The International Journal Of Engineering And Science (IJES)
|| Volume || 2 || Issue || 11 || Pages || 07-12 || 2013 ||
ISSN (e): 2319 – 1813 ISSN (p): 2319 – 1805

An assessment of groundwater potentials of the Central Area District and its environs, Federal Capital City, Abuja, Nigeria

[1]Abam, T.K.S and [2]Ngah, S. A.
[1, 2] Institute of Geosciences and Space Technology, Rivers State University of Science and Technology, Port Harcourt, Nigeria

ABSTRACT

The movement of administrative headquarters of Nigeria from Lagos to Abuja and return to civilian rule, under the bogus presidential system of government with retinue of political aids and associates resulted in unprecedented influx of people just as commercial activities sprang up to service the large population. Satellite towns and semi urban and rural settlements emerged. Water supply projections were overshot and supply became grossly inadequate. Residents particularly in the satellite towns have to source their water supply. Surface water sources are few and distant. Groundwater became attractive as the source for domestic water supply. This paper examines the groundwater potentials of the Federal Capital City, Abuja. Although the area situates on the basement complex, the occurrence of thick regolith comprising weathered basement which overlies a highly fractured basement combines with high rainfall to create large subsurface water reservoir into which precipitation drains. The regolith receives the rainfall and transmits it to storage sites formed by deep seated interconnected fractures. Thickness of weathered basement can be as high as 70m with an average of 30m. Local communities obtain their water supply from shallow hand dug wells lined with concrete rings and motorized boreholes are constructed in the metropolis. Yield of motorized boreholes are as high as 20m^3/hr – 40m^3/hr and depth to water level varies from 4m – 19m. The weathered basement has excellent water yielding properties but the water level is very responsive to seasonal changes. Conjunctive use of both surface and groundwater sources will ensure uninterrupted water supply to the Federal Capital City.

Key Words: Groundwater potentials, Federal Capital City, Nigeria

Date of Submission: 05 November 2013 ⟺ Date of Acceptance: 30 November 2013

I. INTRODUCTION

The new Federal Capital City (FCC) and its environs form part of the Federal Capital Territory (FCT) Abuja which has a total landmass of about 8000 km^2. The FCT is bounded by latitudes 8^{o}45'N and 9^{o}40'N and longitudes 6^{o}50'E and 8^{o}55'E (Fig. 1). However, the FCC study area lies between latitudes 9^{o}00'N and 9^{o}07'N and longitudes 7^{o}25'E and 7^{o}30'E (Fig. 2). The major establishments in the study area are aligned along the General Muhammed Buhari express Road that traverses the whole area. The geologic formation in the area comprises of basement complex rocks that formed prominent hilly physiographic features where gully erosion has formed deep valleys.

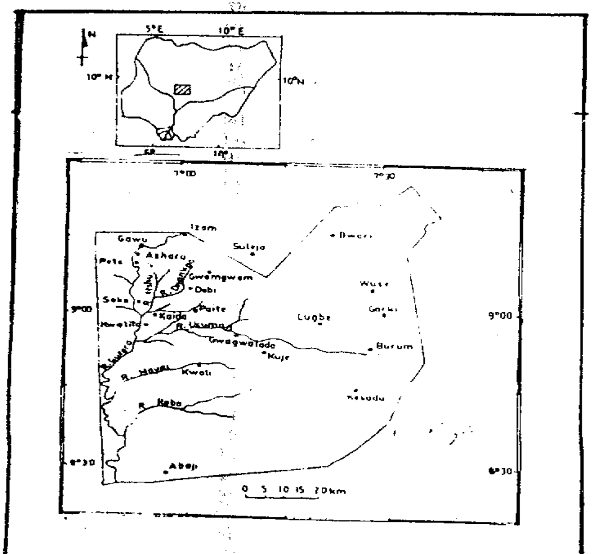

Fig. 1: Location of Study area Federal Capital Territory, (Abuja), Central Nigeria.

