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Research Article

GROUNDWATER EXLPORATION AND ASSESSMENT IN PARTS OF BANSARA AREA BASEMENT COMPLEX OF SOUTHEASTERN NIGERIA

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ABSTRACT

The quantity and quality potentials of groundwater in parts of Bansara and its environs have been carried out. Vertical Electrical Sounding (VES) using Schlumberger array were used to detect depth to the basement. The migmatitic gneiss of granodiorite composition at Katchuan were fractured while the granite with pegmatite at Isobens were less fractured. Water samples were obtained from some boreholes out of the seventeen boreholes drilled and analysed for some physio-chemical and bacteriological composition. The cations like magnesium and calcium indicated increases while the total hardness was very high at Katchuan. At Isobens, the two cations indicated increases while iron and total hardness were more than two times the recommended limit by World Health Organization (WHO) standard. The anions were within the recommended limit. The bacteriological composition shows that the water in the area is contaminated with pathogenic bacteria and must be treated from source before use.

Keywords: Groundwater, VES, rock type, water quantity/quality, Bansara, SE Nigeria.

INTRODUCTION

Groundwater found in the zone of saturation usually an aquifer is a material that undergoes natural filtration as it passes through the soil. As water infiltrates through soils and rocks, it dissolves the soluble minerals of these materials into the groundwater system. Hence it is always important to access the levels of these dissolved constituents and compare them with the internationally acceptable standards. This helps to access the portability of water for its various uses. The study area is located at Katchuan and Bansan Isobens in Boki Local Government Area of Cross River State. It is located between latitude 06° 13′ to 06° 28′ N and longitude 08° 49′ to 08° 53′ E. The area is accessible by road from Ikom – Ogoja road through Okundi – Bansan – Nsedup – Iso Bendiga – and Okundi – Okubuchi – Katchuan - Bikpor (Figs. 1 and 2). The area falls within the sub-equatorial rain forest zone. According to Iloeje (1972), the area is characterized by two seasons (dry and rain). The area is covered by thick forest canopy vegetation which holds an 88.7 km^2 wild life sanctuary. In this contribution, we present report on the lithology of near surface inhomogeneity and groundwater quality in parts of Bansara and its environs to determine its suitability for domestic and industrial purposes and also document the hydrogeology of the area.

