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Research Article

STRUCTURAL AND HYDROCHEMICAL ASSESSMENT OF SOME ARTESIAN SPRINGS WITHIN SHARE SHEET 202 SOUTHWESTERN NIGERIA

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ABSTRACT

The inhabitants of the study area have been faced with scarcity of clean water and sometimes suffer an outbreak of epidemics; the studied artesian springs are their major alternative source of water. Ten artesian springs were assessed using magnetic methods, and hydrochemical analysis. Total magnetic intensity data were processed to obtain the lineament distribution responsible for groundwater flow. Physicochemical parameters analyzed include pH, total hardness, electrical conductivity, and chemical parameters were analyzed. Results showed a magnetic anomaly range of -79.1 - 132.9 nT. There is a series of lineaments, depicting fractures with a high concentration in the northern part. Three of the springs fall on Martins multiple fracture locations, around the high magnetic anomaly, indicating a highly promising location. The range of parameters are as follow; pH: 5.91 – 7.09, electrical conductivity: 30 - 450 µs/cm, total hardness: 20 - 136 mg/L, chloride: 10.01 - 56.0 mg/L. All these are within the World Water Quality Standard tolerable values, with exception of the iron content that is above 1 in all the locations, which falls above the permissible standards of 0.3. This could be associated with the contaminations from open defecations practiced in the area.

Keywords: Artesian spring, Magnetic method, Hydrochemical parameters, Groundwater.

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1. INTRODUCTION

Water is a vital service with an unmatched worth after air. Water has substantial quantities in the biosphere (in animals and plants), atmosphere (air), and lithosphere (rock units) [1,2]. It denotes an inimitable piece in every settlement for drinking, sanitation, washing, fishing, restitution, and industrial uses. Water can take place as surface water in lakes, rain, and stream as well as groundwater in wells, boreholes, and springs. Freshwater from the spring could be discharged onto the ground surface, straight into the beds of rivers or streams, or the ocean below sea level. Springs are used both for drinking and irrigation purposes. Spring water was associated in the public mind with exceptional quality and was even considered holy in some places. Selling spring water in a bottle has become a flourishing business across the world [3,4]. The local community in the study area has been facing a scarcity of clean water and sometimes suffers an outbreak of epidemics. Thus, a search for clean subsurface water is imperative in this area. however, no matter how prolific the spring zone may be, the quality of the enclosed water can constitute a major setback for water usage, even for modest application. Assessment of Share Artesian springs is therefore necessary as increased knowledge of processes that control the structural and hydrochemical compositions of the spring water can bring about the understanding of its usability status. Though, many types of research in the Share area focused on the occurrence of spring using the geophysical methods within the subsurface environment. Issa et al. [5] carried out a hydrological and physic-chemical assessment for domestic and agricultural purposes in Oke-Oyi, a close range to the present location. Search for good water has been a big challenge around the area. This study is therefore aimed to evaluate structural settings that are responsible for the artesian springs and hydrochemical standards of the discharged water via Aeromagnetic data and hydrochemical parameter analysis. The hydrochemistry and Aeromagnetic data will help to distinguish the fractures leading to the source of the springs and hydrochemical was aimed at assessing the water quality in the area.

2. Study Area

The studied springs lie in the area between latitude 08^0 48' to 08^0 50' N and longitude 04^0 56' to 04^0 59' E, around Share metropolis. The springs were accessed via foot, traversing through bushes, and farmlands.

Share, located in the Kwara state of Nigeria, lies majorly in the southwestern portion of the Precambrian basement complex terrain (Schist belt) of Nigeria. A part is intruded by Cretaceous sediment of the Bida basin, making the area to be a transition/contact zone of the basement and sedimentary rocks. The basement complex consists of a variety of migmatized rocks and quartzite intruded by 600±150 ma granite to diorite rock [6-8] and lies within the West Africa Craton[7]. Bida formation is an intra-cratonic basin that lies within west-central Nigeria with a sedimentary infill estimated at 3.5 km thick and occurs as linear structures about 350 km long and between 75 km and 150 km wide, trending NW-SE approximately orthogonally to the Benue trough, separated from the basal continental beds of Sokoto basin to the north basement complex rocks that form high relief within the basin [9]. The studied springs (Figure 1), therefore, are located on the sedimentary formation, near the contact/transition zones of the basement complex and the sedimentary basin in the area.