The people of the area have from time to time been faced with acute problem of water shortages as a result of rapid population growth, urbanization and the non-conventional scientific siting and development of boreholes that were not backed with any hydrogeological and geophysical studies. The gap therefore exists to identify and characterize the geologic structures and aquifer units in the study area that could define and control the groundwater and surface water resources of the area. Since the area comprises essentially of hard rocks, occurrence of groundwater will depend not only on the climate and physiography of the area but also on the existence of adequate proportion of geological structures favourable for housing and transmitting groundwater. An extensive review of the physiography and geology therefore becomes imperative.

II. PHYSIOGRAPHY, CLIMATE AND DRAINAGE

The area is characterized by hills and valleys that are fairly covered by vegetation and soil, though there are several areas where the bed rock outcrops. The topography is rugged and undulating with the basement rocks outcropping as hills and inselbergs. The Gwagwa plains occurring at the west of the FCT are underlain by migmatites and gneisses, and stand about 305m in the south-west and 516m in the east above mean sea level. These plains form part of River Usumanu that originates in the Bwari-Aso hills.

Abuja enjoys a tropical continental climate characterized by two distinct seasons; the dry and rainy seasons. The rainy season spans Mach/April to September/October, while the dry season extends from October to May. The mean annual rainfall is 1630mm, while temperatures vary from 22°C around December/January to 35°C in March/April. The weather conditions reflect the rugged nature of the area with the hills and inselbergs occasionally inducing orographic (relief) rainfall in their immediate vicinity. Vegetation is characterized by thorn bushes and trees, herbs, shrubs, and mango trees, the area being in Guinea Savanna Vegetation zone of Nigeria.

The drainage pattern generally varies from trellis to dendritic. The area is drained by many rivers in and around Abuja including Rivers Gwagwalada and Usmanu while Rivers Wupa, Wosika and other smaller seasonal southerly-flowing streams form the tributaries and drain the study area. These rivers depend on rainfall for their recharge. As such, their stages are high in rainy season and decrease appreciably in the dry season.

III. GEOLOGY AND STRUCTURES

The study area is located within the Central Nigeria Precambrian Basement Complex.The geology of the area has been studied and discussed by previous workers like Oyawoye (1972), McCurry (1976) etc,. They described the rocks as comprising mostly granite, gneisses, mica schists, hornblende and feldspathic schists and migmatites. The rocks are highly fractured and jointed showing essentially two fracture patterns, NE – SW and NW – SE. These fractures control the drainage and flow patterns of rivers in the area, (Fig. 2).

However, minor Cretaceous deposits of Nupe sandstones occur in the southern part of FCT between Kwali and Abaji, extending to Rubochi and the border with Nassarawa State. Similarly, metasediments have also been mapped along a general NNE-SSW direction through the west of Kusaki (in the south) and east of Takushara (in the north) (USGS 1977). Mica schists and amphibolite schists occur around Kusaki and Buze villages outside the study area.

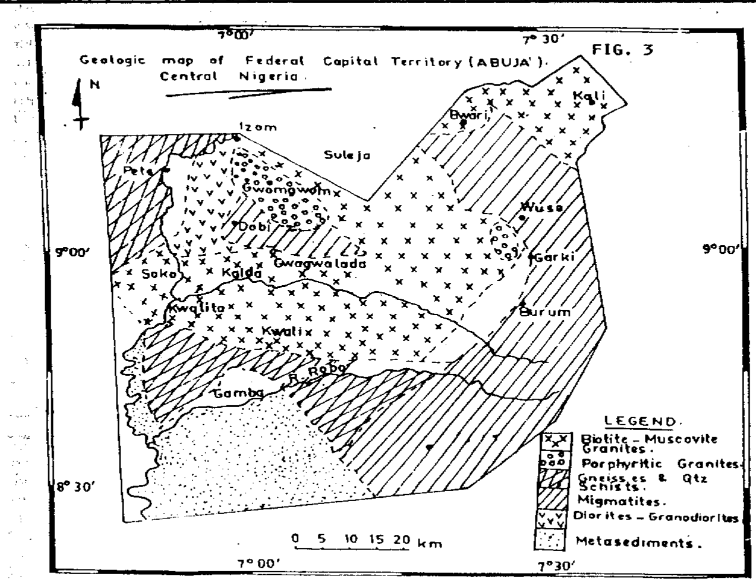

Fig. 3: Geologic map of Federal Capital Territory (Abuja), Central Nigeria.

