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Studies in Multiple Aquifer Systems and their Comparism in the Geological Character of Kazaure Crystalline Rocks, Northwestern Nigeria.

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ABSTRACT

In this study, the geology, hydrogeological character, groundwater quality and multiple aquifer features of Kazaure area, northwestern Nigeria has been carried out. The two different aquifers selected for the research are the long, elongated or extended regional aquifer and the localized pearchedwater storing medium. The methodology adopted for the study was primary and secondary data sources. Detailed geochemical analyses was done for four (4) physical parameters and eighteen (18) chemical parameters which are associated with the groundwater. Of both aquifers, three (3) samples each were considered for the analysis. In the laboratory analysis, the AAS and XRF machines were used to analyze the samples. The result of the analysis shows that all the samples except the copper, Manganese concentrations in the pearched aquifer, and Lead content of both the aquifer systems that go slightly above the recommendations of WHO, are in conformity with the standard. The study further recommended that appropriate measures should be taken to bring the higher concentrated parameters to desired levels. The comparative analytical results of the six samples are shown in tables and further discussed thereafter, based on the chemical and physical analysis.

Keywords: Geology, Groundwater formations, Comparisms, Kazaure Southeast, Northwestern Nigeria

I. INTRODUCTION

In many areas of northern Nigeria, regional aquifers are commonly associated with sedimentary strata, extending through entire zones (Kankara and Muktar, 2018). These aquifers do not need any reconnaissance and full survey before they can be dug to obtain water. Any borehole drilled within here is expected to have high yield than in the other geological zones/formations (Kankara and Idris, 2020)

The geology of the study area covers intrusive and extrusive rhyolites (of Daura and Kazaure axis) and their related granites and syenites. They were emplaced much later during the Mesozoic era. Apart from the exposed ridges defining the metasediments, other ridges may exist buried beneath the intervening superficial sand and clay deposits of the Chad formation. The structures in the rocks follow a similar structural, framework outlined by two isoclinal foldings. In the context of the disposition and surfacing of Pan-African rocks of the area of study .The present work considered the Kazaure Basement complexes and other adjoining areas to be of similar lithologies and evolution.

The sediments from Cambrian to Pleistocene times are 1,500 to 2,000 metres (4,900 to 6,600 ft) thick, with alternating layers formed when the basin was at undersea and above sea level. Potentially valuable minerals include uranium and copper ores and coal and salt deposits (Kankara and Shazali, 2020)

The northern part of the study area forms the southern fringes of the Illo-Gundumi formations. Details of the major parts of these formations which lie outside the region can be obtained as the main sedimentary rocks in the Chad formations are cretaceous sandstones and conglomerates, while Pliocene to Pleistocene sands and clays form the argillaceous Chad Formations of lacustrine origin (Kankara and Mukhtar, 2018)

Common examples of rocks found here are associated with a lot of iron minerals that gives the material nearly reddish color. Areas covering these formations include areas within Daura and Kazaure southeastern parts.

The study area (Figure 1) covers a lot of laterites and alluvium deposits formed as a result of weathering of different lithologies around the region. Erosional activities are observed in some remote villages, with a lot of laterites and quartz sands, few kilometres away.

In some occasional places there are outcroppings of weathered Basement with laterites at the top and feldspar at the bottom exposed due to weathering. Indurated laterite occur as low-lying hills and ridges which forms a hard cover and are very common occurrences in and around the area.

River deposits houses pale-colored sands occurring in the better developed drainage channels and alluvium in poorly developed drainages. There are quite a lot of artificial and burrow pits observed. The alluvium contain varying amount of sands, silt and clay. Almost half of this area is covered by red sandy soils which support the thick thorn vegetation. Most of the laterite and alluvium are exploited, for economic purposes like construction of roads, buildings and bridges. In the south eastern portion of the region, there are silica deposits in and around some swampy areas. Man-made ponds are seen scattered everywhere within (Kankara, 2012). Within the study area (Figure 1), the groundwater obtained from wells, boreholes and springs may not undergo considerable treatment before becoming potable due to the natural filtration process it has undergone through the soil horizons (Abdullahiet al., 2005). Because groundwater is widely known to be more hygienic than surface water, the possibility of utilizing it as a source of water supply for public use is always attractive (Abdullahiet al., 2005).The aquifer systems in the basement complex rock are complex and as a result, targeting of groundwater in basement is not an easy task. Groundwater occurrence is limited to the weathered part of the basement and fractured zones. Different portions exhibit different permeability and porosity and therefore heterogeneous. Thus, crystalline rocks are multiple aquifer system instead of a single homogenous aquifer (Ogunjobi, 1983).Groundwater exploration in the basement complex rocks relies on the physical and chemical characteristics of water such as conductivity, salinity as well as subsurface element that could indicate its presence. There are various methods of targeting groundwater, such as geological, hydrogeologic, and photogeological techniques. Most people in Asia (India) and Africa, particularly in Nigeria solely depend on geophysical method of groundwater exploration (Dezider and Davieta, 1992; Offodile, 2002). The importance of geologic structures in exploration of oil, gas, water and Ore deposits cannot be underestimated. These structures especially lineaments such as joints, fractures and faults, acts as a reservoir for the deposition of important Ores as well as oil, gas and water (Johnpaul, 2013).

These structures can be detected in the form of lineaments not only by ground mapping but also more easily using RS data (such as conventional aerial photographs and satellite imagery). The good correlation between structures mapped in the field and those mapped using the lineament system enable the lineament to be regarded as representative of the structural indication of a particular area (Morelli and Piana 2006).