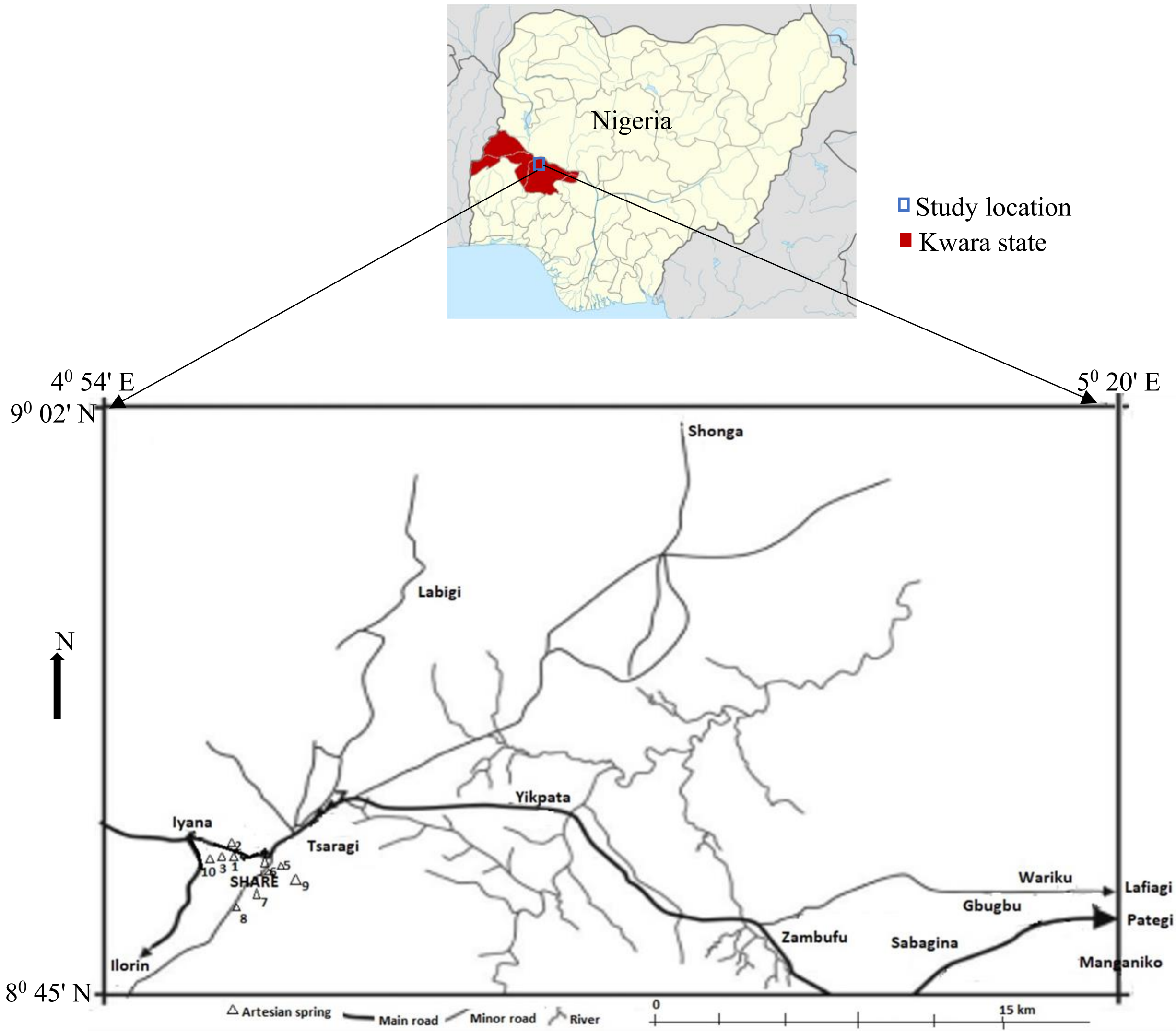


Fig. 1. Location map of the study area

3. MATERIAL AND METHODS

Aeromagnetic data from sheet 202 (Share), which is limited by longitudes 4.300^0 E to 5.00^0 E and latitudes 8.300^0 N to 9.00^0 N was acquired from the Nigerian Geological Survey Agency (NGSA) [10]. Water samples from springs were acquired as well. The total magnetic intensity (TMI) field was resolved into regional and residual fields. The latter, which is of interest, is further subjected to filtering processes, needed for meaningful decision-making. The filtering processes that were applied to the processed data are reduced to the equator, analytic signal, and first vertical derivatives. These processes result in the production of a total magnetic intensity map, residual and regional maps, and a lineament map needed for the final decision.

A total of ten (10) water samples collected from springs in the study area were also analyzed.

Standard procedures for sampling were followed and at each sampling point, certain physical parameters such as temperature, electrical conductivity, and pH were measured in-situ using a thermometer, portable electrical conductivity cell, and pH meter respectively. Analysis of the collected water samples for their chemical components was carried out at a Central Research and Diagnostic Laboratory.

4. RESULTS

4.1 Magnetic methods

The total-field magnetic intensity (TMI) anomaly map (Figure 2) reveals three main types of total-field magnetic anomalies ranging in intensity from -79.1 – 132.91 nT that are classically categorized in red and pink, green and yellow, and blue colors. The anomalies were classified into high, moderate, and low amplitude respectively. The high amplitude total-field magnetic anomalies associated with intensity between 47.30 and 132.91 nT, which are shown in red and pink colors, occupied the predominant portion of the northern central part, trending towards the