GROUNDWATER FLOW DIRECTION AND WATER QUALITY ASSESSMENT (A CASE STUDY OF KERRI-KERRI FORMATION IN POTISKUM NORTHEASTERN NIGERIA)

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ABSTRACT

The Kerri-Kerri Formation is predominantly arenaceous, consisting of loose cemented sands and grits with minor clayey sandstones, massive clays and silts; bands of ironstone and conglomerate occur locally. Groundwater mainly occurs under water-table conditions in the Kerri-Kerri Formation. However occasional clay lenses give rise to perched aquifers in some parts. Confined water also occurs in the Formation where the aquifer is overlain by impervious sediments. A water-table contour map has been constructed by subtracting the depth to water level from the ground surface elevation. The water-table contour map indicates the groundwater flow towards the lower surface elevation areas of Rigiyan Master in the Central part of town, and also towards the Southwest in places like Anguwan Jaji and Anguwan Jigawa respectively within the study area. Major ions analysis of the groundwater confirmed the groundwater to be generally good and safe for both domestic as well as agricultural purposes, based on comparism with the Standard Organization of Nigeria (SON) 2007 drinking water regulatory standards.

Keywords: *Kerri-Kerri Formation, Water-table, Hydrogeology and Piezometer*

INTRODUCTION

The Potiskum town is underlain by the sediments of Kerri-Kerri Formation which is an elevated plain land located in Yobe State Nigeria. The Kerri-Kerri Formation is bordered in the west by the Crystalline Basement Complex rocks of Bauchi area which are of Precambrian to early Paleozoic age and to the east by the folded Cretaceous rocks of Gombe Sandstone and to the north by the Pleistocene lacustrine clays of Chad Formation (Dike and Dan-Hassan, 1992). The Kerri-Kerri Formation was laid down on uneven surface of the Basement Complex and folded Cretaceous rocks with the thickness variation from few meters to estimated 300 m (Dessauvagie, 1975; Adegoke et al, 1978). The Kerri-Kerri Formation comprises medium coarse sandstones, sands, sandy gravel and sandy clay, although fine sands, siltstone and clay stones are well developed (Dike and Dan-Hassan, 1992). The Kerri-Kerri Formation is a continental sequence of Paleocene age deposited in a wide variety of sedimentary environments, namely alluvial, fluviatial and marginal lacustrine, although deltaic environment has also been suggested (Carter et al., 1963; Du Preez and Barber, 1965). The Kerri-Kerri Formation outcrops in a number of places particularly in the Alkaleri, Dukku and Potiskum areas respectively. Generally the occurrence of groundwater in the Kerri-Kerri Formation aquifers occurs mainly under water-table conditions but locally it occurs under semi-confined conditions. At shallower levels, these give rise to perched aquifers which are exploited by dug-wells in some areas (Carter and Barber, 1958). The heterogeneity of the aquifers caused by the occurrence of interbedded, intra-bedded and interstitial clays and

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shales, has been responsible for some low yields, as suggested by (Du Preez and Barber, 1965). The saturated portion of the Kerri-Kerri Formation contains a large quantity of water, though much of it is not readily exploitable owing to the low permeability of the sediments due to interstitial clay and silt in the sandstones.

Location and Accessibility

The study area falls within Yobe State of Nigeria, which is located between latitudes 11◦40'–11◦50'N and longitudes 11◦00'–11◦10'E (Federal Geological Survey of Nigeria Potiskum Topographical Sheet 86). Potiskum lies on the main road from Maiduguri to Kano, It is about 108 Km from Damaturu (Fig. 1) below.

