likely due to high Ca^{2+} and Mg^{2+} from carbonate or silicate weathering, and making it unsuitable for direct consumption without treatment. In Minna, similar hardness values were recorded in groundwater, linked to granitic intrusives (Ibrahim et al., 2022).

The nutrients (Nitrate, Nitrite, Phosphate) values suggest contamination from agricultural runoff or decomposed organic waste, especially around dumpsites. NO_3^- (Groundwater): 38.8 mg/L High in some samples (e.g., RMP 17 = 92.86 mg/L); possibly from fertilizer or sewage; NO_3^- (Surface Water):

45.4 mg/L High in some samples (e.g., RMP 09 = 91.68 mg/L); possibly from surface runoff. NO_2^-: Exceeds safe limits in several groundwater samples (up to 2.28 mg/L) exceeds WHO limits (0.2 mg/L) in several samples, indicating pollution, the surface water has above WHO limits; indicates organic pollution, the elevated nitrate levels are a significant health concern, particularly for infants, due to the risk of methemoglobinemia ("blue baby syndrome"). PO_4^{3-} is elevated in both water types, high values in all groundwater samples; possibly from agricultural runoff or domestic effluent, high values in surface water making it a potential for eutrophication. Oju area of the Middle Benue Trough had similar high nitrates (>50 mg/L), linked to fertilizer use and leachate from waste (Eyankware et al., 2018).

The Fluoride (F^-) mean values in the Groundwater is 8.6 mg/L, which exceeds WHO guideline (1.5 mg/L); RMP20 has a critically high value (24.08 mg/L), so also the surface water with mean 12.4 mg/L exceeding the WHO limit, posing health risk. All values far exceed the WHO limit (1.5 mg/L), indicating geogenic origin likely from fluorite-bearing granites in the Jos Plateau region. In Langtang, high fluoride levels (up to 10 mg/L) were reported by Saidu et al, (2022), traced to the weathering of granite pegmatites. The Chloride (Cl^-) values in both the Groundwater with mean value of 412.2 mg/L and Surface Water mean value 300.06 mg/L exceed WHO limit (250 mg/L) in several locations, with possible sources of contamination including domestic waste, leachate, and geological salts.

The temperature values suggest natural ambient conditions consistent with natural conditions, Sulphate values are within acceptable limits, this was also found by Gusikit et al (2022), in their study of Awe and environs Middle Benue Trough.

The major cations (Ca, Mg, Na) mean values contribute to the hardness of the water in both the groundwater and surfacewater. Calcium is higher in groundwater (66.5 mg/L) which maybe from the silicate rocks, Magnesium has high values (99.6 mg/L) and Sodium very high in RMP24 and RMP01 (>600 mg/L); implies pollution or mineralization.

Comparative summary of the Groundwater and surface water shows that Fluoride is very high in both, which is a critical concern in both water sources. The Nutrients (NO_3^-, NO_2^-, PO_4^{3-}) are also high which suggests anthropogenic pollution in both sources. EC and TDS values indicate higher mineral content in groundwater. Chloride and Salinity being higher in groundwater suggests saline intrusion or domestic contamination in groundwater. Total hardness is very high which reflects the mineral-rich geology underground.

Table 2: Result of physico-chemical parameters and chemical analysis of the groundwater samples