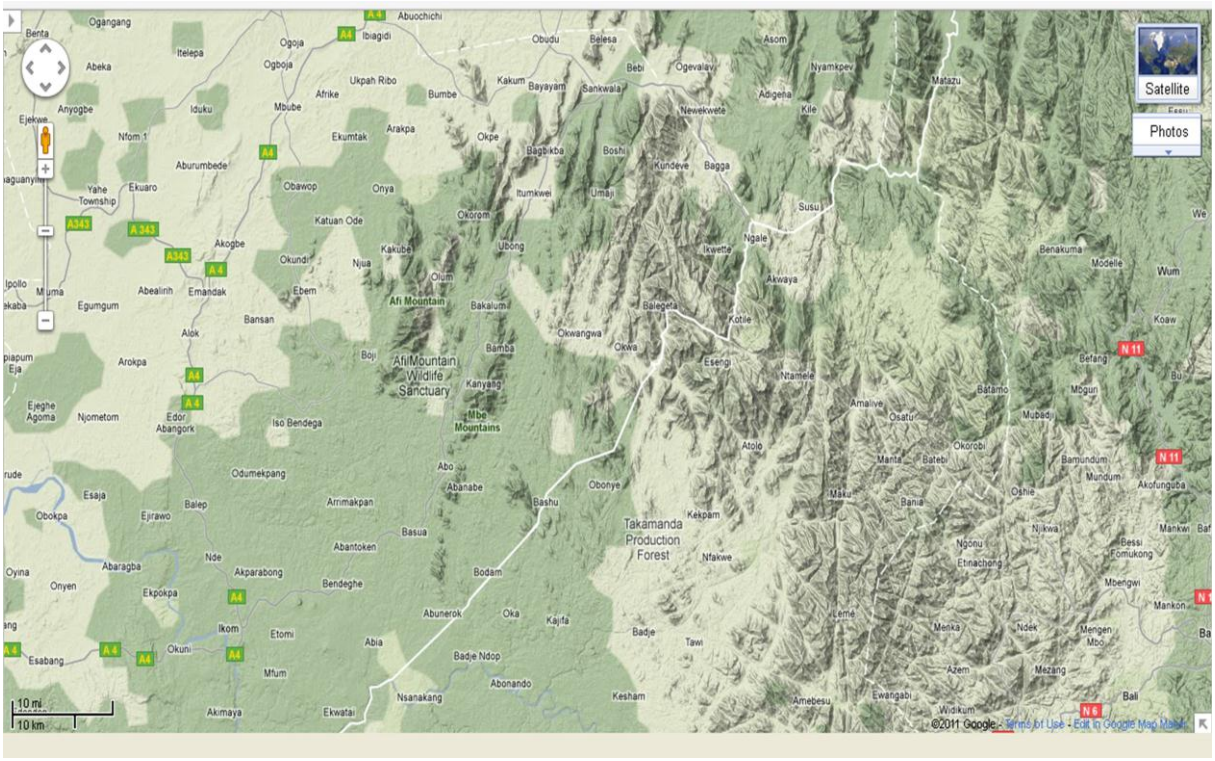
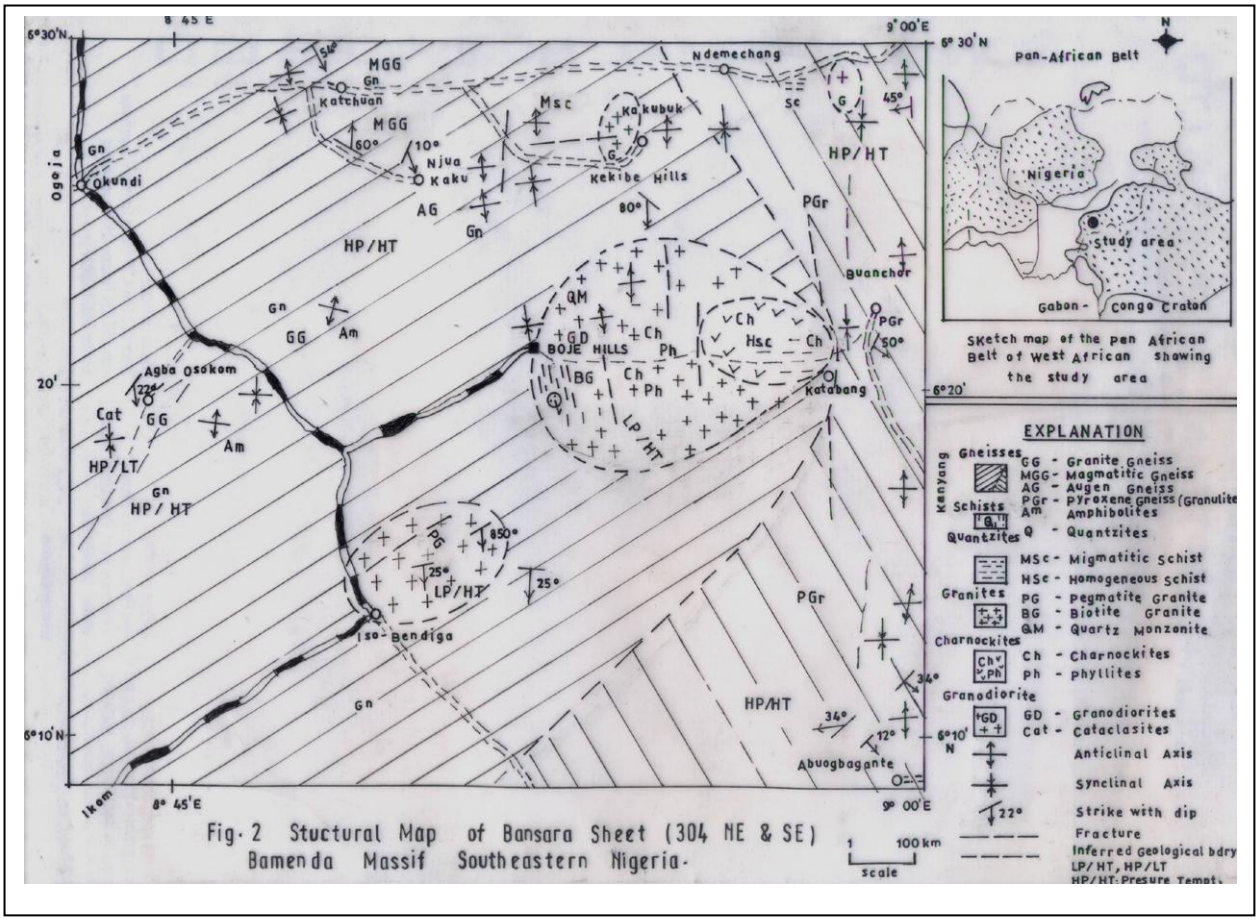