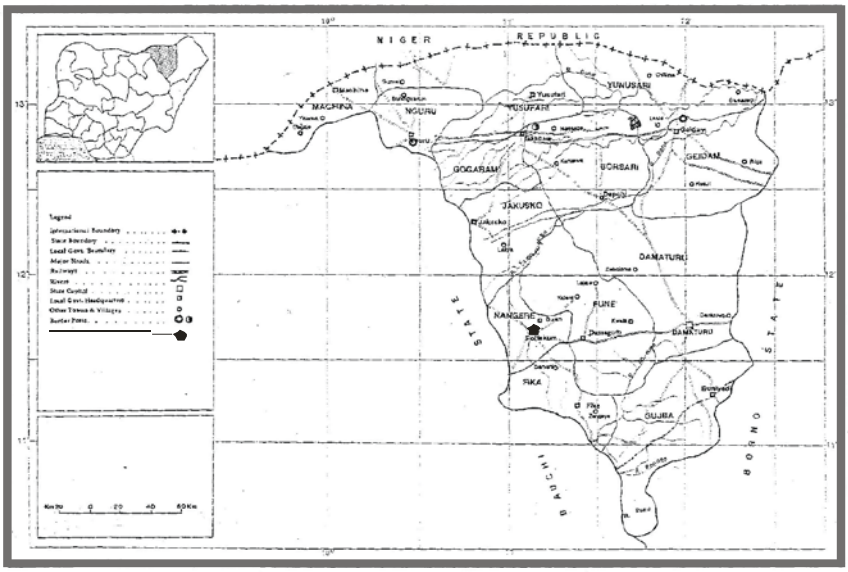

Fig. 1 Location Map of the Study Area (Potiskum)

Hydrogeology

The depth to water-table varies widely in the Kerri-Kerri Formation, ranging from 5-20 m, below ground surface. The saturated portion of Kerri-Kerri Formation contains a large quantity of water though much of this is not readily exploitable owing to the low permeability of the intercalating clay and silt in the sandstones. In areas of Old Prison well and Rigiyan Gawo well where the interstitial clay does not exist, it gives a very good yield. In areas with comparatively dense drainage pattern, the water-table is usually shallow which can be tap by hand-dug wells because there are possibilities of the shallow aquifers to be recharge. Potiskum town lies in a plain area inspired by small ridge of consolidated sand dunes. Despite the looseness and coarseness of the Kerri-Kerri Formation, this apparently, highly permeable Sandstone Formation is known to be unpredictable hydrogeologically.

Much of the arenaceous beds are dry with little or no water at top beds. The highly permeable nature of the Kerri-Kerri Formation sand probably makes it possible for the infiltrating water to run through the aquifer very easily and rapidly to very low levels. However, groundwater tends to be suspended in areas where it is supported, at convenient intervals, by interbedded clays, shales, siltstones; hence the large variation in depths of water-tables ranging from 5-20m in places.

Methodology

Field measurement of physical parameters:

Groundwater sample collection in the field is a very tedious taxed, because on every sample collected one has to be very careful. The physical parameters measurement most be made right there in the sample collection point in the field cause almost all the parameters do changes before the samples were taken to the laboratory for further analysis.

Procedure: about 100 ml of the sample is collected in a clean beaker. The sensitive electrode on the meter is dipped into the water and the mode knob on the meter is pressed to select either pH or EC measurement. After a few minutes a stabilized reading of the selected parameter is displayed on the small screen together with temperature of the solution. The measurements of these parameters are done in the field when the sample is being collected. The meter type is Combo / Hanna equipment: Combine pH, EC.

Measurement of Total dissolved solid (TDS) was also carried out on the field using the meter Toledo-type with (TDS) electrode. The sensitive electrode membrane is placed in the solution or sample and the "read" knob is pressed. The value of the selected parameter i.e. (TDS) is displayed after few seconds. Other parameters measured in the field include the coordinates of the wells monitored. The global positioning system (GPS) instrument is digital hand held equipment which uses satellites to give the coordinates, (latitudes, longitude) and elevation of the wells' location.

Water sample collection for laboratory analysis:

The Water samples for this study were collected using plastic bottles that were thoroughly washed with deionised prior to the sampling exercise. The sample bottles were filled to the brim with the sample and sealed thereafter by screwing the cap very tightly. All the samples were preserved in a frozen box following the standard procedure for storing samples and were later sent to the laboratory for the analysis of major ions.

Measurement of depth to water level: Several techniques of measuring the elevations of water level in observation wells or piezometers are available, commonly an electrical water level indicator is used to measure the distance from a fixed measuring point on a well casing to the water. An electric water level indicator is a plastic tape measured in a meter which has electrical wire running inside and weighted electrode at the end. The measurement of the depth to water level is usually carried out early in the morning hours when the water level has fully recovered from the wells abstractions.