	RMP 05	**RMP 07**	**RMP 11**	**RMP 15**	**RMP 17**	**RMP 19**	**RMP 20**	**RMP 21**	**RMP 24**	**Mean**
Parameters										
Ph	5.73	6.94	6.53	7.47	6.92	7.88	7.35	7.94	5.79	7.0
Temp	22.7	22.6	22.4	22.5	22.5	22.5	22.4	22.4	22.6	22.5
E.C	1263	137.5	631.5	470.5	656	232.6	72.1	83.6	2062	623.2
T.D.S	632	68.6	317	231.5	328.5	117.2	35.1	42.7	1035.5	312.0
Turbidity	6.62	8.49	6.18	4.95	14.62	4.98	9.12	11.64	5.13	8.0
Salinity	2.5	0.3	1.2	0.9	1.3	0.5	0.1	0.2	4.1	1.2
Total Hardness	1205	197.5	540	330.5	722	190.5	33.5	43.5	1882.5	571.7
HCO_3	161.5	291	236	419.5	303.5	450	395	474.5	147	319.8
NO_3	18.77	30.45	34.53	46.38	92.86	45.65	21.48	39.28	19.53	38.8
NO_2	2.28	bdl	0.22	0.82	2.25	0.64	bdl	bdl	1.51	0.9
PO_4	21.69	10.41	11.84	12.46	11.48	21.29	17.73	10.48	11.53	14.3
SO_4	10.35	1.83	13.72	5.84	9.75	6.05	1.42	1.62	22.13	8.1
F	3.48	5.49	5.21	4.71	6.29	8.21	24.08	16.66	3.27	8.6
Cl	896.5	93.5	451.5	284.5	466.5	185	30	36	1266	412.2
Ca	134.18	9.41	64.01	39.26	92.18	25.34	2.17	2.95	228.98	66.5
Mg	216.14	42.69	92.44	56.72	119.28	31.31	7.19	9.52	320.75	99.6
Na	353.5	32.47	146.4	126.54	173.86	75.6	3.57	7.67	675.98	177.3

bdl- Below detection limit

Sample ID	RMP 01	RMP 02	RMP 03	RMP 04	RMP 06	RMP 08	RMP 09	RMP 10	RMP 12	RMP 13	RMP 14	RMP 16	RMP 18	RMP 22	RMP 23	RMP 25	Mean
Parameter																	
Ph	6.14	7.56	7.25	6.91	7.22	6.81	7.1	6.25	6.46	6.82	7.98	7.61	7.24	6.27	6.19	6.65	6.90
Temp	22.5	22.5	22.1	22.2	22.5	22.6	22.5	22.5	22.5	22.5	22.5	22.6	22.5	22.7	22.6	22.5	22.49
E.C	2212	632.5	355.5	327	157.9	192.5	116	98.5	567.5	163.4	88.4	198.5	96.5	62.5	83.2	273.4	351.58
T.D.S	1102.5	311.5	170	163.5	80.5	98.2	58.3	49.7	284.5	82.2	44.7	95.5	48.4	31.2	42.5	135	174.89
Turbidity	9.46	11.03	15.24	4.35	3.75	21.35	16.74	5.26	7.59	10.43	6.51	12.34	3.75	3.27	8.55	3.21	8.93
Salinity	4.3	1.2	0.7	0.6	0.3	0.4	0.2	0.2	1.1	0.3	0.2	0.4	0.2	0.1	0.2	0.5	0.68
Total Hardness	2170	682.5	471	423	118	272.5	232	87	406.5	230.5	63.5	114	136.5	25.5	37	301.5	360.69
HCO_3	223	344.5	315	296	305	257	274	244.5	222	254.5	465	424	314	239	223.5	255.5	291.03
NO_3	67.65	42.44	35.34	31.35	38.4	23.23	91.68	22.37	50.58	35.31	65.37	55.56	64.44	12.42	52.08	38.45	45.42
NO_2	3.76	1.22	0.73	0.46	bdl	bdl	1.15	bdl	1.05	bdl	bdl	0.36	bdl	bdl	bdl	0.46	1.15
PO_4	42.31	11.54	9.35	9.13	12.11	8.77	17.78	23.39	9.17	9.75	19.38	14.61	10.07	17.77	12.42	8.82	14.77
SO_4	18.34	3.13	2.42	2.85	2.7	2.7	10.52	16.27	3.02	6.15	11.39	6.95	11.15	13.46	13.06	13.21	8.58
F	36.59	10.58	6.6	5.66	8.66	8.55	14.72	24.43	5.5	6.57	20.58	10.26	15.39	4.21	17.74	2.5	12.41
Cl	1635	424.5	272.5	223	1016.5	128	81.5	64	333.5	113	51	130	54.5	26.5	29.5	218	300.06
Ca	257.93	70.8	52.4	39.61	11.67	16.73	7.29	4.67	51.62	43.42	7.53	21.55	14.22	1.71	2.51	36.15	39.99
Mg	383.89	121.64	85.1	80.28	21.33	57.29	51.7	18.45	67.28	29.66	11.34	15.42	24.47	5.33	6.53	51.29	64.44
Na	690.99	182.43	95.68	90.34	47.73	59.34	16.36	10.41	126.57	53.36	8.31	65.44	10.62	3.08	3.93	82.36	96.68

Table 3: Result of physico-chemical parameters and chemical analysis of the surfacewater samples

The EC and TDS values measured in the study area for both the groundwater and surfacewater exhibit a linear correlation, reflecting the established linear relationship between specific conductance and ionic strength typically observed for conductance values ranging from 10 to 10,000 µS/cm (Lind 1970). In this study, the proportionality constant is 0.50 (see Figures 5 and 6), which aligns closely with previously reported values ranging from 0.55 to 0.85 (Walton 1989; Atekwana et al. 2004).