northeastern part of the area which could be associated with deep sources of magnetic causative bodies. Other areas of high amplitude include the Eastern part of the map also trending towards the North. The moderate amplitude magnetic anomalies values ranging from 44.51 to 11.79 nT, are shown in yellow and green colors. The yellow color is predominant in the southern half while the green is widespread throughout the area which is ascribed to the magnetic background signature which is assumed to characterize the country rock. The prominent low amplitude anomalies ranging in intensity from -79.91 to -3.70 nT are shown in blue color and are widespread throughout the study area, but dominant in the Western part of the study area trending North, maybe due to rock formations constituted by very low susceptibility minerals probably sedimentary formations. The configuration of positive anomalies may be attributed to relatively deep-seated low relief basements structures. This means that the TMI anomalies are strongly influenced by the regional tectonic. And can also be a source for storing groundwater. Generally, the anomalies were depicted as short and high wavelength anomalies that are linear and shapes are not variably circular trending along with ENE-WSW, NE- SW, E-W, and NW-SE directions. Figure 3 is a contour representing the estimated regional magnetic field showing a regional trend along NW-SE, with a uniform NE-SW gradient, dipping to the SW direction magnitude ranging from 33109.0 to 32997.0 nT. The regional field increases in magnitude from the northern to the southern portion of the study area and reflects the major tectonic elements of deeper and regional extent which affect and control the structural framework of the study area (Annor, 1995). Figure 4 shows the color-shaded map of the residual magnetic field intensity over the study area ranging from -73.29 to 67.88 nT and depicted in red, pink, yellow, green, and blue colors.