The Study Area

Location and Accessibility

The study area is located in northwestern part of Kano State, about 65 km away from Kano metropolitan city. It also covers part of Jigawa and Katsina States. The whole area is part of Kazaure schist belt, northwestern Nigeria. It lies between latitude 12º 30′ 00″ N to 12º 45′ 00″ N, and longitude 8º 15′ 00″ E to 8º 30′ 00″ E, covering an area of about 770.063 km² (Figure 1). It is accessible through major roads, namely: Kano-Danbatta-Kazaure-Daura road, Kazaure-Roni-Ingawa and Kazaure- Shuwaki-Lamba road. There are also numerous networks of footpath throughout the area (Kankara and Idris, 2020)

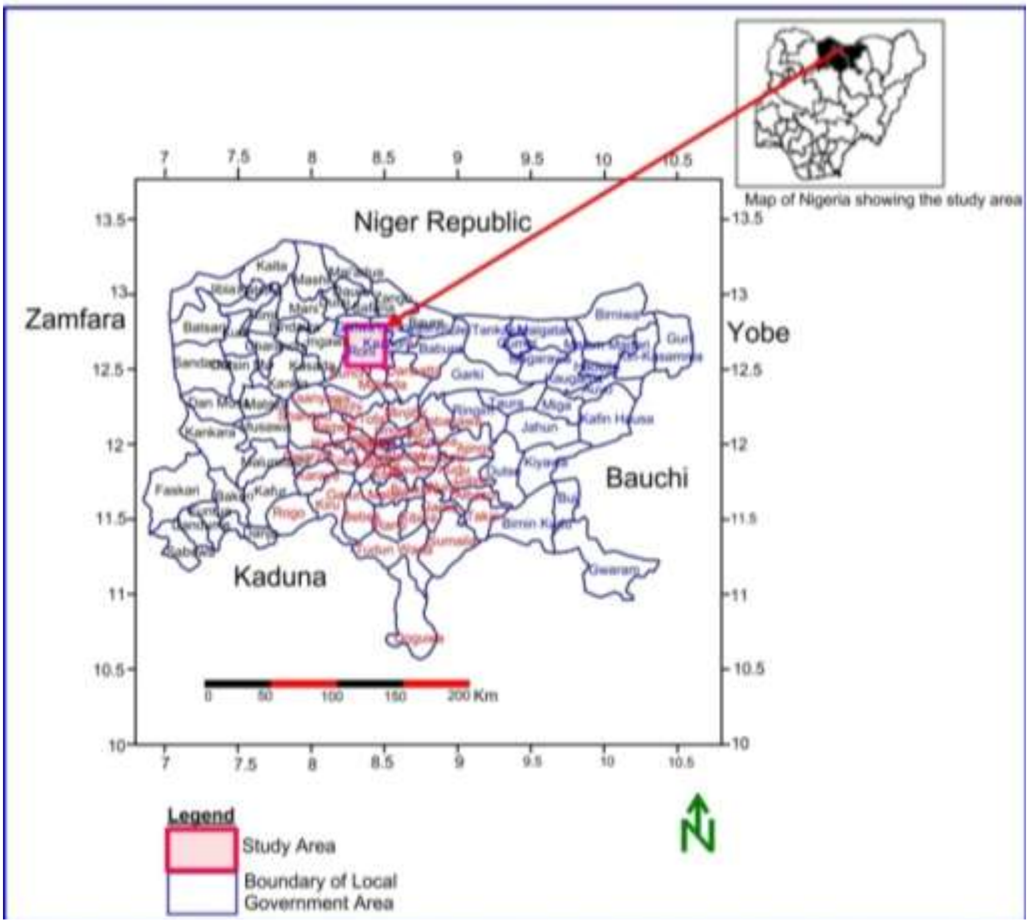

Figure 1: Location map of the study area

Relief and Drainage

Generally, the landforms in the area conform to those obtainable in many parts of northern Nigeria. It is characterized by flat to undulating relief. The noticeable features are the discontinuous ridges of metasediments that trended NE-SW. The granitic rocks which are dome to whaleback occur in the northwestern part of the area. The peak point is on the BabbanDutse ridge near Kazaure town, and is about 106 m above the plain (Danbatta, 1999 and Ibrahim, 2003). The lowest relief is located around GadarKazaure southeastern part of the mapped area.

The geology of the area controls and influences the pattern of the drainage. The drainage pattern is mostly dendritic (Figure 2). Highly weathered minerals such as muscovite, biotite and feldspar of the metasediments of the area, result to the formation of secondary clay minerals (kaolinite). Alteration of these minerals favoured a relatively high storage capacity but low permeability of groundwater (Acworth, 1987). Low permeability produced fine drainage texture which indicates a high frequency of streams and its tributaries in a dendritic pattern (tree branches form), especially near matasediment ridges of Kazaure area (Figure 2).

Major rivers in the area include, Tuwari, Gari, Kiye, Sabke and Tagwai. The Tuwari River flow northeastwards through a rugged terrain and turn southeastern near Kazaure town. River Gari flows northeastwards across regional strike to its junction with the Tagwai River, from where it changes course to a more easterly flow direction similar to that of River Kiye. However, River Kiye is an important river and empties into lake Kiye. Other lakes are Dandi, Dakwat, Kwaita and Wawan-Rafi.

Justification for the Study

Most of the previous works conducted/carried out in the area were of regional extent and only conventional methods were used. One of these is hydrogeological investigation carried out by the Geological Survey of Nigeria in 1926 for exploration of groundwater through hand dug wells and boreholes.

Beside this, no hydrogeological work has been done in this area, except that of Bala (2001) who produced a Hydro spectral and fracture density symbological maps using remote sensing technique within the adjoining area. Other hydrogeological studies carried out in other basement terrains around the world using RS, have shown that areas of most probable occurrences of groundwater could be obtained from the interpretation and analysis of a suitable satellite image (Idris, 2017). Inferences are usually based on geomorphology, drainage pattern, lithology, vegetation cover and structural geology of the area. (Kushreshtha, 1998)

The high population growth rate in the study area gave rise to an increasing demand of water for various uses, to the extent that groundwater is becoming scarcely enough for domestic purpose, and irrigation of arable land in order to boost food production. Therefore, in order to meet water demands, it is necessary to develop strategies that will enable effective ways of exploring groundwater using multi-techniques. These are highly required to locate favorable sites to drill boreholes in order to minimize cases of abortive boreholes within the area (Fredrick, 1990).