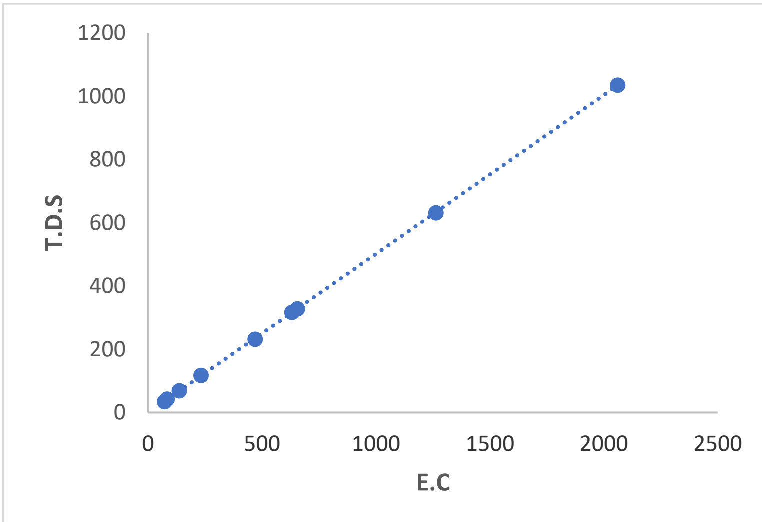

Figure 5: Linear relationship between EC and TDS as observed in the Groundwater of study area.

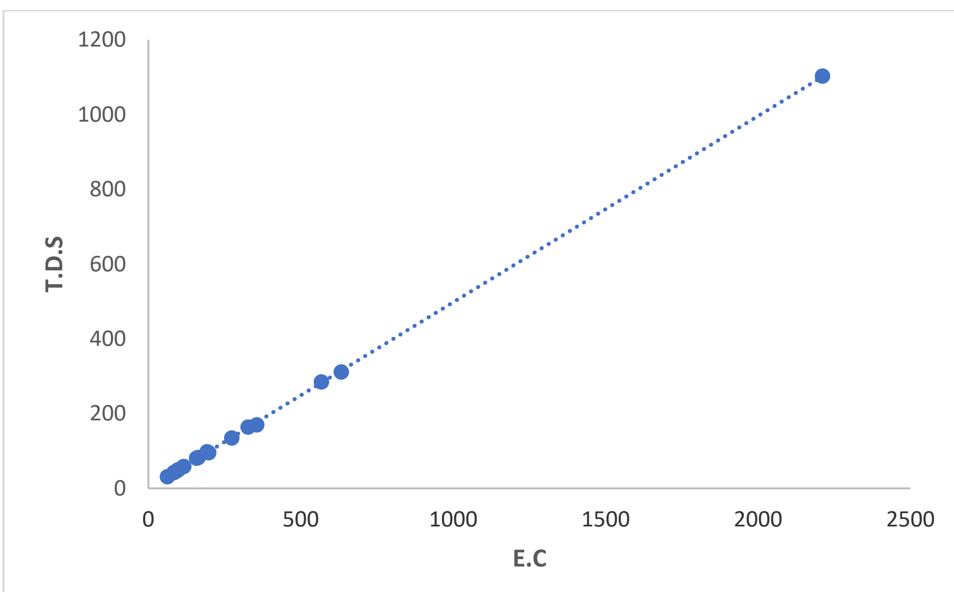

Figure 6: Linear relationship between EC and TDS as observed in the surface water of study area.

To assess the quality of groundwater in the area for irrigation, the Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR) and Kellys Ratio (KR) were determined based on ionic concentrations (Meq/l) calculated from the results of chemical analysis (Table 4).