Figure 1b Remote sensed map of study area showing fractures which increases from the west to east. (Source Google Earth 2011)



Geological Setting

The geology of the area has received little attention. The Geological Survey of Nigeria (GSN) in the 1974 edition described the area as undifferentiated basement and in (2006) as granullite terrain. The study area is within the Southeast hydrogeological province of Nigeria/Cross River Basin Development Authority (Egboka, 1988). Other previous works on the geology of the study area are only available on regional basis such as; Regional aeromagnetic study of Oban and Obudu Precambrian Massifs (Iliya and Bassey (1993). Lineament analysis for groundwater exploration in the Precambrian Oban Massif and Obudu Plateau (Edet et al., 1994) and Ekwueme, (2003) The Precambrian Geology and Evolution of the southeastern Nigerian Basement Complex. The magnetic analysis result indicates preponderance of NE trending anomalies while the lineament analysis result showed that high lineament densities are mapped in areas of outcropping bedrock and thin overburden. Recently, Faculty and students of Geology, University of Port Harcourt, Port Harcourt started intensive mapping in the area. A detail report on the geology of the area can be found in Egesi and Ukaebgu (2010a,b and 2011). The rock units are granite with pegmatites, quartz monzonite, granodiorites,

quartz diorites, charnockites, granite gneisses, migmatitic gneisses, migmatitic schists and quartzites. The area is characterized by undulating topography, which has a relationship to its geology. Several streams flow from the highlands to the valleys trending N – S to NE – SW directions which indicate they are structurally controlled with a dendritic pattern of flow into Afi river, which is one of the sources of Cross River. Bansan Isobens area is underlain by granite with pegmatite while the Katchuan Irruan is underlain by migmatite of granodioritic composition.

MATERIALS AND METHODS

Global Positioning System (GPS) was employed for elevation and location of coordinates. The samples were put in suitable containers was labeled for easy identification. A total of five Vertical Electric Soundings (VES) were carried out to locate and drill boreholes. Water samples were collected from the two boreholes for physical, chemical and bacteriological analysis in Bansara area of Boki Local Government. The petrography of the rocks shows pegmatitic granite and migmatitic gneiss of granodiortic composition. The modal composition of the rocks are shown on Table 1.

Mineral	**Migmatitic Gneiss**	**Granite with Pegmatite**
Quartz	25	30
K-spar	20	29
Plagioclase	22	15
Biotite	10	8
Muscovite	5	7
Chlorite	-	-
Hornblende	6	-
Ortho-pyroxene	-	-
Clino-pyroxene	-	-
Garnet	8	-
Olivine	-	-
Kyanite	-	-
Sillimanite	-	-
Myrme kite	-	7
Perthite	2	<1
Opaque minerals	2	3

Table 1: Modal compositions of rocks in the Katchuan and Bansan Isobendege area

As a result of borehole failures in the basement complex terrain, geophysical method of groundwater investigation was adopted with the main objective of sustainable production of adequate water supply. Resistivity method is best suited for the problem where groundwater is involved such as locating water bearing horizon. Four electrodes array are generally used at surface, one pair for introducing current into the earth, the other pair for measuring the potential associated with current.