The positive residual intensities range from 0.54 to 67.88 nT with the high amplitudes ranging between 8.85 to 67.88 nT and depicted in red and pink colors. The negative residual intensities are ranging between -73.29 and -1.15 nT. The high negative amplitudes are depicted in green color ranging in intensity between -1.15 and -19.80 nT while the low negative amplitudes ranging between –73.29 to -22.82 nT are depicted in blue color. The high positive amplitude anomalies are widespread throughout the study area while the low positive amplitude anomalies are dominant in the southern part of the area and with less dominance in the northern part of the area. Similarly, the high negative amplitude anomalies are widespread throughout the study area with dominance in the half southern region. But, the very low negative anomalies are dominant in the northern half region.

Fig. 2. TMI Anomaly map

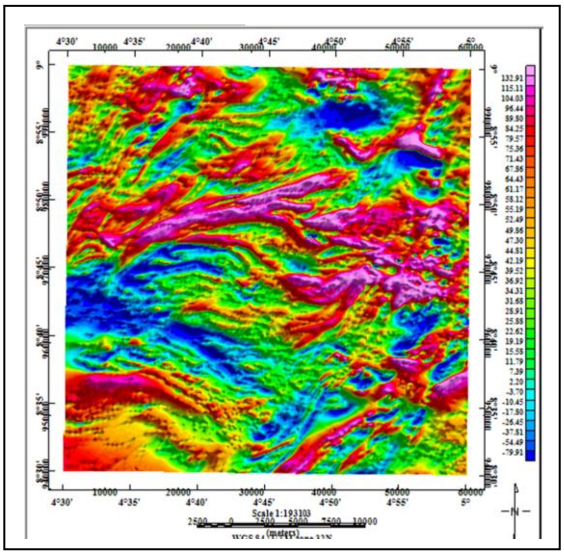
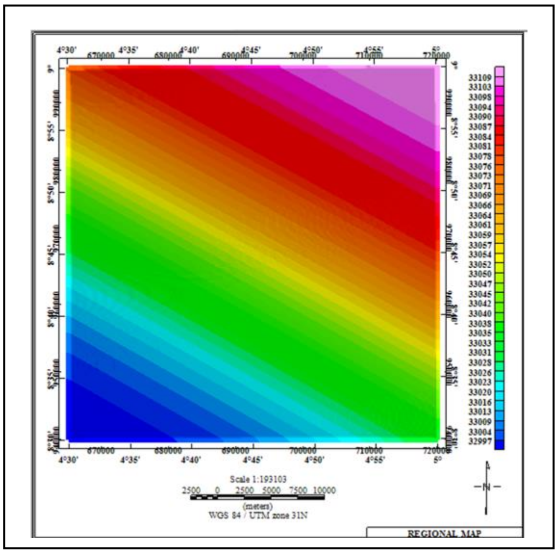


