Journal of Mining and Geology Vol. 59(1) 2023. pp. 49 - 57 0022-2763
© Nigerian Mining and Geosciences Society (NMGS) - Printed in Nigeria.

Geo-Electric Response of Earth Materials Between Some Soak Away Pits and Hand Dug Wells at Legislative Quarters Jos, Plateau State

Maduka, C.R. and Akanbi, E.S.
Department of Physics, University of Jos, Jos, Nigeria.
Corresponding E-mail: **rosechinwa15@gmail.com**

Abstract
Legislative Quarters, Jos, Plateau state is predominantly occupied by families and students and has most of its water sources (hand dug wells) close to soak away pits. This contravenes the World Health Organization (WHO) recommended safe distance of 30m and above for construction of soak away pits in areas with ground water sources like wells and boreholes. Vertical Electrical Sounding (VES) field procedure of Electrical Resistivity method was deployed to investigate the geoelectric response of earth materials between some soak away pits and hand dug wells in legislative quarters Jos, Plateau state. Also, physiochemical and microbial analysis were also carried out on the well water sample collected from the study area. VES was carried out using the half-Schlumberger configuration and an Ohmega resistivity meter. The soundings were carried out along a traverse with two soak away pits and two wells located at various points along the traverse. Two soundings were taken between the first soak away pit and first well which were about 7m apart. Three soundings were taken between the first well and second well which were about 19m apart while the last two soundings were taken between the second well and the last soak away pit which were 14.4m apart. IX1D software was used for the interpretation of seven VES points so as to determine the subsurface layer parameters (resistivity, depth and thickness). For the physiochemical analysis, pH and electrical conductivity of the water sample was determined using pH and conductivity meters respectively. Microbial analysis of water sample was carried out using the method of serial dilution using petri dishes, test tubes, pipettes, nutrient agar (NA), saline, inoculating needle and filter paper. The quantitative interpretation of the VES points revealed some layers of very low resistivity values which depict contamination suspected to be effluents from the soak away pits. These zones are found in VES 2, VES 6, and VES 7 with resistivity values of 6.41Ωm, 16.21Ωm and 14.29Ωm to the depths of 2.68m,1.46m and 2.13m respectively. A pH value of 5.09 which is below the WHO specification for drinking water was obtained. The microbial analysis revealed that the water collected from the well about 7m from the soak away contained coliform at a count of 9.0 X 10^4 ml and also microorganisms like Streptococcus, faecalis, proteus spp and salmonella typhi were observed to be present in the water showing that the water is contaminated and hence the need to be treated for human consumption.

Keywords: *Half -Schlumberger, Contamination, Sounding, Soak away, Effluents, Legislative quarters*

Introduction

Water is a natural resource that plays a very important role in the existence of plants and animals. Accessibility and availability of fresh clean water does not only play a crucial role in economic development and social welfare, but also, it is an essential element in health, food production and poverty reduction (Ashbolt et al., 2001). Groundwater is one of the world's most abundant and vulnerable natural resource (Eze and Eze, 2015). Groundwater is particularly important as it accounts for about 88% of man's safe drinking water (Kumar, 2004).

The potability of ground water can be contaminated by leachate from dumpsites, salt intrusion, oil spillage, mining activities, sewage (from latrines, underlined petroleum pipes and septic tanks) (Makeig, 1982). Dumpsite and latrines are sited without considering the hydrogeological settings of the area, thereby rendering the future of ground water at risk (Ugbaja and Edet, 2004). Aquifer protection is essential for sustainable use of the ground water resources, protection of the dependent ecosystems and a central part of spatial planning and action plans (Egbai et al., 2015). Subsurface sewage disposal are the largest sources of waste water to the ground and are the most frequently reported cases of ground water contamination (Miller,1980). Contaminants are carried into aquifers through dispersion and advection (Emongor et al.,2005). The rate of groundwater contamination depends on permeability, porosity, and overburden thickness of geologic formations (Obiora et al., 2015). When the underlying geologic material such as coarse sand is unconsolidated and uncompacted, the polluting influents are capable of escaping into the subsurface to contaminate ground water, rendering the soil corrosive and forming a polluting plume that extends hundreds of meters (Keswick et al., 1982).

Geophysical methods particularly Electrical Resistivity method have been employed in the exploration of groundwater and assessment of ground water contamination. The Vertical Electrical Sounding (VES) procedure of Electrical Resistivity method used in this study, has been extensively used for location of the aquifer and determining their hydraulic parameters because the instrument is simple and analysis of the data is easy and less tedious than other methods

(Lashkaripour et al., 2005; Batayaneh, 2007; Sikandar et al., 2009; Anomohanran, 2013; Dauda and Akanbi, 2018).

The study area, which is predominantly occupied by families and students, has most of its water sources (hand dug wells) close to soak away pits. The World Health Organization (WHO) recommends a safe distance of 30m and above (WHO, 2006) from soak away pits in areas with ground water sources like wells and boreholes. Widespread ground water contamination has occurred in many rural areas where wells are constructed less than 30m from soak away pits. This is because of the effluent, which is discharged into the same aquifer tapped by wells for domestic water supply (Banda et al., 2014). Considering the proximity of soak away pits to wells in the study area, in the long run due to climatic conditions like rainfall, the seepage from the soak away pits can find its way into nearby wells thereby causing contamination and posing a great risk to those who use the water domestically. The objectives of this study are to determine the geo-electric response of earth materials between the soak away pits; carry out physiochemical and microbial analysis of well water sample in order to ascertain if there is a possible risk of ground water contamination.

Study Location

The study area is bound by longitude $008^{\circ}54'06.0"$ to $008^{\circ}54'07.1"$ E and latitude $09^{\circ}57'11.3"$ to $09^{\circ}57'12.5"$ N. It is located in Legislative quarters, opposite Mega park Ring road in Jos North L.G.A of Plateau state Nigeria. It is accessible by road and the exact site is about three minutes walk from Legislative quarter's first gate. Figure 1 shows the location and topographical map of the study area. Geologically, the area is underlain with Aegirine granite. Figure 3 shows the geological map of the study area.