The rocks comprise migmatites, migmatitic-gneisses, fine to medium grained gneisses, mica schist, calc-silicate rock, amphibolite, coarse grained older granites occasionally overlain by superficial deposits that include laterites, soils and alluvium deposits. The gneisses and migmatitic gneisses formed the bedrock at the low-lying areas while the migmatites occur as very large massive and well-formed hills with the gneisses occurring as cluster of elongated hills.

The migmatite constitutes about 35% of the study area outcropping in the SW part while the migmatitic gneiss occur in the central and eastern part constituting 40% of the area. The gneisses outcropping as fine to medium grained granite gneisses in the NE part cover about13% of the surface area, while the coarse grained Older Granites are exposed in the extreme NE corner where they constitute about 6% of the area forming small-sized residual hills with rounded tops.

Minor lithologies take up the remaining 1% of the surface area and include amphibolite and calc-silicate rocks as well as mica schist. The schists form rounded ridges and valley forms due to their low resistance to erosion (UNIFE, 1979). They are commonly seen to have weathered into reddish micaceous sandy clay capped by laterites and other superficial deposits such as alluvium deposits and soils. While the reddish brown laterites partially or completely overly and conceal other lithologic units, the alluvial deposits are found in river and stream channels in the area.

A general NNE-SSW orientation of lithological facies exist in the area apparently related to Pan-African orogeny. Similarly, there is the presence of dense fracture network which is the dominant structural control of groundwater occurrence in the area. The fractures take the form of cracks and tensional joints resulting from stresses occasioned by alternate heating-up and cooling of the rocks. Both horizontal and vertical joints are very common, with the width of the fractures generally decreasing with depth. Major NW-SE and NE-SW fault lines had been reported by Avci (1983). The fractures increase the hydrologic significance of the basement rocks by providing the necessary porosity and permeability; factors necessary for the occurrence and movement of groundwater in subsurface environments. Porosity receives the precipitation and provides storage sites while permeability enables the transmission of water thereby fulfilling the two primary functions of an aquifer; storage and conduit functions.

IV. HYDROGEOLOGY

The water resources of the area comprise both the surface and groundwater sources including the streams and rivers that occur in the sloppy terrains in the south. Lower Usumanu and Jabi dams which supply water to the Federal Capital Territory, Abuja are located in the area.

The groundwater component of the water resources of the area are contained in the aquifers and basement rocks. Hydrogeologically, two types of aquifers are recognized namely, the regolith or weathered basement aquifers and the fractured zone aquifers. Therefore geology and climate are the limiting factors of groundwater occurrence in hard rocks. Fortunately there exists in the area a thick loose and discontinuous blanket of decayed and decaying rock debris (regolith). A combination of thick regolith and high rainfall and favourable temperature pattern in the FCT offers a conducive condition for occurrence of groundwater. The decayed/decaying and fresh rock fragments lie on top of, below and adjacent one another in an irregular manner creating intergranular spaces between rock fragments lying together. Precipitation introduces water into the regolith through the usually numerous porespaces. The regolith therefore acts as a storage medium for water from rainfall and can also transmit water vertically and horizontally to underlying rocks. If the underlying bed rock has high fracture density, regolith can serve to transmit water to underlying bedrock storage sites.

The occurrence of the groundwater is a function of the overburden thickness, the type, composition and texture of rock fragments that constitute the overburden and the degree density and interconnections of the fractures. The overburden aquifers occur extensively and receive recharge directly from rainfall. Some measure of artificial recharge come from the Lower Usumanu and Jabi dams. Villagers extract the groundwater from the overburden through hand-dug wells. Most of the boreholes are located on the overburden aquifer and have shown the depths to bedrock to vary from 0m (where the bedrock outcrops) to about 73m with an average of 30m. The direction of groundwater flow is generally downhill converging in the valleys and river channels.

Depths to water table vary from place to place (Table 2) with the water level rising during the rainy season and falling during the dry season resulting in seasonal fluctuation in the actual volume of water in storage.