Fig.3. Regional anomaly map



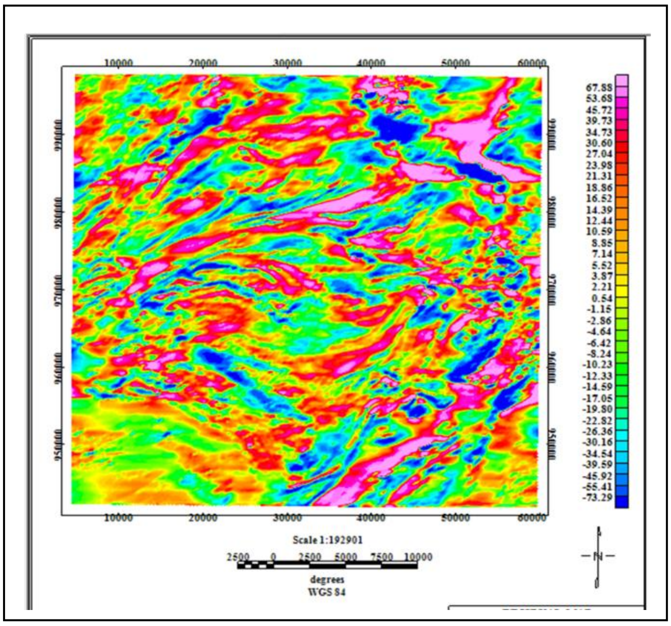


Fig.4. Residual field map of the study area

Figure 5 shows the contour map representing the estimated first vertical derivative intensities over the study area. The map shows that the first vertical derivative is ranging from -0.1923 to 0.1924 nT and is depicted in red, pink, yellow, green, and blue colors. The positive residual intensities range from 0.0014 to 0.1924 nT with the high amplitudes ranging between 0.0290 to 0.1924 nT and depicted in red and pink colors. The negative residual intensities are ranging between -0.0013 to -0.1923 nT. The high negative amplitudes are depicted in green color ranging in intensity between -0.0067 to -0.0396 nT while the low negative amplitudes ranging between –0.0460 to -0.1923 nT are depicted in blue color. Figure 6 shows extracted FVD lineament impressions showing geological features such as dykes, faults or folding, geological boundaries, or contact of different lithologies or boundaries between formations revealing linear and circular magnetic features allowing interpretation at a regional scale, with the location of springs superimposed on the lineament showing wells that fall on the high and low magnetic anomalies. These marked transition zones show several edges which may mark transition zones and could be the presence of intensely folded zones.

Figure 7 equally shows the superposition of the wells on the lineament, properly extracted from

Figure 5. The locations of the springs confirmed that the flows are structurally controlled, as many of the wells are seen underlain by subsurface lineament, tantamount to a fracture system in the area. In general, there are a series of fractures trending NE-SW and NW-SE in equal proportion in the area. Figure 8 shows the geologic implication derived from the geomagnetic field in the area with the locations of the springs superposed. The predominant rock in the area is Cretaceous sediment, intruded at the southern part by migmatite gneiss. All the studied springs fall within the Cretaceous sedimentary rocks which constitute the dominant rock in the area. It can be seen from Figure 8 that, with exception of springs 1, 2, and 7, all other springs fall on the major fractures in the area, giving a clue to the artesian nature. Thus, the free flow is partly initiated by the fractures underneath them. Spring 5 and 8 fall on the multiple fracture junctions; this could account for the reason why they are the most prominently yielding artesian wells in the area.