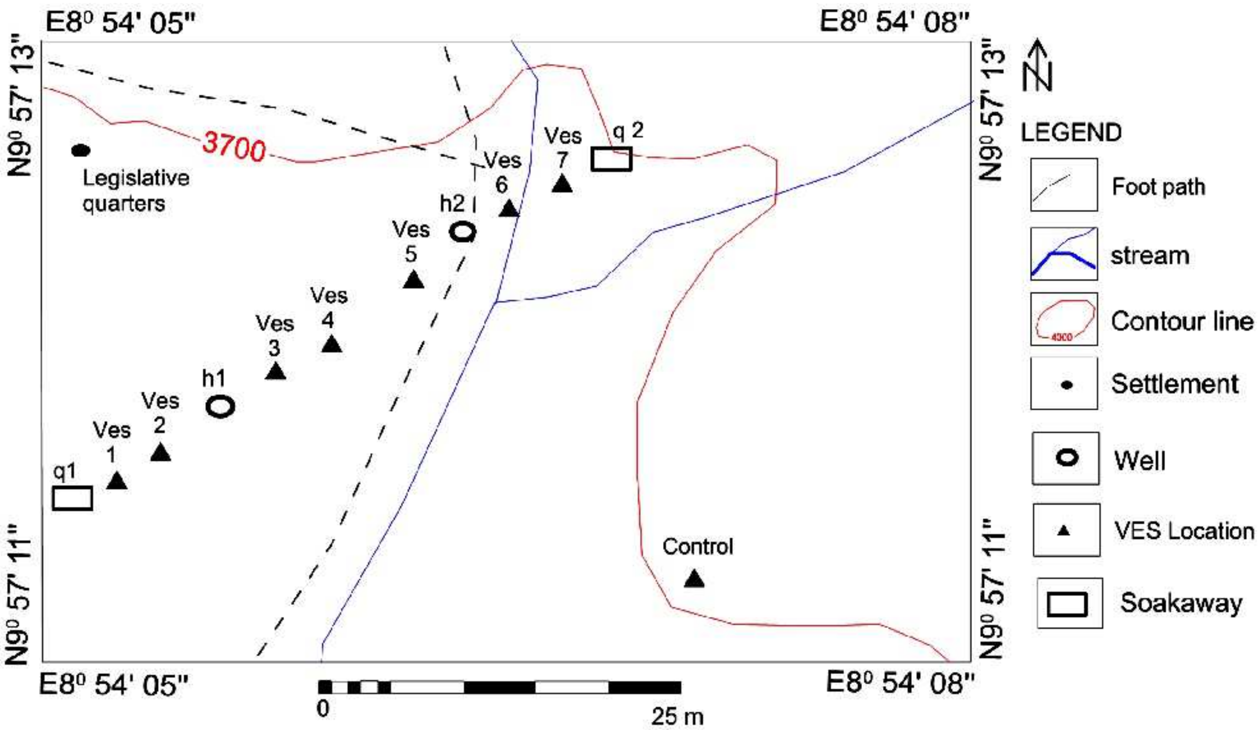

Fig. 1: Location map of the study area showing VES locations. Elevation in meters.

Materials and method

Materials: Ohmega resistivity meter, electrodes, Gamin Etrex20x GPS model, measuring tape, hammer, cables, pH meter, conductivity meter, petri dishes, test tubes, pipettes, Nutrient Agar (NA), saline, inoculating needle, filter paper.

Software: IX1D version 2.06, Surfer 11.

Method: Seven soundings were carried out along a traverse. The VES points lie along a traverse where two soak away pits and two wells were located in a straight line, few distances away from each other. VES 1 and VES 2 are located between soak away pit A and well A; VES 3, 4 and 5 are located between well A and well B