II. MATERIALS AND METHODS

Geology and Geological Mapping

Geologic mapping was carried out on a scale of 1:50,000. (Figure 2) It involved observing and recording (in the field notebook), occurrence of rock outcrops and exposures, noting geographical location, recording co-ordinate position obtained from Global Positioning System (GPS). Color of rock, texture, mineralogy and structures were also examined. Strike and dip of foliation were measured with compass-clinometers and plotted on the base map. Traverses used include rivers and streams channels, foot paths and roads network. Rock samples were labeled using waterproof markers and stored in the sample bag for petrographic studies (see Figure 2)

From the data obtained, a geological map was drawn with boundaries between lithologies inferred.

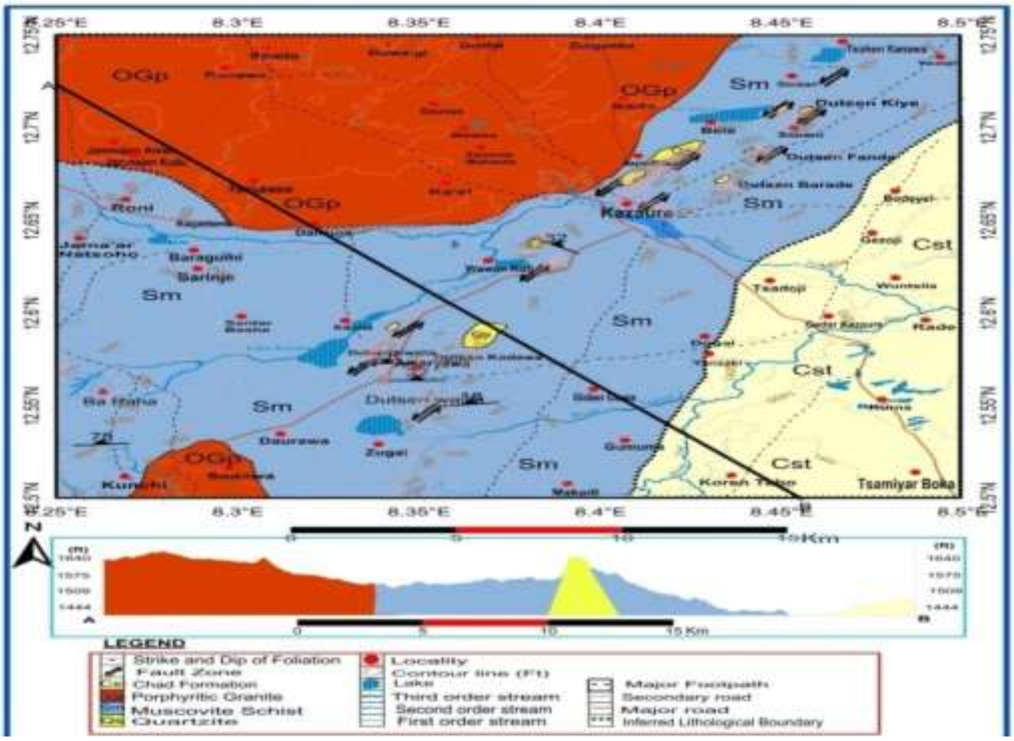

Figure 2: Geological Map of the study Area

Hydrogeological Mapping

The depth to static water level (SWT) which is also called depth to water level, of 89 hand dug wells was measured using metric tape. The first measurement was done during the peak of dry season in May 2015, while the later took place at the end of rainy season in October 2015 (Kankara and Idris, 2020).

The tape had a metal base which allowed tying small piece of metal to it. This help in stretching and preventing of sagging of the tape, since most wells were deep (more than 40 m depth) (Binnic et al, 2002; Idris, 2012)

Measurements were made during the day time. It was easy to observe when the tape makes contact with the surface of water in the wells. (see Figure 3) Consequently, the tape was lowered until it made contact with the water in the well and the depth of the static water level was calculated by noting the length of the tape from the surface of the water to the ground level. Special caution was taken to ensure that measurements of SWT were made with reference to the ground surface around the well and not the head or cover of the wells. This procedure was repeated for all the sample locations and was done for both the end of wet season and the peak of the dry season (see Figure 3)

Review of Related Literature

1. Geology of the Chad Formation

According to Kankara and Idris (2020) the Chad Formation is of lacustrine origin, and was deposited by rivers flowing towards Lake Chad on the Basement Complex during the Plio-Pleistocene. The Formation consists of clays, sandy clays, small amounts of Carbonaceous materials and with the presence of diatomite been reported by (Raeburn and Jones, 1934; and Du Preeze and Richards, 1958).The sand and gravel beds are intercalated with clays while lenses of sands and gravels are not uncommon within the clays. The clays are whitish, greenish-gray in color, with fine to gritty variety (Slipigum and Von, 1991)

2. Ground water Maps

Although maps of phreatic surfaces may not have been part of the survey, but more indices on the theoretical aspects can be thrown for better understanding. They refer to groundwater configuration maps, prepared for the peak of dry season and end of the wet season (Idris, 2017). The maps can be prepared by contouring (joining points of equal groundwater elevation), a base map on which altitudes of the water levels in hand dug wells, and altitude of points of intersection of topographical contour lines with streams had been plotted. The altitudes of the water level in hand dug wells are found by (assuming a linear gradient), subtracting the depth to static water level in each location from the altitude of the location as interpolated from a topographical map. Using visual observation, special caution was taken to avoid topographical highs in plotting a map when desired.