The water level indicator is lowered down into the well, as it torches the water surface; an electric circuit is completed turning on a buzzer or light on. The electrode is constructed so that in mineralized water current is conducted to complete the circuit. In air, the circuit remains open and buzzer remains quiet. The actual elevation of the water surface is determined by subtracting the measurement on the tape from elevation of the fixed measurement point at the top of the well lining or casing. Great care is usually taken to completely clean the tape before the next measurement in order to avoid cross contamination of the piezometers or the observation wells.

Construction of Groundwater Contour Map:

The water-table contour map was constructed with Surfer8 software, after converting the depth to water into groundwater elevations measured above sea level. The conversion is done by subtracting the depth to water-level from the ground surface elevation. The surface elevation was obtained using the global positioning system (GPS).

Sodium Adsorption Ratio (SAR):

The suitability of groundwater for irrigation is governed by the chemical quality of the water, the soil type and the type of plant to be grown. The effects of salts on the soil results in changes in the soil texture, permeability and aeration which indirectly affect plant growth. The groundwater suitability for irrigation purpose was obtained based on Sodium Adsorption Ratio (SAR) using (Hem 1959) classification Formula given below.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Groundwater Chemistry

Groundwater moves from recharge zones to discharge area, as it moves it does interact with the soil and different geologic formations and the water chemistry changes. The measured total dissolved solids (TDS) of the samples at the lower groundwater level areas, such as Tandari, Anguwan Jigawa and Rigiyan Master (Fig. 2) shows a total dissolved solids (TDS) values of 409, 54 and 60 ppm Table 1, whereas areas around higher groundwater level such as Old prison and Anguwan Dole (Fig. 2) show total dissolved solids (TDS) values of 139 and 25 ppm respectively. The difference in the total dissolved solids (TDS) could explain the various interactions between the groundwater and the heterogeneous rocks of the study area. It is important to compare the results of the analysis with the Nigerian standards for drinking water by Standard Organization of Nigeria (SON 2007), to ascertain its quality for domestic purposes. The comparison shows that most of the pH measured falls outside the Nigerian standards recommended limits of 6.5 and 8.5 respectively. The Electrical Conductivity (EC) values falls within the recommended limit of 1000 µS/cm and the total dissolved solids TDS values also fall within the recommended limit of $\leq$ 500 mg/l. The hand-dug wells water samples results for major cations and anions are all within the Nigerian drinking water quality standard (SON 2007) see Table 3. The sodium adsorption ratio (SAR) for the 10 samples is presented in Table 2 which ranges from 0.20-4.38. These values are in conformity with the sodium adsorption ratio developed by (Hem 1959) shown in Table 4.

Table 2 reveals that the groundwater samples in the study area falls within an excellent class and low sodium water quality and thus very suitable for agricultural purposes.

Groundwater Flow Direction

The water-table contour map (Fig. 2) below was used to the determined the general flow direction of groundwater in the study area that is Potiskum town. Based on the water-table contour map constructed the groundwater flows towards the Central part of the town behind the Local Government Secretariat were the Rigiyan Master is located and also towards the Southwest to areas like Anguwan Jaji and Anguwan Jigawa respectively.