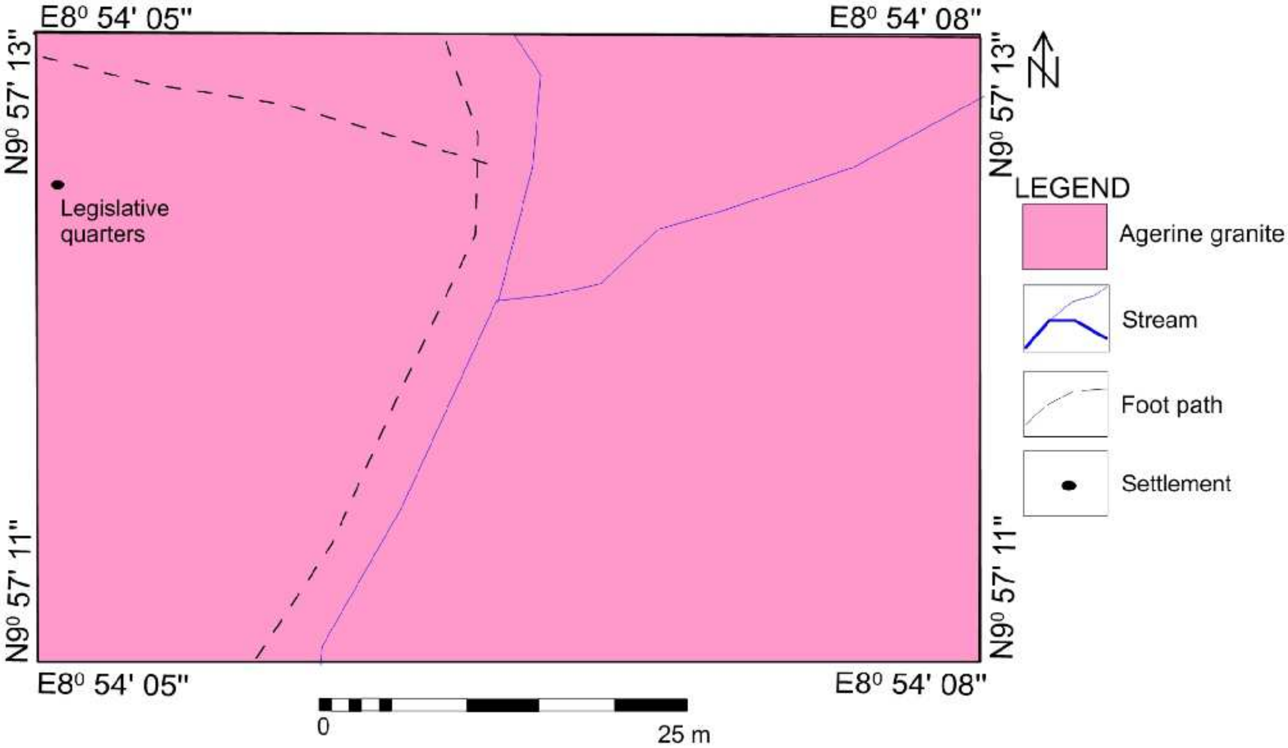

Fig. 2: Digitized Geological map of the study area

while VES 6 and 7 are located between well B and soak away pit B. These were separated by short distances of 7m (soak away pit A to well A), 19m (well A to well B) and 14.4m (well B to soakaway pit B) on the traverse. The electrode configuration used for the survey was the half-Schlumberger array. Theory and method of this array has been discussed extensively in Anjorin and Olorunfemi (2001), Akintorinwa and Abiola, (2012) and Alao et al. (2019). The terrameter was set up and was powered by a DC source. The coordinates of each VES points were taken using the Global Positioning System (GPS). The potential electrodes M and N were planted with an electrode spacing (MN) of 0.5m. The depth range of penetration was changed by displacing the current electrode (B) while the potential electrodes remained fixed. The current electrode spacing (AB/2) used varied from 1 to 32m. The potential electrode spacing was increased to 1m and 2m when AB/2 was 6m and 15m respectively. At each point when the electrode was moved, current was sent into the ground and resistance value recorded on the terrameter. For accuracy, the value with the least percentage error was recorded. These procedures were repeated for VES2, VES3…, VES7 and the resistance values recorded appropriately. The resistance data obtained was converted to apparent resistivity values by using the geometric factor for half-Schlumberger configuration. The depth of to surface of water in the wells were measured.

The data obtained for each VES point was entered and saved in the IX1D software. With the forward and inverse modelling routine of the software, multiple iterations were carried out to obtain the VES (resistivity sounding) curves and geoelectric layers. The values for resistivity, depth, thickness, and elevation for every layer on each VES point were determined and recorded using the software. Water collected from the well A was taken to the Microbiology laboratory, Department of Microbiology, University of Jos, Plateau state to determine some physiochemical properties (pH and electric conductivity) and analyse the microbial content. For the physiochemical analysis, pH and electrical conductivity of the water sample was determined using pH and conductivity meters respectively. Microbial analysis of water sample was carried out using the method of serial dilution using petri dishes, test tubes, pipettes, Nutrient Agar (NA), saline, inoculating needle and filter paper.

Results

Resistivity sounding curves for the seven VES locations are presented in Figures 3-9. Representative resistivity values of earth materials derived from Baimba (1978); Hassan et al (1991) and Loke, (2004), resistivity values of earth materials in Table 1 were used in classifying the geologic layers in the study area. The type of curve obtained in electrical soundings over a horizontally stratified earth is indicative of the number of layers as well as the electrode configuration adopted (Zohdy et al., 1974). The qualitative interpretation of the sounding curves obtained from this study revealed three to four geo-electric layers (Table 2). The sounding curve types obtained for VES 1 to VES 7 were H, KH, H, H, H, HA and H type curves respectively.

The summary of quantitative interpretation is also shown in Table 2. Quantitative interpretation gives the geo-electric parameters (true resistivity of the layers, depth to these layers and thicknesses of these layers).