III. RESULT AND INTERPRETATION

The Geological Context

1. Top Soil/Laterite Sand/Sandy Clay

The top layer has resistivity value ranging from 32.4 to 2424 ohm-m showing that it consists of clay sandy, clay and clayey sand with maximum layer thickness of 6.39 m (Table 1). Walter (1990) described a top soil as a body that makes its contributes to the development of groundwater, because it is the passage for the flow of surface water to the fractured layer (Kankara and Shazali, 2019) (Figure 4)

2. Synopsis of Chad Formation

Kankara and Muktar (2018) suggested that this layer has resistivity value range of 121 to 4977 ohm-m with a thickness of about 5.33 to 49.6 m. It served as good aquifer because of its good storativity and permeability as observed in geo-electric section of E–W (B–B′) (Figure 4)

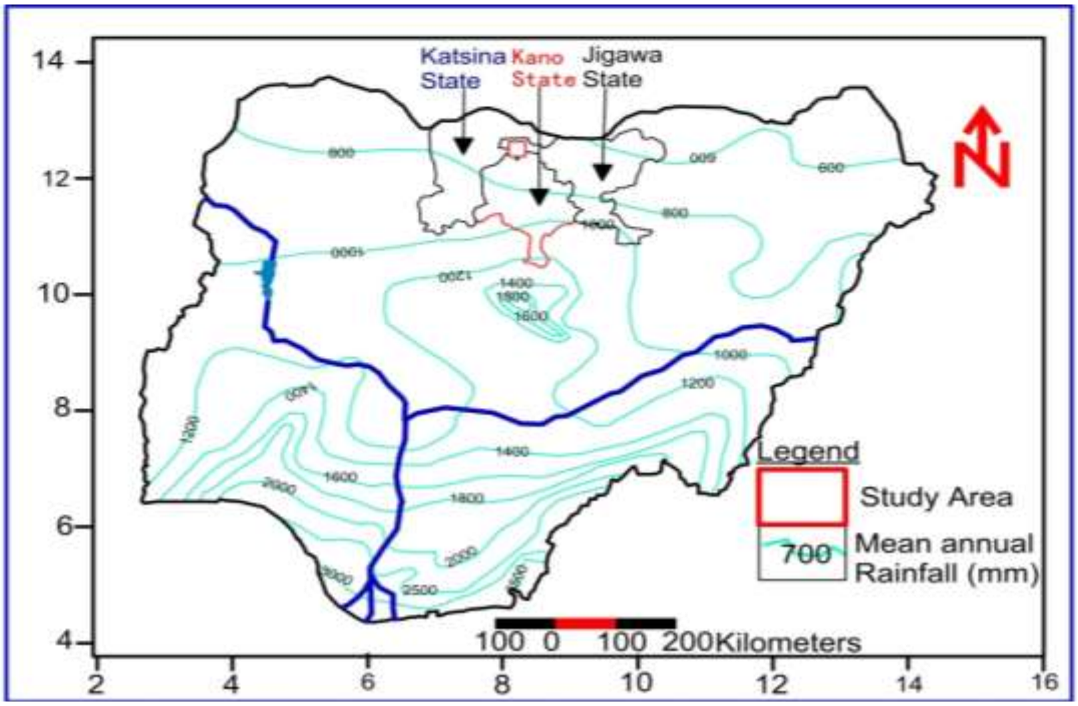

Figure 3: Map of Depth of Rainfall in Nigeria. (Modified after Schoeneich and Garba, 2010)

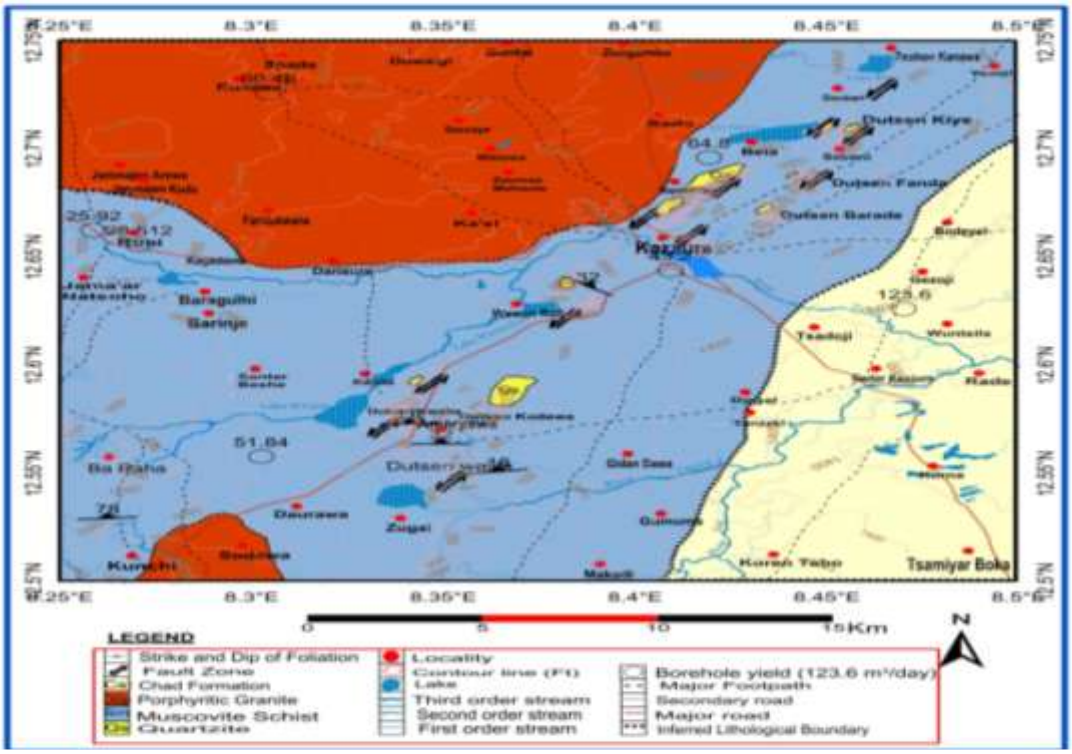

Figure 4: Borehole yield superimposed on the geological map of the Area

3. Weathered Layer/Transition Zone

The resistivity of this layer ranges from 14.3 to 10356 ohm-m while the thickness varies between 0.57 to 40.2 m. According to Dan Hassan and Olurenfemi (1994), it consists of clayey sand/ sandy clay layer. The layer is highly decomposed by weathering to form sand and clayey sand depending on the local variation of the mineralogy. Dan Hassan and Olurenfemi (1994) identified this layer to be the major aquifer unit. If the depth of weathering is sufficiently thick as exhibited by most of the VES points in the study area; the weathered mantle could contain water in storage large enough to produce successful wells (Tebut, 1998) Fractured zones occur immediately beneath the weathered horizon. Where the fractured zone is saturated, a high groundwater yield can be obtained from borehole penetrating such a sequence.