The various aquifer parameters obtained from developed boreholes sited in adjacent areas show that the area has low to moderate water yielding properties (maximum $18m^3/hr$) The yields of boreholes vary from one rock type to another. For instance yields are generally lower in parts of Garki, Wuse and Maitama where migmatites and schist are dominant compared to areas with granites and granite gneisses. Wherever the weathered basement is deep and underlain by highly fractured bedrock, borehole yields are generally high. For instance, resistivity surveys (vertical electrical sounding) carried out at a location at the Presidential Palace and another at the Nicon Noga Hilton Hotel revealed the existence of deep fracture systems below the overburden. Boreholes drilled and completed into these deep fractured basement rocks have depths of 100m each and yielded 40m3/hr and 21.6m3/hr respectively with drawdowns of 26.5m and 46.5m respectively after 120 minutes of pumping (Offodile, 1983).

Table 1. Location, depths of boreholes and static water tables in some boreholes within F.C.T. Abuja (D.R.D., 1989)

S.No.	Location	Total Depth (m)	Static water level (m)
1.	Kwali	47.0	4.0
2.	Dobi	70.0	6.7
3.	Agyana	42.2	19.0
4.	Paikon Kore	70.0	3.6
5.	Anagada	72.0	3.1
6.	Zuba	70.0	2.0
7.	Jiwa	70.0	10.7
8.	Gwagwa	70.0	3.2
9.	Tungan Maje	70.0	3.2
10.		69.0	3.1
11.	Abaji I	47.0	4.0
12.	Garki Central Area I	70.0	6.7
13.	Garki Central Area II	42.2	19.0
14.	Asokoro	70.0	3.6
15.	Bwari	72.0	3.1
16.	Garki	70.0	2.0
17.	Garki	70.0	10.7
18.	Abaji	70.0	3.2
19.	Atako	70.0	3.2
20.	Central Area	69.0	7.1

V. GROUNDWATER QUALITY

Etu-Efeotor (1998) undertook an evaluation of hydrogeochemical properties of surface and groundwater in the study area and compared the values of the physic-chemical parameters with WHO standards for drinking water supplies, (Table 4).

Table 2. Hydrogeo-chemical data of ground water from Central Nigeria (Etu-Efeotor 1998)

Geochemical parameter	Dobi	Gwagwalada Specialist Hospital	Nija	Uni-ABUJA	Paiko -1	Paiko -2	Izom	WHO
Appeareance	Clear	Clear	Clear	Clear	Clear	Clear	Clear	clear
Colour (Hazen units)	2	1.0	1.0	2	3	2	2	5
Odour	-	-	-	-	-	-	-	No odour
Turbidity (NTU)	0.45	0.64	0.82	0.56	0.52	0.78	0.48	5
Ph	7.1	7.1	7.40	7.2	7.1	7.2	6.7	7.0-8.0
Conductivity (µScm^{-1})	354	106.6	495	110.8	246.0	868	98.7	-
Alkalinity mg/1	95.2	-	123.4	-	101.4	97.4	-	50-100
Hardness mg/1	93.7	76.6	114.3	80.8	84.5	72.6	92.1	100
B.O.D. mg/1	-	-	-	-	-	-	-	-
Calcium (Ca++) mg/1	5.90	9.80	16.50	7.40	4.60	8.40	12.85	72-200
Magnesium (Mg^{2+}) mg/1	0.20	0.42	1.80	0.86	0.70	1.10	1.24	30
Sodium (Na^+) mg/1	3.50	8.2	11.40	6.5	5.60	3.20	10.2	-
Potassium (K^+) mg/1	2.20	1.08	3.60	0.96	2.50	1.60	0.68	-
Zinc (Zn^{++}) mg/1	-	-	0.02	-	-	-	-	5.0
Copper (Cu^{++}) mg/1	-	-	0.02	-	0.10	0.08	-	1.0
Total Iron (Fe^{2+}. Fe^{3+}) mg/1	0.5	0.4	0.5	0.5	0.4	0.3	0.5	0.3-1.0
Carbonate (CO_3^{2-}) mg/1	-	-	-	-	-	-	-	-
Bicarbonate (HCO_3^-) mg/1	85.4	74.3	90.6	86.1	84.6	70.2	84.2	-
Chloride (Cl^-) mg/1	22.6	21.6	28.6	22.0	20.4	22.5	26.5	200
Sulfate (SO_4^{2-}) mg/1	9.26	10.16	11.8	9.04	8.1	7.7	8.8	200
Nitrate (NO^{3-}) mg/1	-	-	-	-	-	-	-	50
Phosphate (PO_4^{2-}) mg/1	-	-	-	-	-	-	-	-
Suspended Solids mg/1	0.52	0.31	0.24	0.46	0.61	0.80	0.68	500
Dissolved Solids mg/1	213	276.6	306.8	230.2	198.6	206.4	284.8	500
Lead (Pb)								0.05
Selenium (se)								0.01
Arsenic (As)								0.05
Chromium (Cr)								0.05
Cyanide (CN)								0.02
Cadmium (Cd)								0.01