RESULTS AND DISCUSSION

The results of the VES carried out in Katchuan are shown in Table 2, while that of Bansan Isobens is shown in and Table 3. The lithology of the borehole at Katchuan indicate brownish lateritic sandy clay, 0-3m, light brownish clay 3-23m, brownish micaceous clay 23-25m, greyish slightly weathered migmatite 25-35m, hard greyish migmatite grades into fresh rock 35-45m. Water was struck at 23-24m and the rock fractured at 34-35m. The Bansan Isobens lithology shows reddish brown lateritic sandy clay 0-3m, brownish silty clay 4-6m, highly weathered brownish granite 6-9m, minor fractured brownish granite 9-13m, very hard greyish granite 13-21m, fairly weathered dark brownish granite 21-22m, major fractured dark grayish porphyritic granite 22-28m, very hard dark grayish porphyritic granite 28-29m, hard dark greyish granite (fresh rock) 29-40m. The drilling was terminated due to low rate of penetration, water was struck at 6-7m, 21-22m and 28-29m.

	Thickness of layer (m)	Resistivity (Ohm-m)
Station No.	1 2 3 4 5 6	1 2 3 4 5 6
VES1	1.00 1.50 2.00 15.00 30.00	650 290 400 1200 120.0 1000
VES2	1.00 1.50 2.00 15.00 30.00	15001400 400 1300 135.0 1000

Table 2: Katchuan VES 1 and 2. Summary of the results of the interpretation

	Thickness of layer (m)	Resistivity (Ohm-m)
Station No.	1 2 3 4 5	1 2 3 4 5
VES1	1.00 2.00 5.00 20.0	1000 400 650 500 2000
VES2	1.00 2.00 5.00 10.0	480 900 900 1200 1300
VES3	1.00 2.00 4.00 12.0	280 200 150 750 1500

Table 3: Bansan Isobens VES1, 2 and 3. Summary of the results of the interpretation

Five Vertical Electrical Soundings (VES) were carried out at Bansara and its environs namely Katchuan and Bansan Isobens using Schlumberger electrical configuration with maximum electrode separation of 100m. The current and potential electrodes were iron stakes. A digital self-averaging resistivity meter ABEM Terrameter SAS 1000 series was used for the data acquisition. Some of the special factors of the equipment include; its ability to display apparent resistivity, self potential and chargeability value directly on the screen, its portability to automatically compensate for polarization at the electrodes, induced polarization of the material and instrumental drift effects.

DISCUSSION

Various curve types were obtained from the quantitative interpretation because the first step in interpretation is plotting (Parasnis, 1997). The result of the interpretation for Katchuan shows that VES 1 and VES 2 has five geoelectric layers with low and high resistivities VES 1 $\rho1 > \rho2 < \rho3 < \rho4\rho > \rho5 < \rho6$ while VES 2 $\rho1 > \rho2 > \rho3 < \rho4 > \rho5 < \rho6$ with the resistivity of the sixth layer tending to very high value which is probably the basement.

The sounding at Bansan Isobens VES2 provides the most useful information among all the sounding because resistivity increases with depth, which is nearly linear. The fifth geoelectric layer in Katchuan has a depth of 30.0m and resistivity value of 120 – 135 Ohm-m is the productive layer while at Isobens the productive layer is the fourth for VES1 and third for VES2 and VES3, having 500 Ohm-m, 900 Ohm-m and 150 Ohm-m respectively. The pumping rate is 1.58 l/s, total discharge is $1.36m^3/d$, transmissivity is $1.67m^2/d$ at Isobens while 2.0l/s, $172.80m^3/d$, $1.98m^2/d$ respectively, was recorded at Katchuan. The well yield is high to very high and successful. Okereke et al., (1995) noted that successful boreholes with adequate yields of 1.4 to 6.7 l/s have been drilled into unconfined acquiferous overburden in the highlands of basement complex in Oban massif and Obudu Plateau.