4. Fresh Fractured Basement

Hydrogeological Character of Kazaure SE

1. **Regional Aquifers**: Hydrogeologically speaking, here, the Basement Complex or water-bearing objects here are regional aquifers. They do not exceed 90 meters, where they exist. Investigations have shown that depths of boreholes drilled into the migmatite-gniess in around regional aquifers fall within the range of 25.0 m to 77.10 m and 29.0 m to 79.50 m for boreholes tapping the Biotite granite rocks (Aliyu and Idris, 2020) As is always observed, and as suggested by Kankara (2020), regional aquifers in the southern parts of the study area are extended or elongated and which cover many kilometers. They have high yield or have water (see Figure 4).

2. **Pearch/Localized Aquifers**: The localized aquifers on the other hand have very low to moderate yield. They are further categorized into regoliths aquifers and fractured crystalline aquifers, which are directly underlying the soft over-budden aquifers. Some fractured aquifers in most southern parts are highly prolific, in areas where they are extensively interconnected and link to the surface for recharge. Aquifers here have low yield, due to absence of, or poor or even no porosity, and so the permeability. They therefore have low yielding boreholes, unless drilling is made across a fracture. The average yield of an aquifer here is 0.2 to 0.5 liter per second. If the aquifer is soft overbudden with very good hydrologic characteristics, the yield can stand at 0.2 l/s or more. But, if eventually, a driller hit a fracture in a regional aquifer, then the yield can be from 1 to 2 liters per second, and sometimes up to 3 or 4 liters per second (Kankara, 2020) These categories are otherwise pearch systems.

Procedure for Physical Analysis

1. Color Determination: Distilled water and the sample were poured into the test tube. The hazendisc which was numbered was inserted in the iovibond. The hazen disc being positioned on the distilled water was then watched to know the particular disc number that have the same color with the sample. When rotated, the disc number that has the color with the distilled water checked and the value was recorded (Lowrie, 1997).
2. OdourThis is done with the nose.
3. Electricity ConductivityThe electrode was wetted thoroughly and then plugged into the conductivity meter before it was inserted in to a 250ml beaker containing distilled water. The conductivity meter was then switched on, and zero error was corrected. The distilled water was replaced with raw water samples and the electrode was inserted in each case. The system was allowed to stabilize and the reading was recorded.
4. Determination of PH ValueThe glass electrode was thoroughly wetted with distilled water. The ph meter was switched on and was standardized. This was done by connecting glass electrode to the PH meter and inserting the electrode into the buffer solution. This was allowed to stabilize and ph meter reading indicated 4.0, which is equal to its known value. The same thing was repeating using buffer solution with PH of 9.0. The beaker containing buffer solution was then replaced consecutively with the ones containing raw water samples and the electrode was inserted into it. This was then allowed to stabilize and the readings were recorded.

Procedure for Chemical Analysis

1. Determination of Total Solidempty beaker was initially weighed, 50mls of the water sample was measured and poured into the weighed beaker and heated gently to dryness at about 70^0c, then it was cooled and reweighed. The process was repeated until a constant mass was obtained and the value noted.

2. Determination of Dissolved SolidProcedure: empty beaker was weighed; 50mls of the water sample was measured and filtered into the beaker. The filtrate was heated to dryness, cooled and reweighed with the beaker, until a constant mass is obtained and the value was recorded.

3. Determination of Suspended SolidsThe water sample was filter with a filter paper and the residue on the filter paper was calculated as S.S= (T.S-D.S) mg/l.

4. Determination of Acidity10ml of water sample was pipette into a conical flask. Three drops of phenolphthalein solution was added to each sample and titrated with 0.1m NaOH solution to give a pink color.