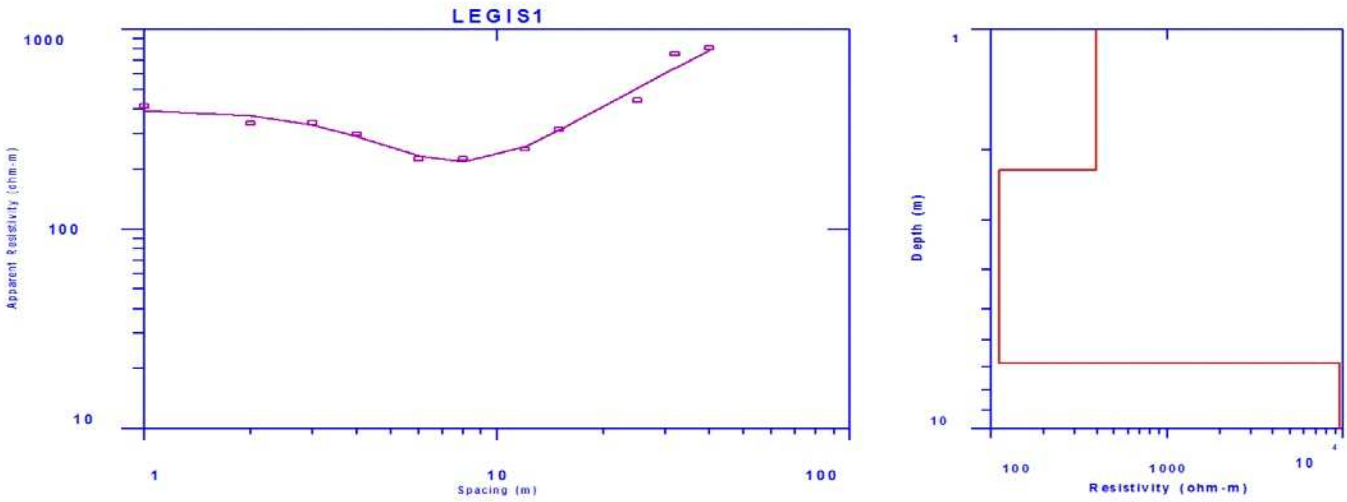

Fig. 3: Resistivity Sounding Curve for VES 1

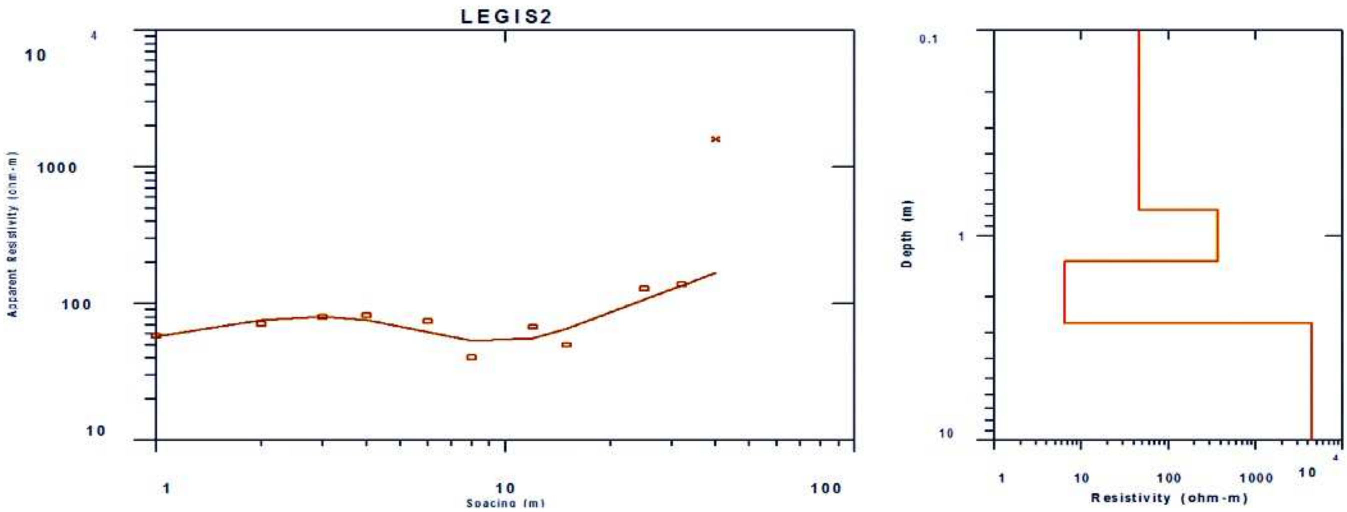

Fig. 4: Resistivity Sounding Curve for VES 2

Table 2 was used to produce the geo-electric section, which is a graphic representation of the subsurface layer parameters is presented in Figure 10. The results of the physiochemical and microbial analysis (bacteria count and biochemical properties) of the well A water sample are presented in Tables 3, 4 and 5.

The result of the physiochemical analysis (Table 3) shows that the water sample from well A has a low pH of 5.09. This is below the World Health Organization (WHO, 2011) standard value, which is between 6.5 and 8.5. This indicates that the groundwater in the study area is acidic and not good for drinking. Also, the electric conductivity value of the water sample from well A was lower than the 1000 µs/cm recommended by the

Table 1: Typical Resistivity values of earth materials (adapted from Baimba (1978), Hassan et al. (1991) and Loke, (2004)

Rock Type	Resistivity (Ωm)
Fresh Ground water	10-100
Clay	1-100
Weathered Basement	50-100
Slightly weathered Basement	200-500
Fresh Basement	<1000