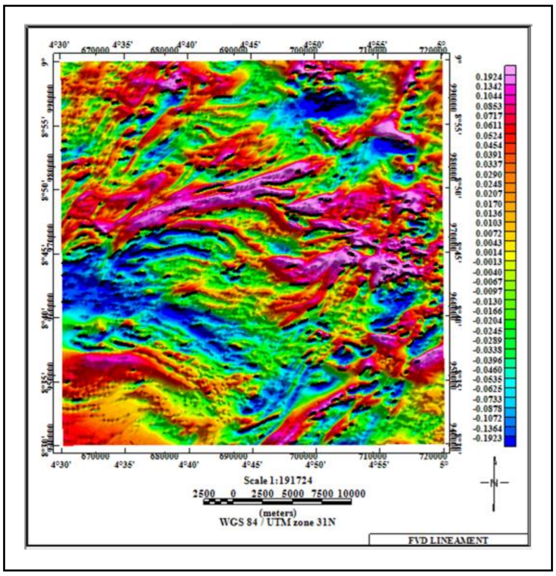


Fig.5. FVD map

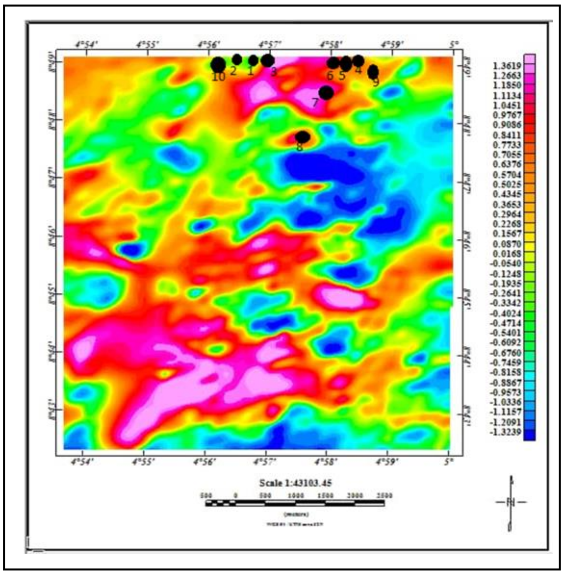


Fig.6. Lineament impression from FVD

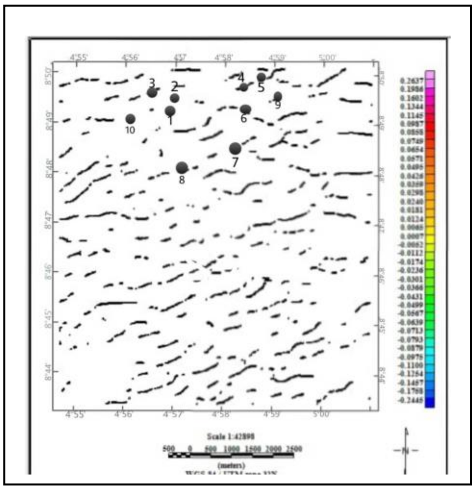


Fig.7. Studied springs superposed on the lineaments

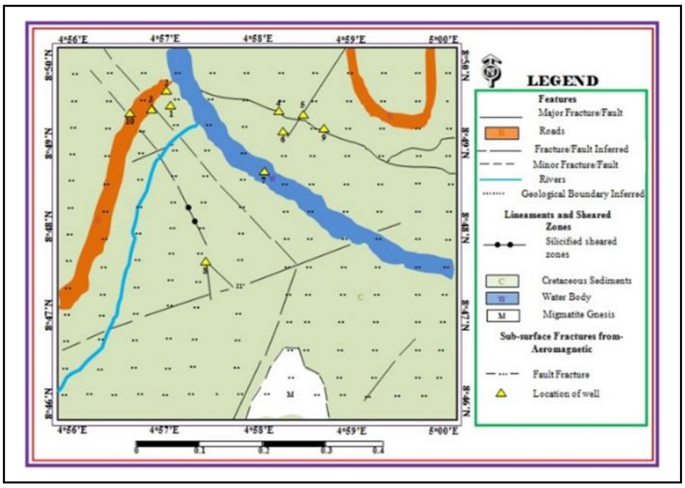


Fig.8. Studied springs superposed on the inferred geology

4.2 Hydrochemical analysis

Table 1 shows the results of the hydrochemical analysis. Table 1 and Table 2 shows the tolerable standard of hydrochemical parameters set by the World Health Organization standard (WHO) [11], Nigeria Industry Standard (NIS) [12], and Nigeria Standard for Drinking Water Quality (NDSWQ) [13] which are used as a benchmark for decision making in this work. The potential of hydrogen (pH)/hydrogen ion concentration of groundwater samples varied from 5.91 to 7.09 with a mean value of 6.56. The lowest pH values of 5.91 and 5.92 were recorded at location 3 (L3) and location 6 (L6) springs and this can be attributed to the high acid content in the spring water discharged, lower than the WHO standard, which is 6.5. The rest of the water samples can be considered suitable for drinking and other domestic purposes, as their pH lies between 6.17 and 7.09 which fall within the tolerable limit. The turbidity of the groundwater samples varied from 5.27 to 6.29 Nephelometric Turbidity Unit (NTU) in Location 2 (L2) and Location (9) with a mean value of 5.764 NTU. Out of the 10 water samples, only 2 (i.e., L2 and L8) were above the WHO standard of <5 (Sawyer and McCarty, 1967). According to the WHO, National Industrial Standard (NIS), and Nigerian Standard of Water Quality (NSDWQ) criteria based on hardness, shown in Table 2, out of the 10 water samples 8 samples were graded as soft while only 2 other samples at L7 and L9 where the value is 136.00 mg/L and 108.00 mg/L respectively was graded as moderately hard. It implied that out of the 10 water sample 8 were suitable for drinking while 2 was found unsuitable for drinking. The high value implies that L7 and L9 are characterized by hard water and this may be due to limestone lenses or outcrops in the Formation. Here, the water needs to be treated before it conforms to the standard for human consumption and other domestic uses. Chloride, Cl, occurs naturally in all water samples. The amount of chloride content in the groundwater samples was recorded from 10.01 to 58.06 mg/L with a mean value of 6.93mg/L. Weathering and dissolution of salt deposits, seawater intrusion, and irrigation return flow are commonly responsible for the increasing chloride content in the groundwater[14]. According to Walker et al.[15], Cl ion concentration in the groundwater normally arises from sources like paleoseawater entrapped sediments, the solubility of Cl-bearing evaporation deposits, and anthropogenic sources. The concentration is generally low because chloride does not show any correlation with the components of pore water derived from the mineral breakdown [16], and because of the fact, that sedimentary rocks are the major source of chloride in groundwater due to evaporating [17]. Another source of chloride in groundwater is the leaching of chloride from fine-grained marine shales which might retain some chloride for a long time. These values are very low and imply also that the groundwater in the study area is free from fecal pollution. Regarding chloride, all water samples under investigation were found suitable for drinking.