5. Determination of Alkalinity 10ml of water sample was pipette into a conical flask. Three drops of methyl orange indicator was added and titrated with 0.1m NaOH to give an orange color.
6. Determination of Chemical Oxygen Demand (C.O.D) 10ml of water sample was pipette; 5ml of 0.025m potassium dichromate was measured with a measuring cylinder.15ml of concentrated sulphuric acid was added and diluted with 40ml of distilled water to get 70ml solution. 7 drops of phenolthroline ferrous sulphate indicator was added. The colour changes from greenish blue to orange colour, and then titration was done on the blank sample. The titer value for the blank sample is higher than the titre value of the sample.
7. Determination of Dissolved Oxygen (D.O) 20ml of water was pipette. 1ml of potassium fluoride was also pipette. 20ml of 0.1m manganese sulphatewas also added together with 2ml of alkaline iodine solution. Then 2ml of concentrated $H_2SO_4$and 5ml of freshly prepared starch indicator were added and the colour changes to blue black. This was titrated using sodium thiosulphate solution (0.05m) to a colour and point.
8. Determination of Calcium10ml of water sample was measured into a beaker, a pinch of potassium cyanide was added together with a pinch of hydroxylamine hydrochloride. 5ml of 8 molar potassium hydroxides was added then a pinch of indicator (patton and readers reagent) was added and titrated with 0.01M EDTA using a burette. The colour change from brown to green.
9. Determination of magnesium 10ml of the sample was measured, a pinch of hydroxylamine hydrochloride was added and 5ml of mono-ethanol buffer or (buffer 10) was added, then 2 drops of eriochrome black T indicator was added. This was titrated with 0.01M EDTA.The colour changes from purple to blue black.
10. Determination of chloride10ml of water sample was pipette, 3 drops of 0.1M potassium indicator was added and titrated with 0.1M silver nitrate. The colour changes from yellow to light orange.
11. Determination of Iron5ml of water sample was pipette into a test tube. 5ml of sodium acetate buffer was added. 0.5ml 0f 105 of hydroxylamine hydrochloride was also added and 5ml of 0.02% phenothroline. This was made up to 50ml in the volumetric flask with distilled water and wasallowed to develop from 50mins and the absorbance was read with the aid of spectronic 20 machine. The wavelength of iron = 510nm.
12. Determination of Zinc20ml of water sample was measured, 2ml of buffer PH was added with 2 drops of eriochrome black T indicator and titrated with 0.01m EDTA until colour changes from wine red to blue.
13. Determination of Lead 10ml of water sample was measured. 5to 6 drops of 10% potassium cyanide was added together with 25ml of 1.2m ammonium solution and 0.5ml of 10% Na_2S (sodium sulphide). This was made up to 50ml with distilled water. The wavelength of lead is 430nm.
14. Determination of Manganese20ml of water sample was added to the $50cm^3$volumetric flask.. 5ml of phosphoric acid was added and 0.3g of potassium peroxide was added and shaken well. This was boiled for 15mins and allowed to cool, then made up to 50ml with distilled water. This was read in spectronic 20 machine.Themanganese wavelength is 520nm.
15. Determination of Copper 10ml of the digested water sample was measured into a 50ml of volumetric flask; 10ml of 0.01m NH_4OH was added. This was made up to the mark with distilled water. The absorbance was read with a spectrometer at wavelength of 620nm.
16. Determination of Nitrates50ml of each water sample was measured. 1ml of sodium arsenate was added and shaken thoroughly. 5ml was measured from the mixture in a separate test tube. 1ml of Brucinesulphate/ phenothroline ferrous sulphate indicator was added was mixed and allowed to develop for about 30mins to 1 hour. The reading was done with the aid of spectronic 20 machine.
17. Determination of Phosphate10ml of the neutralized sample was pipette into 50ml volumetric flask. 4ml of sulphuric acid was added and shaken on each addition, 6 drops of stannous chloride was added then shaken and distilled water was added to make it up to 30ml. the absorbance in the spectronic meter was read and at a wavelength of 650nm using red.

Table 1: Results of the Sampling Analysis

Parameter	**Unit**						
Physical Analysis		A	B	C	D	E	F
Odour		-ve	-ve	-ve	-ve	-ve	-ve
Colour	Hazen	5	5	5	5	5	5
pH		6.78	7.5	7.0	6.5	6.62	6.5
Conductivity	µs/cm	4.5×10^2	4.5×10^2	3.7×10^3	2.8×10^3	3.4×10^2	3.4×10^2
Chemical Analysis							
Acidity	Mg/l	52	55	55	50	50	50
Alkalinity	Mg/l	150	175	170	85	135	120
Total solids	Mg/l	11.45	20.25	15.00	4.15	5.25	7.60
Suspended solids	Mg/l	0.98	1.02	1.05	0.20	0.72	0.95
Dissolved solids	Mg/l	10.47	19.23	13.95	3.95	4.53	6.65
Dissolved oxygen	Mg/l	1.25	1.10	1.22	0.65	0.72	1.13
C.O.D	Mg/l	Trace	Trace	Trace	Trace	Trace	Trace
Calcium	Mg/l	3.45	2.90	3.05	1.84	2.02	1.90
Copper	Mg/l	1.21	1.8	1.25	0.41	0.55	0.50
Iron	Mg/l	125	1.25	1.09	1.06	1.20	1.10
Manganese	Mg/l	0.46	0.73	0.44	0.12	0.35	0.38
Lead	Mg/l	1.01	1.05	0.25	1.01	1.10	0.95
Phosphate	Mg/l	4.55	5.53	5.55	4.34	4.32	4.39
Chloride	Mg/l	52.2	60.4	56.0	56.52	65.2	70.5
Nitrate	Mg/l	0.44	0.43	0.30	0.35	0.40	0.47
Zinc	Mg/l	0.45	0.51	0.26	0.34	0.66	0.32
Magnesium	Mg/l	1.40	1.43	1.57	0.85	1.25	0.70

TABLE 2: Mean of the Results

Parameters	**Units**	**Pearch Aquifer**	**Regional Aquifer**
Physical Analysis			
Odour		-ve	-ve
Colour	Hazen	5	5
pH		7.1	6.5
Conductivity	µs/cm	5.4×10^3	4.6×10^3
Chemical Analysis			
Acidity	Mg/l	54	50
Alkalinity	Mg/l	165	113
Total solid	Mg/l	15.6	5.7
Suspended solid	Mg/l	1.02	0.62
Dissolved solids	mg/l	14.55	5.04
Dissolved oxygen	mg/l	1.19	1.83
C.O.D	mg/l	Trace	Trace
Calcium	mg/l	3.1	1.92
Copper	mg/l	1.42	0.49
Iron	mg/l	1.20	1.12
Manganese	mg/l	0.54	0.28
Lead	mg/l	0.77	1.01
Phosphate	mg/l	5.21	4.05

Chloride	mg/l	56.2	64.1
Nitrate	mg/l	0.39	0.41
Zinc	mg/l	0.41	0.44
Magnesium	mg/l	1.47	0.93

TABLE 3: WHO Standard Specification for Drinking Water (Idris, 2017)

Parameters	Units	WHO
Physical Analysis		
Odour		-
Colour	Hazen	5
Ph		6.5-8.5
Conductivity	µs/cm	1000
Chemical Analysis		
Acdity	mg/l	-
Alkalinity	mg/l	-
Total solids	mg/l	500
Suspended solids	mg/l	-
Dissolved solid	mg/l	500
Calcium	mg/l	75
Sodium	mg/l	Not≥ 5
Copper	mg/l	1.3
Iron	mg/l	0.3
Manganese	mg/l	0.1-0.5
Lead	mg/l	0.01
Chloride	mg/l	250
Nitrate	mg/l	0.5
Zinc	mg/l	-
Magnesium	mg/l	Not >30
Dissolved oxygen	mg/l	-
C.O.D	mg/l	-

According to the results shown on Table 1 and the mean results on Table 2 above, the pearch water samples and regional aquifer water samples are odorless and colorless, that is in conformity with WHO standard. The pH of water from regional aquifer is 7.1 which is higher than that of the pearch aquifer which has a mean value of 6.54. This indicates that they are slightly acidic. An acceptable pH range for drinking water is 6.5-8.5; therefore the water samples are fit for drinking. Hence the pH values of the different water samples analysis are in accordance with the WHO standard.