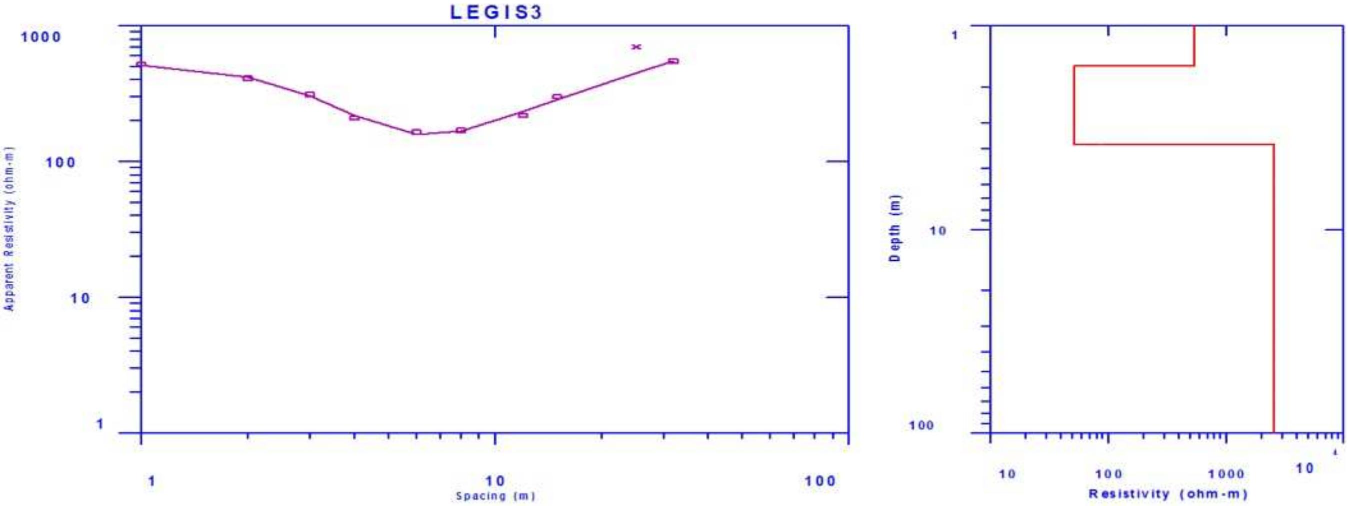

Fig. 5: Resistivity Sounding Curve for VES 3

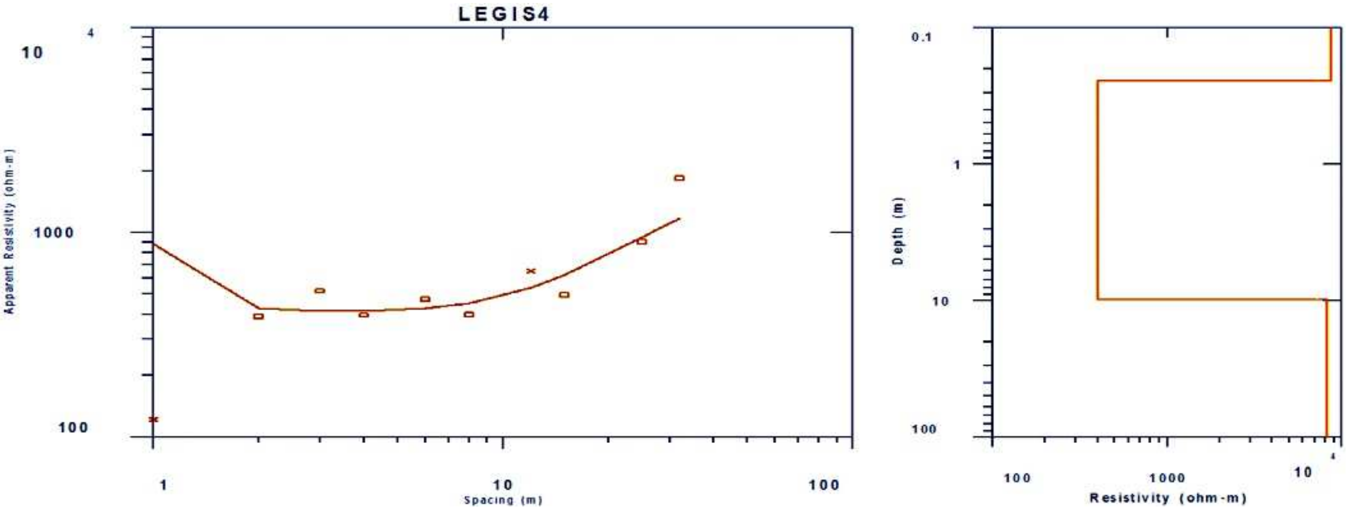

Fig. 6: Resistivity Sounding Curve for VES 4

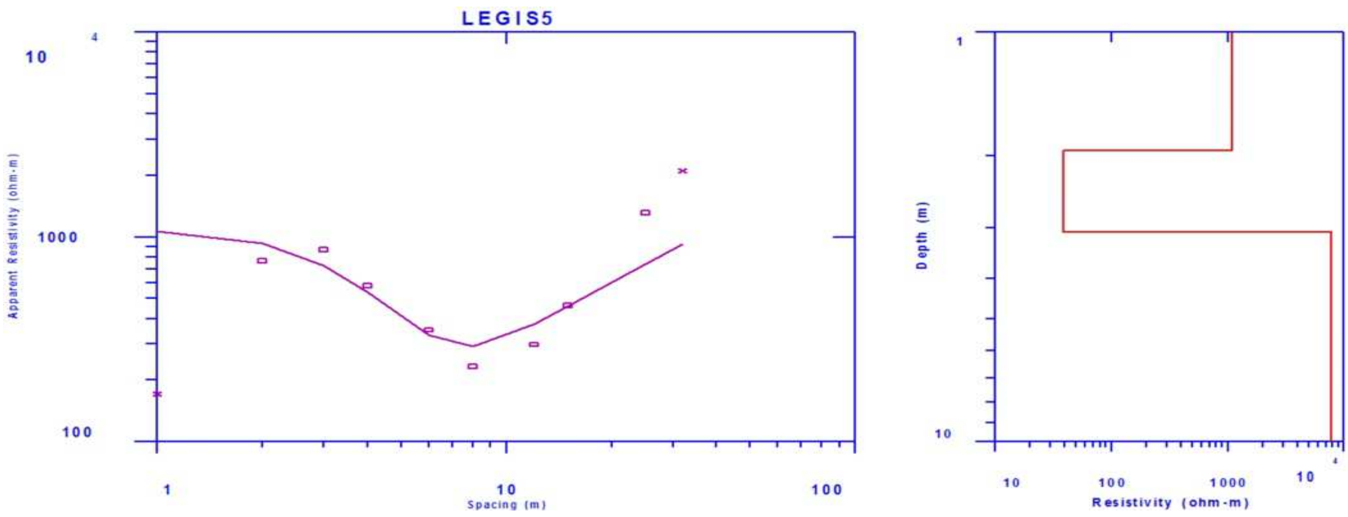

Fig. 7: Resistivity Sounding Curve for VES 5

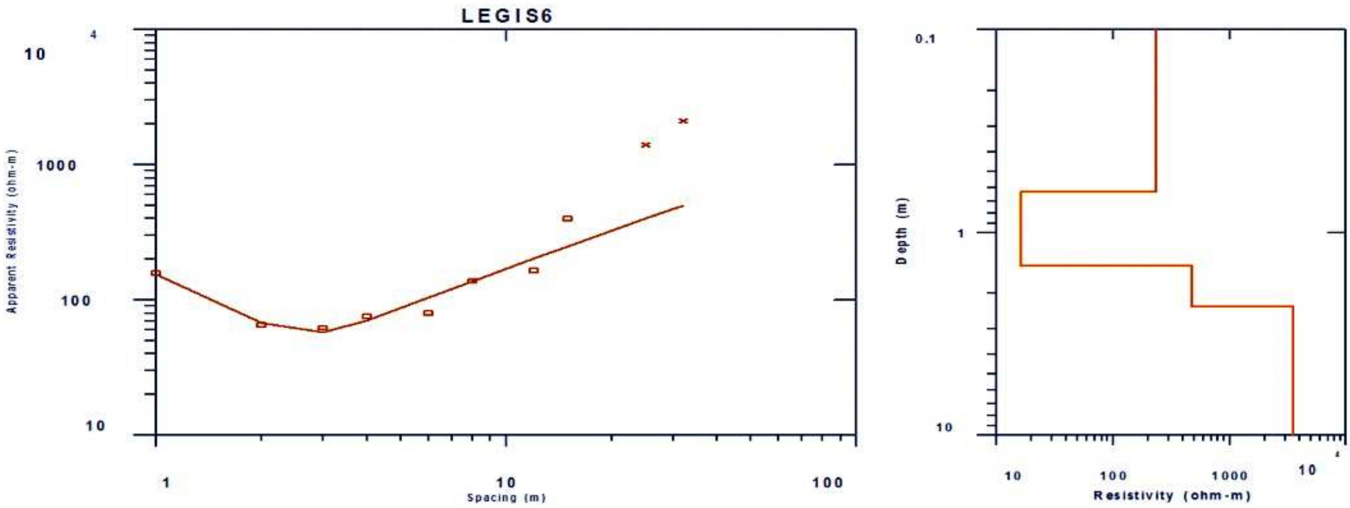

Fig. 8: Resistivity Sounding Curve for VES 6

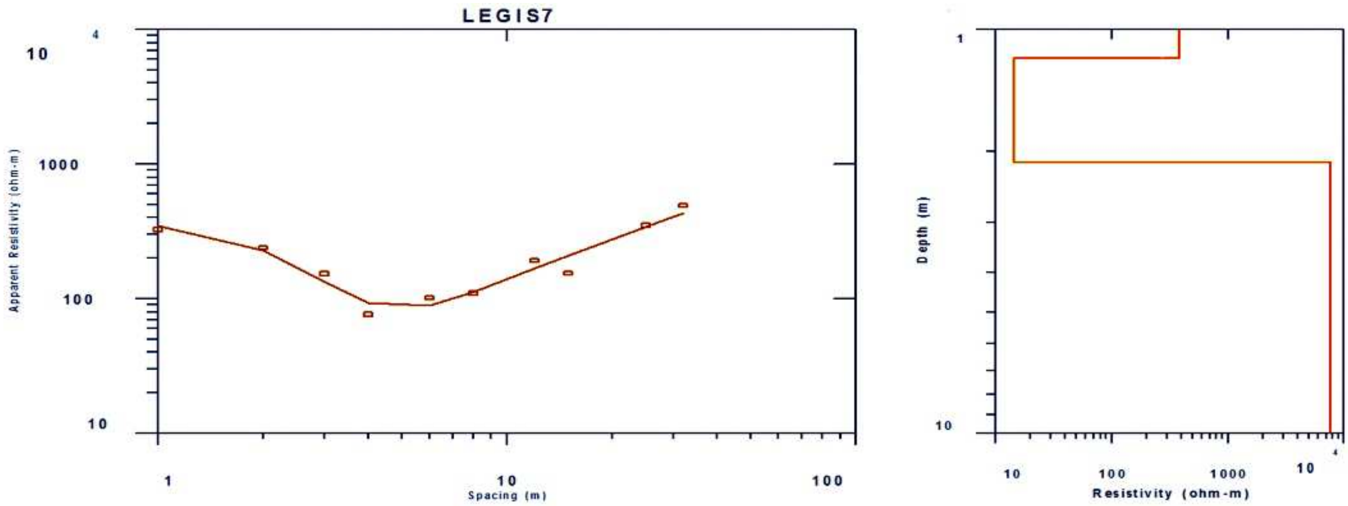

Fig. 9: Resistivity Sounding Curve for VES 7

Standard Organization of Nigeria (SON, 2007). Electrical conductivity is the ability of any medium water in this case, to carry an electric current. Conductivity does not have direct impact on human health. It is used however to determine mineralization rate (existence of minerals such as potassium, calcium, and sodium). High mineral contents in water results in higher conductivity value (Rahmanian et al., 2015).

The result from the microbial analysis (Table 4 and 5), show the presence streptococcus, faecalis, proteus spp and salmonella typhi. The presence of faecalis indicates that the water is contaminated with faeces from the soak away pit. Ideally, water should not contain any microorganisms known to be pathogenic, capable of causing disease or any bacteria indicative of faecal pollution (WHO, 1997). For all water intended for drinking, E. coli or coliform bacteria must not be detectable in any 100ml of the sample. (WHO, 1997). The presence of coliform at a count of9.0×10^4 ml and a total count of 8.3×10^5ml in the water sample, which is above the standard specification for drinking water is an indicative that the water is unfit for human consumption.

Discussion

In this study, the very low resistivity values (16.21Ωm, 14.29Ωm and 6.41Ωm) were obtained in the second (VES 6 and 7) and third geo-electric layers (VES 2) respectively. These geo-electric layers lie within the weathered and fractured basement, which usually have good ground water potential and will allow free flow and storage of water due to its weathered and fractured nature. The depths at which these low resistivity values were obtained are 2.68 m, 1.46 m and 2.13 m in VES 2, 6

Table 2: A summary of the qualitative and quantitative interpretation of the VES curves

VES Station	Layer	ρ (Ωm)	h (m)	d (m)	Curve Type