Water Quality:

The physical, chemical and bacteriological characteristics of water define its quality (Todd, 1980). The natural quality of water is the quality of the water present in various rock terrain. A study of the physical, chemical, and bacteriological composition is equally as important as that of its quantity, storage, movement and recharge. The physical properties include colour, taste, odour, turbidity, pH, electrical conductivity, total dissolved solids, temperature. At Katchuan, the magnesium hardness is high, calcium hardness is high, phosphate is slightly high while total hardness is very hard Table 2. The borehole at Bansan Isobens is characterized by over two times high iron concentration, very hard and contaminated with pathogenic bacteria Table 3. The water should be disinfected before use.

Table 2: Laboratory report of physic-chemical/bacteriological examination of borehole

Location: Katchuan Irruan

Local Government Area: Boki

Date of Analysis: 20/11/15

Total Depth: 45.47m Static Water Level: 6.57m

	PARAMETERS	UNIT	NDWQS/W.H.O STANDARD	TEST RESULT	HEALTH IMPACT
1	Taste	Mg/l	Unobjectionable	Unobjectionable	
2	Odour		Unobjectionable	Unobjectionable	
3	pH		6.5-8.5	7.1	
4	Temperature ^{0}C	^{0}C	Ambient	19.4	
5	Colour (Platinum-Cobalt) scale	Pt-Co	<5	0.0	
6	Turbidity (Formazin Turbidity Unit)	FTU	<5	0.0	
7	Conductivity mS/cm	mS/cm	1000	0.46	
8	Calcium mg/lCa^{2+}	mg/l	200	39.2	
9	Magnesium mg/Na^{+}	mg/l	150	33.5	
10	Sodium mg/lNa	mg/l	200		
11	Potassium mg/lK^{+}	mg/l	10-12	0.0	
12	Sulphate mg/lSO^{2-}_{4}	mg/l	400	0.0	
13	Chloride mg/lCL^{-}	mg/l	250	3.0	
14	Magnesium hardness mg/l	mg/l	100	138	High
15	Total Alkalinity mg/l	mg/l	100		
16	Calcium Hardness mg/l	mg/l	50	98	High
17	Nitrite mg/lNO_2^{-}	mg/l	0.2	0.02	
18	Nitrate mg/lNO_3^{-}	mg/l	50	9.3	
19	Ammonia mg/lNH_3	mg/l		0	
20	Ammonium mg/lNH_4^{+}	mg/l		0	
21	Phosphate mg/lPO_4^{3-}	mg/l	3.5	0.36	High
22	Fluoride mg/lF^{-}	mg/l	1.5	0.07	
23	Chlorine mg/lCl_2	mg/l	0.5	0.0	
24	Iron mg/lFe	mg/l	0.3	0.0	
25	Manganese mg/lMn^{2+}	mg/l	0.1	0.0	
26	Copper mg/lCu^{2+}	mg/l	1	0.0	
27	Arsenic ug/lAS	ug/l	10	0	
28	Lead ug/lPb^{2+}	ug/l	10	0	

29	Aluminium mg/lAL^{3+}	mg/l	0.2		
30	Total Hardness mg/l	mg/l	150	236	V. hard
31	Salinity mg/l NaCl	mg/l	100	4.95	
32	Total Dissolved Solids g/l (TDS)	g/l	500	0.23	
33	Total Suspended Solids mg/l (TSS)	mg/l	0	0	
34	Feacal Coliforms/100ml of H_2O	CFU/100	0	0	Safe
35	Total Coliforms/100ml of H_2O	CFU/100	0	0	Safe

Remarks: Borehole though very hard is acceptable since hardness is known to be good for the heart.