The Conductivity is higher in samples from regional aquifer with a mean value of 5.4x10^{3}µs/cm, while lower in pearched aquifer with a mean value of 4 6x10^{3} µs/cm. Though all conform to the WHO standards for drinking water,

The acidity of regional aquifer water is 54 which is higher when compared to pearched aquifer water which has a mean value of 50, though the values conform to the WHO specification.

In alkalinity, sampled water from regional aquifer has a higher value of 165 mg/l when compared to water from pearched aquifer, which has the value of 113mg/l.

The concentration of Total Dissolved Solids is higher in water from regional aquifer, with a value of 15.6mg/l while water sampled from pearched aquifer has the value of 5.7mg/l. this is due to the filtration process which water from pearched aquifer undergoes during recharge.

It was observed that all the samples analyzed are fit for domestic consumption, and are in accordance to WHO specification. The concentration of suspended solids is higher in regional aquifers with a value of 1.02mg/l, while it is lower in pearched aquifers with a mean value of 0.62mg/l.

The Total Dissolved Solids (TDS) is higher in regional aquifer water with a mean value of 14,55mg/l, while that of pearched aquifer water is lower in concentration with a value of 5.04mg/l. tough all are in conformity to the WHO standard for drinking water (Table 3).

Calcium content in regional aquifers is higher with a mean value of 3.1mg/l when compared to those of pearchedsystem which has a mean value of 1.92mg/l.

This shows that the entire samples are soft waters, hence little or no probability of causing hardness. They will produce leather with soap easily. However, all the values conform to the WHO standards.

Copper content in drinking water has a normal range of 1.3mg/l, Regional aquifer water in the sampled areas is higher than the WHO standard with a value of 10.49mg/l while water in the pearch system conform to W.H.O standard with a value of 0.49mg/l (see Table 3)

The iron concentration is higher in regional system with a value of 1.20mg/l when compared with pearchsystem which has a lower value of 1.12mg/l. All the samples fall within the range stipulated by the WHO specification for drinking water.

Manganese value is higher in regional aquifer with a value of 0.54mg/l which is higher than the W.H.O standard of 0.5mg/l, while pearch system has a lower value of 0.28mg/l which is in conformity with the WHO specifications (Table 3)

Lead content of the regional system and the pearched water samples are higher than the WHO specification of 0.01mg/l. For pearched systems, it is due to the lead pipe through which the water flows, hence the water must have dissolved some parts of the pipe in the water.

Nitrate content of the water samples as shown in table 2, conform to WHO standard and are portable for consumption. Water from regional system is lower than that of pearched system with a value of 0.39mg/l while the later has 0.41mg/l.

Chloride values in pearchedsystem are higher than that of regional systems with a value of 64.1mg/l While regional system has a mean value of 56.2mg/l. All of them conform to WHO specification of 250mg/l for drinking water.

Phosphate content of regional system is higher with a mean value of 5.21mg/l when compared to pearched system which has a mean value of 4.05mg/l. all are within the range of W.H.O standard for drinking water.

Zinc concentration of pearched system is little higher than the regional system with a value of 0.44mg/l while regional aquifer has 0.41mg/l. All the samples are within the range of W.H.O specification for drinking water. Magnesium content of all the samples are within the WHO standard for drinking water, but the sampled water from regional aquifers has a higher value of 1.47mg/l, while the pearched water has a lower value of 0.93mg/l.

Dissolved oxygen is higher in waters from regional aquifers with a mean value of 1.19mg/l when compared to pearchedaquifers which has a mean value of 0.83mg/l.

However, all are in conformity to WHO specification for drinking water. The Chemical Oxygen Demand of the entire samples is not detected.

IV. DISCUSSION

Studies in the groundwater condition of multiple aquifer systems of Kazaure zone, which comprised of regional and pearched localized crystalline aquifers was carried out. Due to moderate population in the study area, most of the tests done in the laboratory of parameters selected conform to the WHO standard for water consumption. But, knowingly or unknowingly, regular monitoring to ensure conformity to World Health Organization standards and to assure the public of the portability of their water is necessary. In fact simple tests carried out regularly at short interval are of more value than detailed test mode occasionally.

V. CONCLUSION

From the test carried out there is no much difference in quality between the waters sampled from regional aquifers and the pearched aquifer systems in the area, analyzed. After production and treatment, water delivered to consumers/sold to consumers should contain no pathogenic organisms, should not contain concentration of chemicals which may be physically harmful to health. Finally, results from the study indicate that all three sampled water both from the two different aquifers are quite safe for human consumption.

VI. RECOMMENDATION

The Federal Government of Nigeria should establish a meteorological station in the area, to enable the rate of evapo-transpiration and rate of recharge from precipitation be established, for the appropriate management of the water resources. Care should be taken to make sure that the rate of groundwater exploitation does not exceed the recharge rate in order to avoid over abstraction, which could have environmental consequences.

REFERENCES

[1]. Abdullahi, A.S. Musa, S.M. and Illiya, A.G. (2005). Aquifer depletion and groundwater situation in Damaturu, Northeastern Nigeria. Water Resources. 16: 59-64.

[2]. Acworth, R.I. (1987). The Development of Crystalline Basement Aquifers in a TropicalEnvironment. Quarterly Journal of Engineering Geology 20, 265–272.