1	1	399.07	2.26	2.26	H
	2	110.81	4.63	6.89	
	3	19284.00	-	-	
2	1	46.81	0.75	0.75	KH
	2	364.55	0.58	1.33	
	3	6.41	1.34	2.67	
	4	4422.50	-	-	
3	1	536.65	1.57	1.57	H
	2	51.47	2.26	3.83	
	3	2582.60	-	-	
4	1	9256.80	0.20	0.20	H
	2	417.39	9.26	9.46	
	3	2455.00	-	-	
5	1	1091.00	1.94	1.94	H
	2	39.23	1.13	3.07	
	3	7812.70	-	-	
6	1	273.16	0.63	0.63	HA
	2	16.21	0.83	1.46	
	3	479.32	0.86	2.32	
	4	3573.90	-	-	
7	1	382.00	1.17	1.17	H
	2	14.29	0.95	2.12	
	3	7670.00	-	-	

Key: ρ = resistivity, h = layer thickness, d = layer depth from earth's surface

and 7 respectively. These depths are within the range of depths for soakaway constructed for families and villages which is 1 ½ m and least 2 m deep respectively (Ahrens, 2005). It can also be noted that the VES points (VES 6, 7 and 2) with low resistivities (16.21Ωm, 14.29Ωm and 6.41Ωm) also have wells close to them. Consequently, these low resistivity values can also be attributed to be due to the resistivity effect of the nearby wells containing water and the earth material in the weathered basement. However, an important observation is that the lowest resistivity values (6.41Ωm, 16.21Ωm and 14.29Ωm) were estimated at the VES points (VES 2, 6 and 7 respectively) closest to the soak away pits when compared to the rest. As wastewater percolates through the soil from the soak pit, small particles are filtered out by the soil matrix and organics are digested by microorganisms. The wastewater effluent is absorbed by soil particles and moves both horizontally and vertically through the soil pores (Tilley et al., 2014). Sub-soil layers should therefore be water permeable in order to avoid fast saturation (Heeb et al. 2008). The distance between soakaway pit A and well A is 7m while the distance between soakaway pit B and well B is 14.4 m; these distances are below the recommended which is more than 30 m (WHO, 2006). Also, ground water flow direction should be considered when siting soakaways near water sources in other to avoid possible contamination/pollution. The resistivity results reveal likely percolation of effluence waste water from the soak away pits into the soil and the wells, since the depths are in close range and lie within the same geoelectric layer. The low pH value of 5.09 obtained