Table 3: Laboratory report of physic-chemical/bacteriological examination of borehole

Location: Basan Isobendege

Local Government Area: Boki

Date of Analysis: 20/11/15

Total Depth: 40.85m Static Water Level: 6m

S/NO	PARAMETERS	UNIT	NDWQS/W.H.O STANDARD	TEST RESULT	HEALTH IMPACT
1	Taste	Mg/l	Unobjectionable	Unobjectionable	
2	Odour		Unobjectionable	Unobjectionable	
3	pH		6.5-8.5	6.8	
4	Temperature ^0C	^0C	Ambient	19.3	
5	Colour (Platinum-Cobalt) scale	Pt-Co	<5	0.0	
6	Turbidity (Formazin Turbidity Unit)	FTU	<5	0.0	
7	Conductivity mS/cm	mS/cm	1000	0.45	
8	Calcium mg/lCa^{2+}	mg/l	200	57.6	
9	Magnesium mg/Na^+	mg/l	150	45.2	
10	Sodium mg/lNa	mg/l	200		
11	Potassium mg/lK^+	mg/l	10-12	0.0	
12	Sulphate mg/lSO^{2-}_4	mg/l	400	4.0	
13	Chloride mg/lCL^-	mg/l	250	12.0	
14	Magnesium hardness mg/l	mg/l	100	186	
15	Total Alkalinity mg/l	mg/l	100		
16	Calcium Hardness mg/l	mg/l	50	144	
17	Nitrite mg/lNO_2^-	mg/l	0.2	0.02	
18	Nitrate mg/lNO_3^-	mg/l	50	10.3	
19	Ammonia mg/lNH_3	mg/l		0.19	

20	Ammonium mg/lNH_4^+	mg/l		0	
21	Phosphate mg/lPO_4^{3-}	mg/l	3.5	0	
22	Fluoride mg/lF^-	mg/l	1.5	0.07	
23	Chlorine mg/lCl_2	mg/l	0.5	0.3	
24	Iron mg/lFe	mg/l	0.3	0.61	High
25	Manganese mg/lMn^{2+}	mg/l	0.1	0.0	
26	Copper mg/lCu^{2+}	mg/l	1	0.9	
27	Arsenic ug/lAS	ug/l	10	0.0	
28	Lead ug/lPb^{2+}	ug/l	10	0	
29	Aluminium mg/lAL^{3+}	mg/l	0.2		
30	Total Hardness mg/l	mg/l	150	330	V. hard
31	Salinity mg/l NaCl	mg/l	100	19.8	
32	Total Dissolved Solids g/l (TDS)	g/l	500	0.23	
33	Total Suspended Solids mg/l (TSS)	mg/l	0	0.0	
34	Feacal Coliforms/100ml of H_2O	CFU/100	0	7	Contaminated
35	Total Coliforms/100ml of H_2O	CFU/100	0	19	Contaminated

Remarks: The Borehole characterized by high iron content, very hard, Feacal Coliforms and Total Coliforms are high the water is contaminated not safe for drinking, chlorination is necessary before use.

CONCLUSIONS

The results of the interpretation of the soundings have offered an opportunity to know the possible aquiferous zones within the Basement rocks of Boki area. The depths and thickness of aquifers varies from the granite at Bansan Isobens to migmatitic gneiss at Katchuan rocks with the former at about 6m while the later at 30.0m. Water sampling and testing for geochemical and bacteriological data should be on a continuous basis to check increasing incidence of pollution and consequent outbreaks of epidemics. In particular, bacteriological tests should be done as there is contamination of the water with pathogenic bacteria. Such tests in the Bansan Isobens area is very necessary. The shallow thickness of the lateritic deposit/overburden 6m and relatively high population at Isobens, while Katchuan is relatively deep at 30m, may be responsible for the contamination of water with feacal coliforms and total coliforms.

Data on hydrological/hydrogeological information should be documented and kept in an easily accessible areas as research is greatly hampered by either the complete absence of hydrological/hydrogeological information or incomplete/inconsistent or non-existent data. The United Nations International Children's Education Fund (UNICEF), assisted rural water supply programme

international best practices in provision of water in remote areas of Boki is acknowlegded, similarly Cross River State Rural Water Supply and Sanitation Agency (RUWATSSA) made data available, although data in some locations are not available particularly paste water analysis for bacteriological test and water quality analysis which is very important.

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