Table 1. Result of physiochemical parameter and minerals test

Geochemical Parameters	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	MIN	MAX	Mean
pH	6.17	5.98	5.92	6.99	6.63	5.91	7.02	7.09	7.07	6.87	5.91	7.09	6.56
Turbidity	5.725	6.295	5.455	5.914	5.799	5.543	5.551	6.272	5.27	5.818	5.27	6.295	5.764
Electr. Conduct. (µS/cm)	30	70	30	40	20	10	450	160	380	70	10	450	126
Total hardness (m g/L)	24	32	20	24	16	16	136	92	108	32	16	136	50
Silica as Sio2(mg/L)	20	16	9	20	23	9	16	40	50	60	9	30	18.8
Total Iron as Fe (mg/L)	1.104	1.83	1.224	1.152	1.434	1.38	1.416	1.572	1.284	1.5	1.098	1.83	1.38
Chloride as CL (mg/L)	10.01	12.01	20.02	18.02	12.01	10.01	56.06	28.03	50.05	20.02	10.01	56.06	23.61
Colour(Haze n Units	3.57	3.93	3.41	3.69	3.62	3.46	3.46	3.92	3.29	3.63	3.29	3.93	3.59
Temperature 0C	28	28	29	28	29	28	29	29	28	29	28	28	28.5

Table 2. WHO, NIS and NSDWQ standards for physiochemical parameters

Geochemical Parameters	WHO	NIS	NSDWQ
pH	6.5	6.5	6.5-8.5
Turbidity	5	5	
Electr. Conduct. (µS/cm)		1000	1000
Total hardness (m g/L)	200	150	200
Silica as Sio2(mg/L)	35	35	35
Total Iron as Fe (mg/L)	0.3	0.3	0.3
Chloride as CL (mg/L)	250	250	250
Colour(Haze n Units	15	15	Colorless and clear
Temperature 0C	28	28	28

Table 3. Tolerance range for world water quality standard

Parameter	Tolerance range		
	WHO	NIS	NDSWQ
pH	5.5-8.5	6.5-8.5	5.5-8.5
Turbidity	1-5	1-5	1-5
Electrical Conductivity	0-1000	200-1000	200-1000
Total Hardness	0-180	0-180	0-180
Silica	5-35	5-35	5-35
Iron	0.1-0.3	0.1-0.3	0.1-0.3
Chloride	0-250	0-250	0-250