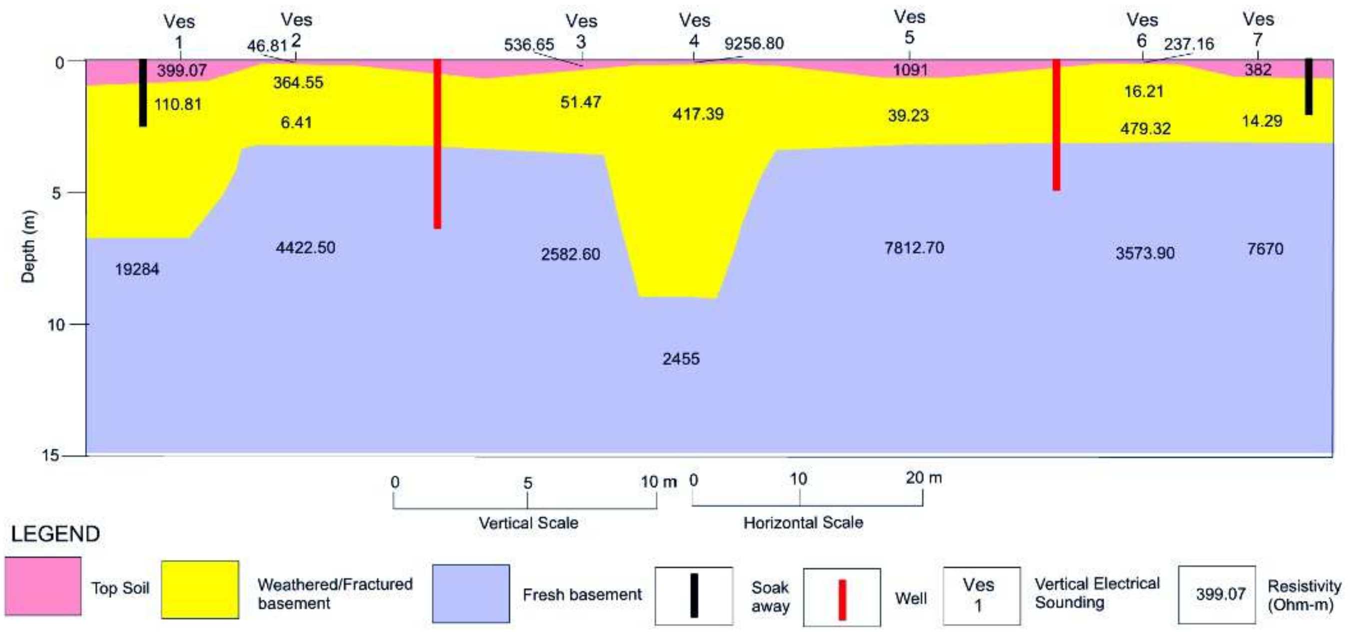

Fig. 10: Geo-electric section for seven VES points along a traverse.

Table 3: Physiochemical properties of well water sample

PARAMETER	UNIT	STANDARD VALUES	MEASURED VALUES
pH		6.5-8.5 (WHO, 2011)	5.09
EC	µs/cm	1000 (SON, 2007)	0.14

EC= Electrical Conductivity; SON = Standard Organization of Nigeria

Table 4: Bacteria count of well water sample

Sample	Total Plate Count (cfu/ml) 10^{-4}	Coliform Count (cfu/ml) 10^{-4}
Well water	8.3×10^5	9.0×10^4

from water sample collected from well A implies that the soil may also be acidic but this may not be a contributing factor to the low resistivity values obtained since soils within the acidic pH range have coarse sand particles as their main constituents and are characterized by high resistivity (Murad, 2012).

Table 5: Biochemical properties of well water sample

Sample	Catalase	Coagulase	Indole	Urease	Oxidase	Triple sugar ion agar slant				Microorganism isolated
						Slope	Butt	H_2S	Gas production	
Well water	+	-	+	+	-	Y	Y	+	+	Streptococcus, faecalis, proteus spp, salmonella typhi

Key: + = Positive, - = Negative, Y= yellow indicating that the production of gas by microorganisms present

Considering the minimum safe distance of 30m and above recommended for construction of soak away pits in areas with ground water sources (WHO, 2006), this was not adhered to in this study as the distance of the wells from soak away pits were less than 15 m. The result of the microbial analysis revealed the presence of microbes especially faecalis implying contamination with faeces. The low resistivity values and presence of microbes could therefore be because of underground seepage from the soak away pits that may likely become worse in future.

Conclusion

This study investigated the geo-electric response of earth materials between some soak away pits and hand dug wells in legislative quarters Jos, Plateau State. The analysis and interpretation of the VES data obtained revealed that low resistivity zones occurred in VES 2, VES 6 and VES 7 and could have likely occurred due to infiltration of effluence waste water from the soak away pits. In addition, the microbial analysis revealed that the water samples contained faecalis (a microorganism found in faeces). Hence, the water is contaminated and unsafe for consumption.

References

Alao, J.O., Dogara, M.D., Danlami, A. and Samson, E.E. (2019). Comparative Assessment of half Schlumberger Configuration as an Alternative Method to the Conventional Schlumberger Configuration at Trade Centre, Mani-Nissi Village, Kaduna, Nigeria. SSRG International Journal of Applied Physics 6(3): 51-56

Ahrens, B. (2005). A Comparison of Wash Area and Soak Pit Construction. The Changing Nature of Urban, Rural, and Peri-Urban Linkages in Sikasso, Mali (Master Thesis). Michigan Technological University.

Akintorinwa, O.J. and Abiola, O. (2012). Comparison of Schlumberger and Modified Schlumberger arrays VES Interpretation Results. Research Journal in Engineering and Applied Sciences, 1(3): 190-197.

Anjorin, M.P., andOlorunfemi, M. (2011). A Short Note on Comparative Study of Schlumberger and Half Schlumberger Arrays in Vertical Electrical Sounding in a Basement Complex Terrain of Southwest Nigeria.

Anomohanran, O. (2013). Investigating the geoelectric response of water saturated and hydrocarbon impacted sand in the vicinity of petroleum pipeline. International Journal of Applied Science and Technology, 3(2), 14- 21.