His work shows that basement geology played a domineering role in the chemistry of groundwater in the area. The order of dominance of major cations in groundwater is as follows: Ca>Na >K>Mg and for anions, HCO_3^->Cl^->SO_4^{2-}. The sequence is believed to be related to the basement geology as the boreholes were drilled in area dominated by granites, and feldspathic quartz schists which will normally yield more Na and K than Mg. Generally, the groundwater is adjudged potable except for slightly elevated values for iron.

VI. CONCLUSIONS

The Federal Capital City (FCC) is underlain by crystalline basement rocks that consist of migmatites, gneisses and granites. Surface outcrops of these rocks are seen to be highly fractured. Fracture density is high and the fractures are highly interconnected although fracture widths tend to reduce with depth. Elsewhere, the area is overlain by thick regolith comprising decayed and decaying rock fragments which are loosely arranged creating large and numerous porespaces that permit easy infiltration of rainfall. They are capped at some places by laterites and other superficial deposits. High rainfall prevalent in the area furnishes water to the regolith which is believed to serve to store and transmit infiltrating rain water into deeper basement storage sites provided by the dense fracture networks. Additional recharge also comes from Lower Usmanu and Jabi dams. The combined thickness of the resulting aquifer (regolith and the fractured basement) can be as high as 70m. The local communities obtain their water supply via hand dug wells lined with concrete rings to prevent collapse. In the metropolis, boreholes are drilled and completed into the fractured bedrock using motorized rigs. Yields of the boreholes vary but can be as high as $20m^3$/hr – $40m^3$/hr. Climatic factors such as temperature and rainfall play significant role as water level fluctuations occur in dry and rainy season. Not minding that the area is basically a bed rock area, prospect for water supply using groundwater as a source is high. However a conjunctive use of both surface and groundwater sources will ensure uninterrupted water supply to the Federal Capital City.

REFERENCES

[1.] Avci, M., (1983). Photogeology and Structural interpretation of the Southern section of the New Federal Capital City site, Abuja, Nigeria. Nig. J. Min. Geol., 20 (1&2), 51-56.
[2.] D.R.D. (1989). Department of Rural Development, Ministry for the Federal Capital Territory, DFRRI Water Borehole Projects, Abuja.
[3.] Etu-Efeotor, J.O. (1998). Hydrochemical Analysis of Surface and Groundwaters of Gwagwalada Area of Central Nigeria. Global Jl Pure and Applied Sciences Vol. 4 No 2
[4.] Federal Ministry of Water Resources of Nigeria, (1978). Pre-drilling Hydrogeological Investigation of Area I-Final Design.
[5.] McCurry, P. (1976). The geology of the Precambrian to Lower Paleozoic rocks of Northern Nigeria. In C.A. Kogbe (Ed). Geology of Nigeria. Elizabethab Press. Lagos. pp 15-39
[6.] Offodile, M.E., 1983. The occurrence and Exploitation of groundwater in Nigerian Basement rocks. Nig. J. Min. Geol., 20 (1& 2): 131-146.
[7.] Oyawoye, M.O. (1972). The Basement Complex of Nigeria (In) African Geology (T.F.J. Dessauvagie and A. J. Whiteman, Eds. Ibadan Univ. Press pp 67-99
[8.] UNIFE (1979). Geology and Engineering Geology of the Federal Capital City Site. University of Ife, Nigeria.
[9.] USGS (1977). Preliminary Engineering Geologic Report on selection of Urban sites in the Federal Capital Territory, Nigeria. Project Report Nigerian Investigations (IR N-1.
[10.] WHO (1984). Guidelines for Drinking Water Quality. World Water 1988.