Sodium adsorption ratio (SAR) is a parameter used in the management of sodium in soils. It is an indicator of the suitability of water for use in irrigation, and it is determined from the concentrations of Na^+,Ca^{2+} and Mg^{2+} present in the water. Irrigation using water with high sodium adsorption ratio may cause long-term damage to the soil (Department of Water Affairs and Forestry (DWAF).1996)

Sodium Adsorption Ratio (SAR) was calculated using Equation 1 according to Richards,1954.

$$SAR = [Na^+] / \sqrt{([Ca^{2+}] + [Mg^{2+}]) / 2} \quad (1)$$

Magnesium Adsorption Ratio (MAR) is an index for calculating the magnesium hazard. Magnesium Adsorption Ratio for the water samples was calculated using Equation 2, according to Raghunath 1987.

$$MAR = ([Mg^{2+}] / ([Ca^{2+}] + [Mg^{2+}])) \times 100 \quad (2)$$

Kelly's Ratio (KR) was calculated using Equation 3 as given by Kelly,1963.

$$KR = [Na^+] / ([Ca^{2+}] + [Mg^{2+}]) \quad (3)$$

Table 4 : Results of chemical analysis of the water samples (ppm) and calculated irrigation parameter indices for water in Faya and environs

Sample	Ca_meqL	Mg_meqL	Na_meqL	SAR	MAR	KR
RMP 01	12.871	31.583	30.056	6.375	71.047	0.676
RMP 02	3.533	10.007	7.935	3.050	73.908	0.586
RMP 03	2.615	7.001	4.162	1.898	72.808	0.433
RMP 04	1.977	6.605	3.930	1.897	76.967	0.458
RMP 05	6.696	17.782	15.376	4.395	72.646	0.628
RMP 06	0.582	1.755	2.076	1.921	75.084	0.888
RMP 07	0.470	3.512	1.412	1.001	88.207	0.355
RMP 08	0.835	4.713	2.581	1.550	84.953	0.465
RMP 09	0.364	4.253	0.712	0.468	92.121	0.154
RMP 10	0.233	1.518	0.453	0.484	86.691	0.259
RMP 11	3.194	7.605	6.368	2.740	70.423	0.590
RMP 12	2.576	5.535	5.505	2.734	68.243	0.679
RMP 13	2.167	2.440	2.321	1.529	52.968	0.504
RMP 14	0.376	0.933	0.361	0.447	71.288	0.276
RMP 15	1.959	4.666	5.504	3.024	70.431	0.831
RMP 16	1.075	1.269	2.846	2.629	54.123	1.214
RMP 17	4.600	9.813	7.562	2.817	68.086	0.525
RMP 18	0.710	2.013	0.462	0.396	73.939	0.170
RMP 19	1.264	2.576	3.288	2.373	67.074	0.856
RMP 20	0.108	0.592	0.155	0.263	84.527	0.222
RMP 21	0.147	0.783	0.334	0.489	84.179	0.359

Sample	Ca_meqL	Mg_meqL	Na_meqL	SAR	MAR	KR
RMP 22	0.085	0.439	0.134	0.262	83.711	0.256
RMP 23	0.125	0.537	0.171	0.297	81.094	0.258
RMP 24	11.426	26.388	29.403	6.762	69.784	0.778
RMP 25	1.804	4.220	3.582	2.064	70.053	0.595

4. Irrigation Suitability

Sodium Adsorption Ratio (SAR)

In the current study, SAR values range from 0.26 to 6.76. These values fall below the critical limit of 10 recommended by the U.S. Salinity Laboratory (1954), indicating that the water poses minimal sodium hazard and is suitable for irrigation. Low SAR values imply that sodium does not dominate the cationic composition, and the risk of soil dispersion is low. This is consistent with the findings of Ayers and Westcot (1985), who reported that irrigation water with SAR less than 10 is generally safe for most crops and soils.