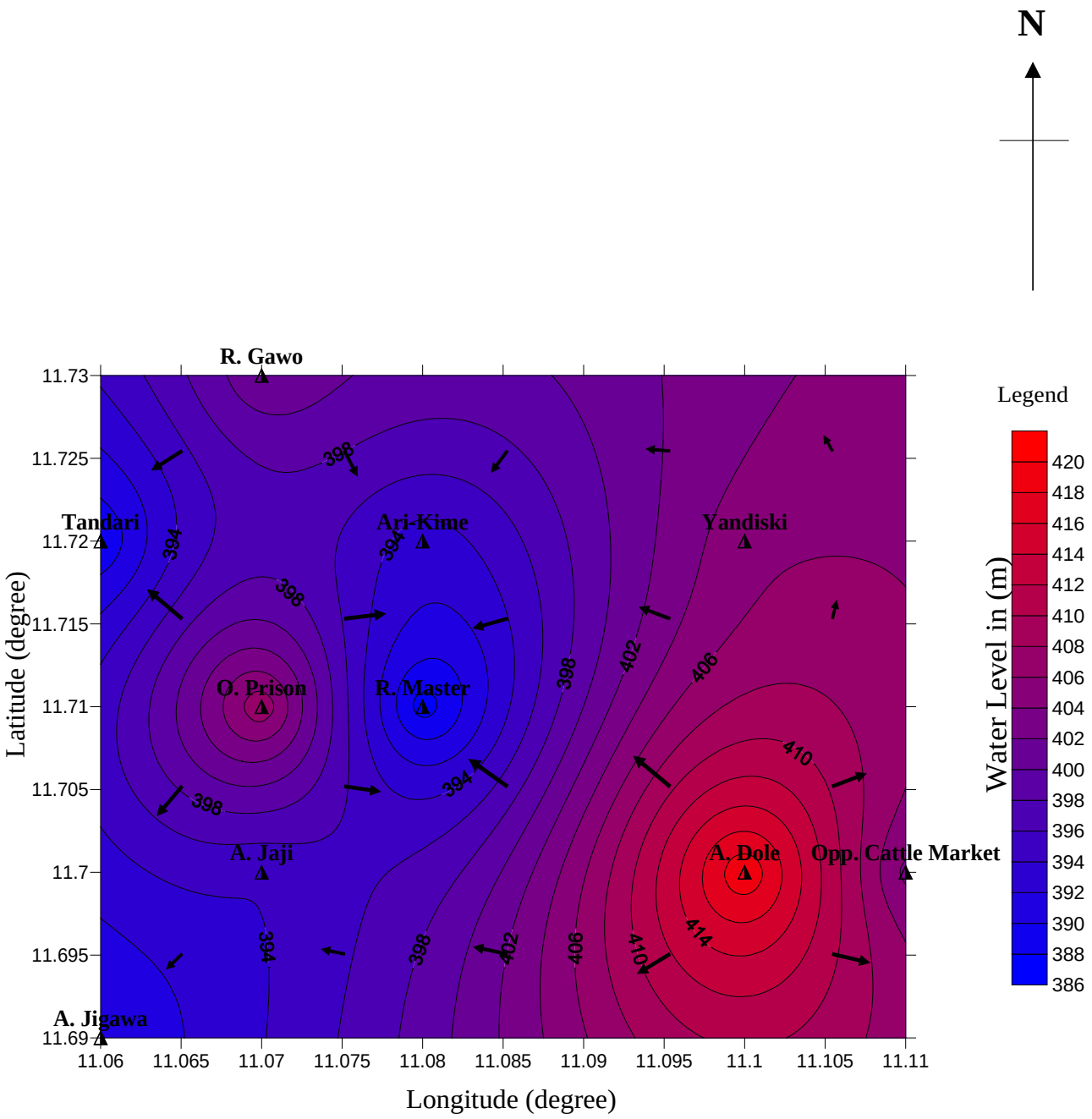

Fig. 2 POTISKUM TOWN WATER LEVEL CONTOUR MAP OF 2008

Groundwater Flow Direction

Conclusions

The Kerri-Kerri Formation aquifer is indeed shallower within the study area because the depth to water level ranges between 5-20m. The water-table contour map of the study area was constructed by subtracting the depth to water level from the ground surface elevation. The contour map was used to established the groundwater flow direction of the phreatic aquifer in the area towards the central part of the Potiskum like the Local Government Secretariat site and lastly towards the Southwest direction to areas of Anguwan Jaji and Anguwan Jigawa areas respectively.

The physico-chemical parameters water quality analysis proved to be safe for domestic consumption and drinking purposes as compared with the Standard Organization of Nigeria (SON) drinking quality water standards of 2007. The Sodium Adsorption Ratio (SAR) standards classification indicates an excellent class and low sodium water quality suitable for agricultural purposes.

Recommendations:

1) A routine water quality assessment of all the dug wells within the area should be carryout from time to time to ascertain possible changes in water quality.
2) Piezometers should be installed in some selected wells drilled for that purpose in order to keep a constant monitoring of the water level fluctuation in the area.
3) A campaign for awareness should be set in place to educate the rural poplars' the need for maintenance culture against possible pollution.
4) It is high time we should encourage the usage of our water quality standard by Standard Organization of Nigeria (SON) 2007.

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