Color	0-70	0-70	0-70
Temperature	10-30	10-30	10-30

Further, the iron content in the water samples ranges from 1.09 to 1.83 mg/L with a mean value of 2.44 mg/L (Table 1). The maximum recommended concentration of Fe suitable for drinking is 0.3mg/L (WHO. 2006). It was observed that all the artesian springs have intolerable Fe content, higher than the maximum tolerance range recommended by World Health Organization (WHO), Nigeria Industry-Standard (NIS), and Nigeria Standard for Drinking Water Quality (NDSWQ) shown in Table 3. These high values imply that adequate treatment should be affected on the water against the abnormal concentration of iron before consumption. The groundwater temperature range is 28 - 29 °C, which falls within an acceptable range, based on the standard set in Table 3. Finally, outcomes are summarized in Table 4 based on the standards set in Table 3.

Table 4. Obtained physiochemical parameters correlated with the world water quality standard

Parameter	Obtained values		Remarks on Artesian Springs	
	Minimum	Maximum	Acceptable	Not Acceptable
pH	5.91	7.09	All Locations	
Turbidity	5.27	6.29		L2 and L8
Electrical Conductivity	10	450	All Locations	
Total Hardness	16	136	All locations	
Silica	9	30	All locations	

Iron	1.09	1.83		All locations
Chloride	10.0	56.06	All locations	
Color	3.29	3.93	All location	
Temperature	28	29	All location	

5. DISCUSSION

Aeromagnetic data was combined with hydrochemical analysis to study 10 artesian springs in the area. The results showed the inferred geologic map with the study area dominated by cretaceous sediment and a migmatite intrusion in the southern region, the aeromagnetic map shows all wells seating on cretaceous sediment. Spring 1, 2, and 10 did not fall on any major fractures but all other wells fall on the major fractures in the area, giving a clue to the artesian nature. Thus, the free flow is believed to be partly initiated by the subsurface geologic structures. Well, 5 and 8 fall on the multiple fracture junctions; this could account for the reason why they are the most prominently yielding artesian wells in the area.

The water samples from each spring were collected, analyzed, and assessed for drinking water quality. The pH value of the groundwater in L2 (pH value 5.98), L3 (pH value 5.92), and L6 (pH value 5.91) is slightly acidic in a few artesian and within the WHO acceptable limit in most places. The pH value determines the dissolution capacity of the materials in the water, L7, L8, and L9 show moderately high values of 7.02, 7.07, and 7.09 in pH which affects the total hardness and electrical conductivity in these three locations L7, L8, and L9. Based on EC classification, the groundwater sample is very fresh to fresh. Geochemical parameters such as chloride, show a good correlation with positive factor loadings. The water samples collected in some places are contaminated with iron dissolution which may cause serious health hazards to the populated areas of the study area and requires detailed analysis to confirm if suitable for drinking. The high concentration of iron of range 1.098 to 1.83 mg/L for groundwater is above the maximum permissible level of water for domestic use which is set at 0.3 mg/L [11]. Waters adversely affected by the abnormal concentrations of iron tend to impart a bitter astringent taste to water and a brownish color to laundered clothing and plumbing fixtures [11]. The aquifers in all locations are considered suitable for consumption but need to be oxidized to reduce iron dissolution which may cause health hazards. Further, iron concentration in the water could be removed by following the US environmental protection agency (EPA) procedure (US water system inc) [18].

6. CONCLUSION

The present study has shown that the artesian springs around the Share area are structurally controlled and that most of the springs conformed to the WHO threshold for portable water. The high concentration of iron content is a thing of concern. Though iron mineral is needed by the human body, the content is preferred to be gotten from sources other than water. So, the US EPA procedure or any other effective methods could be used to remove the iron content. Future project works should consider carrying out an extensive survey in the Southern part of the area to be able to know the continuity and extent of the fractures. Geophysical soundings and profiling could be run in the vicinity of the springs to characterize the aquifers in the area, the results of which could be incorporated with hydrochemical analysis. Logging of the area by digging a pit of considerable depth to study the rechargeability of the spring and also the permeability of the horizon.

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