Magnesium Adsorption Ratio (MAR)

The MAR values range between 52.97% and 92.12%, exceeding the recommended safe limit of 50% (Raghunath, 1987). High MAR values suggest an imbalance in the calcium to magnesium ratio, which may lead to soil alkalinity, reduced permeability, and poor soil aggregation. Such values are not uncommon in crystalline basement terrains in Nigeria. For example, Laka et al. (2019) in a hydrogeochemical study in Plateau State reported MAR values often exceeding 60%, attributing it to the weathering of magnesium-rich minerals such as dolerites and amphibolites. Similarly, Atekwana et al. (2004) linked high MAR to geological controls and groundwater–rock interaction in similar settings.

Kelley's Ratio (KR)

Kelley's Ratio values in this study vary between 0.15 and 1.21. The majority of samples remain below the critical limit of 1.0, which is considered safe for irrigation according to Kelley (1963). However, samples such as RMP 06, RMP 15, RMP 16, and RMP 19 exceed this threshold, indicating moderate sodium hazard in these locations. Todd (1980) notes that high KR values may reflect excessive sodium relative to calcium and magnesium, which could lead to adverse effects on soil permeability and structure. This trend was similarly observed by Tijani et al. (1996) in southwestern Nigeria and by Ocheri et al. (2014) in the Benue Valley, where KR values exceeding 1.0 were linked to anthropogenic inputs and geogenic influences.

Several studies across Nigeria supports the findings in this study. For instance, in their assessment of groundwater quality in the basement complex of southwestern Nigeria, Tijani et al. (1996) observed low SAR values but relatively high MAR values, attributed to prolonged water–rock interaction. Likewise, Ocheri et al. (2014) in the Middle Benue Trough observed high KR and MAR values in some locations, suggesting both geogenic and anthropogenic influences. The current study aligns closely with these observations, further affirming the dominant influence of geological settings on water chemistry. However, Solomon et al (2020) in their study in Wamba found the water suitably for irrigation in the area.

The SAR, MAR, and KR values indicate that most water samples from the study area are suitable for irrigation with respect to sodium hazard. However, the high MAR values and occasional KR exceedances highlight the influence of magnesium-rich lithology and localized sodium enrichment. These results suggest a need for periodic monitoring and the implementation of corrective soil management practices in high-risk zones.

While some regions in Nigeria exhibit water quality parameters within safe limits for both drinking and irrigation, the Faya area stands out for its elevated TDS, hardness, and nitrate levels, likely influenced by local geology and mining activities. This contrasts with findings from Ekiti, Osun, and Ondo States, where water samples generally met safety standards, and contamination factors for heavy metals were low. The variability across regions underscores the importance of localized water quality assessment and management.

5. Conclusion and Recommendations

The Groundwater is more mineralized, harder, and contains higher fluoride and chloride concentrations, the Surface water shows signs of nutrient enrichment and turbidity, likely from surface runoff and waste discharge. Both water sources exceed WHO standards for fluoride, nitrate, turbidity, and phosphates.

Recommendations:

The results highlight the urgent need for:

1. Comprehensive geochemical analyses to identify the sources of contamination.

2. Implementation of water treatment technologies to reduce TDS, hardness, and nitrate concentrations before consumption.

3. Adoption of agricultural practices that utilize salt-tolerant crops and improved irrigation techniques to mitigate the impact of poor water quality on crop yield and sustainable agricultural practices to reduce runoff.

4. Regular monitoring and integrated water management strategies are essential to safeguard public health and sustain agricultural productivity in regions affected by both natural and anthropogenic water quality challenges.

5. An organized public health education on water use in the community.

6. Ongoing geochemical monitoring and region-specific management plans are essential to mitigate the risks associated with both natural and human-induced water quality challenges in the area.

Conclusion

The results of this study reveal a mixed picture regarding the suitability of water in the Faya area for irrigation and domestic purposes. Groundwater samples are characterized by higher mineral content, fluoride, and chloride concentrations, indicating geogenic influences from the local geology, particularly weathering of granitic and carbonate rocks. Surface water, on the other hand, shows elevated nutrient levels and turbidity, likely arising from surface runoff, agricultural activities, and waste discharge. SAR values suggest that the water is generally suitable for irrigation with respect to sodium hazard, while the elevated MAR and occasional KR values call attention to potential long-term impacts on soil structure and fertility. These findings align with previous studies in similar geological settings in Nigeria and underscore the pressing need for integrated water management strategies. Recommendations include the implementation of appropriate water treatment technologies, public education on water use, and adoption of sustainable agricultural practices.

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