[3]. Bala, E. A. (2001). An Evaluation of Landsat 5 Thematic Mapper data as a tool forgroundwater investigation in Basement Complex rocks of Nigeria. Unpublished Ph. D.Dissertation. Ahmadu Bello University, Zaria, 126p.

[4]. Baron, L., Cebcu, Tattamanti, T., M..,Berati, M. (2004). Evaluating the Environmental Impact of Various Datary Patterns combined with different food palliations systems. In European Journal of Clinical Nutrition. (5), 1-28.

[5]. Binnic, C., Kimber, M., &Smethrust, G. (2002). Basic Water Treatment. London: Thomas Telford limited Pp. 6-12.

[6]. Danbatta, U.A. (1999). Geotectonic Evolution of the Kazaure Schist Belt in the Precambrian Basement of NW Nigeria. Published Ph. D. Dissertation. Ahmadu Bello University, Zaria, 289 p.

[7]. Dan Hassan, M. A., and Olurenfemi, M. O. (1994). Hydro-geophysical Investigation ofBasement Complex Terrain in the North Central Part of Kano State, Nigeria.Journal ofMining Geology Vol. 35, pp 189-200.

[8]. Du Preez and Richards, (1958): The Hydrology of Gumel Emirate, Kano provinceRecord of GSN, 1955. Pp 59-64.

[9]. Dezider, I. and Davieta, T. (1992) Microbial Interaction with Chemical Water Pollution. Canada:Lexican Publications. P.17.

[10]. Fredrick, W. P. (1990). Water Quality and Treatment. A Handbook on Community Water Supply. American water work association. USA: Donnelly and sons publishing company. Pp. 89-100.

[11]. Ibrahim, A.A. (2003). Geological Setting and the Geochemistry of Iron Formations in theKazaure Schist Belt, NW Nigeria. Unpublished M.Sc. Thesis. Ahmadu Bello University,Zaria, 89 p.

[12]. Idris, M. A. (2017) Groundwater Potential Assessment of Part of Kazaure Area (Sheet 35) South East, Northwestern Nigeria. An unpublished MSc Thesis submitted to Dept. of Geology, Ahmadu Bello University Zaria, Nigeria.

[13]. Johnpaul, A.A. (2013). Landsat-7 interpretation of lineaments over the Southwesternpart of Adamawa State, Northeastern Nigeria. International Journal of Advances inScientific Research and Reviews (IJASRR). Vol. 1(3) 25, Pp. 13-24.www.academiascholarlyjournals.org/ijasrr/index.htm

[14]. Kankara, I. A. (2012) Local Field Trip of Dept. of Geography Students, Umaru Musa Yar'adua University, Katsina.

[15]. Kankara, I. A. and Muktar, K. (2018) Hydrogeological Analysis of Lithographic Units of Northern Katsina State, Nigeria. FUDMA Journal of Sciences, Vol. 2, No. 4., pp 231-236, December 2018.

[16]. Kankara, I. A, and Idris M. A.(2020) Mapping Geology and Structural Features of Kazaure SE, NW Nigeria: Justifying Groundwater Potential Model. Accepted for publication in the Journal of Sciences, Dept. of Geography, Tourism and Hotel Management, University of Nova, Serbia.

[17]. Kankara, I. A. and Shazalli, N. (2020) Geology and Petrography of Precambrian Rocks in Katsina Urban Area, Northwestern Nigeria. Accepted for publication in the Journal of Sciences, Dept. of Geography, Tourism and Hotel Management, University of Nova, Serbia.

[18]. Kankara, I. A. (2020) Geology and Mineral Resources of Katsina State: An Investor Guide. A text published by Darma Prints, Katsina, 2020.

[19]. Kushreshtha, S.I., (1998). A Global Outlook for Water Resources to the year 2025. Water resources management. New York: academic Inc. 12 (1), 1-18.

[20]. Lowrie, W. (1997). Geomagnetic polarity reversals, in: The Encyclopedia of PlanetarySciences, J.H. Shirley and R.W. Fairbridge, eds., Van Nostrand Reinhold, New York,Chapman and Hall, London, 654-656.

[21]. Lomborg, B. (2001). The Skeptical Environmentalist. Massachusetts: Cambridge University Press.

[22]. Linsey, R. K., Franzin, J. B., Frecyberg, D.L., &Tchobaroglons, G. (1995). Water Resources Engineering. London: Sowy. J. Publishers. Pp. 34-45. Mc- Graw- hill. (9th ed.).(1960). Encyclopedia of Science and Technology. New York: John Wiley and sons, Inc. pp.

[23]. Morelli, M. and Piana, F. (2006). Comparison between remote sensed lineament andgeological structures in intensively cultivated hills (Monferrate and Langhe domains, NWItaly). International journal Remote Sensing, 27 (20): 2471-4493.

[24]. Offodile, M.E. (2002). Groundwater study and development in Nigeria (2nd Ed). Mecon Geology and Engineering Services Ltd. Jos, Nigeria pp 451.

[25]. Ogunjobi, M.B. (1983). The geochemistry of groundwater in part of River Galma Basin;National water resources institute Bulleting Vol. 3 pp 11-20.

[26]. Raeburn, C. and Jones, B. (1934): The Chad basin: Geology and water supply: Bull.Geology. Survey. Nigeria 15. 20 - 23.

[27]. Slipigun, P., and Von, Z. (1991). Ion Chromatography of Water Analysis in Context. USA: Mc-Graw Hill Books Company. Pp121-122.

[28]. Schoeneich, K. and Garba, M. L. (2010). Hydrogeology (Geol. 405). Course Notes.Department of Geology, Ahmadu Bello University, Zaria. pp. 1-

[29]. Tebutt, I. H. (1998). Principles of Water Quality Control. Butterworth: Heinemann Publishers.

[30]. Trivedi, R. R., and Rajo, G.(1997). Water, Pollution. Encyclopedia of Environmental Sciences. Akash India: Deep publishing House. Pp.139-162.

[31]. Walter, A.(1996) . Water: A Natural History. New York: Basic Books.pp. 1-3