Ashbolt, N.J., Grabow, W.O. and Snozzi, M. (2001). Water quality - guidelines, standards and health assessment of risk and risk management for water-related infectious disease: 256-276, World Health

Organization, Geneva.

Baimba A.B. (1978): Resistivity and refractionseismic methods for groundwater exploration at Zango, Kaduna state. Unpublished M. Sc. ThesisAhmadu Bello University, Zaria, Nigeria, 1978.

Banda, L. J., Mbewel, A. R., Nzala, S. H., and Halwindi, H. (2014). Effect of Siting Boreholes and Septic Tanks on Groundwater Quality in St. Bonaventure Township of Lusaka District, Zambia. International Journal of Environmental Science and Toxicology Research, 2(9): 191-198

Batayaneh, A. (2007). Mapping subsurface formations on the eastern red sea coast in Jordan using geoelectrical techniques: Geological and hydrogeological implications. Earth Sciences Research Journal, 11, 97-107.

Dauda, T.S. and Akanbi E.S. (2018). Resistivity Method for Groundwater Prospecting: A Case Study of Army Engineers Quarters Zaria Road, Jos, Plateau State Nigeria. African Journal of Natural Sciences 21: 129-137.

Egbai, J.C., Efeya, P. and Iserhien-Emekeme, R.E. (2015). 2D Geoelectric Evaluation and Imaging of Aquifer Vulnerability of Dump Site at Ozoro Isoko South L.G.A of Delta State.

Emongor, V., Kealotswe, E., Koorapetse, I andSankwasa, S (2005). Water Resources Management. Journal of Applied Sciences, 5, 147-150.

Eze, C.I. and Eze, E.M. (2015). Investigation of Possible Groundwater Contamination from Septic System siting in Port Harcourt, Nigeria. Journal of Natural Sciences Research, 5(10): 83-87

Hassan, M., Ajayi, C.O. andOjo, S.B. (1991). A Basementstructure determined from Geoelectric mapping ofthe Kubanni River Basin, Zaria. Nigerian Journalof Physics, 3: 166-173.

Heeb, J., Jenssen, P., Gnanakan, K. and Conradin, K. (2007). Ecosan Curriculum 2.3. Switzerland, India and Norway: seecon international, International Ecological Engineering Society, Norwegian University of Life Sciences, ACTS Bangalore

Keswick, B.H., Wang, D. and Gerba, C.P. (1982). The use of micro-organisms as groundwatertracers: A review; Groundwater 20(2), 142–149.

Kumar, A. (2004). Water Pollution. Nisha Enterprises New Delhi, pp 1-331.

Lashkaripour, G.R., Ghafoori, M. andDehghani, A. (2005). Electrical resistivity survey forpredicting Samsor aquifer properties, southeast Iran. Geophysical Research Abstracts, 7: 01999. European Geosciences Union

Loke, M.H. (2004). Electrical 1maging Surveys forEnvironmental and Engineering Studies-apractical guide to 2D and 3D surveys. PenangMalaysia. (mhloke@tm.net.my,drmhloke@yahoo.com). Downloaded from http://www.abem.se [Accessed 18 Feb. 2022].

Makeig, K.S. (1982). National buffers for sludge leachate stabilization of groundwater;Geophysics, 20(4), 420– 429.

Murad, O.F. (2012). Obtaining chemical properties through soil electrical resistivity. Journalof Civil Engineering Research 2(6): 120 – 128.

Obiora, D.N., Adeolu, A.E. and Ibuot, J.C. (2015). Evaluation of aquifer protective capacity of overburden unit and soil corrosivity in Markurdi, Benue State, Nigeria, using electrical resistivity method. Journal of Earth System Science, 124(1), 125-135.

Rahmanian, N., Siti, H.B., Homayoonfard. M., Ali, N. J., Rehan, M., Sadef, Y. andNizamiS. (2015). Analysis of Physiochemical Parameters to Evaluate the DrinkingWater Quality in the State of Perak, Malaysia.

Sikandar, P., Bakhsh, A., Arshad, M. and Rana, T. (2009). The Use of Vertical Electricalsounding Resistivity Method for the Location of Low Salinity Groundwater for Irrigation in Chaj and Rachna Doabs. Environ Earth Sci, 60, 1113-1129.

SON, 2007. Nigerian Standard for Drinking Water Quality. Nigerian IndustrialStandard NIS 554, Standard Organization of Nigeria, p30.

Tilley, E., Ulrich, L. Luethi, C., Reymond, P. and Zurbruegg, C. (2014). Compendium of Sanitation Systems and Technologies. 2nd Revised Edition. Duebendorf, Switzerland: Swiss Federal Institute of Aquatic Science and Technology (Eawag)

Ugbaja, A.N. and Edet, M.O. (2004). Groundwater pollution near shallow waste dumps inSouthern Calabar, Nigeria; Global J. Sci. 2(2), 199–206.

World Health Organization (WHO), (1997). Guidelines for Drinking Water Quality, Surveillance and Control of community Supplies. *3*(2).

World Health Organization WHO, (2006). Protecting Groundwater for health; Managing the quality of drinking water, Source: 1SBN1843390795. IWA Publishing London, Uk.

World Health Organization (WHO), (2011). Guidelines for Drinking Water Quality, WHO Press, Geneva, 4th Edition.

Zohdy, A.A.R., Eaton G.P. and Mabey D.R. (1974). Application of Surface Geophysics to Groundwater Investigations. 1st Edn., Chapter Book 2,USGS Publication, USA., pp: 116.

mosunmolu limited

Geological & Petroleum Consultants

4/6 Mobolaji Bank-Anthony (Oil Mills) Street, Lagos
P.O. Box 8066, Lagos, Nigeria
Tel. 01-2646314 & 2636299 *Fax* 234-1-2645154 *E-mail* mos@linkserve.com.ng

BAYAT LIMITED

Geoscience Consultants

27 Kudeti Avenue, Onireke G.R.A., G.P.O. Box 10479, Dugbe,Ibadan, Nigeria
Tel. 02-8100554 & 08034734879 Fax 02-8100554

PRIME EXPLORATION & PRODUCTION LIMITED

Petroleum Consultants

4th Floor Bankers' House, PC 19 Adeola Hopewell Street
P.O.Box 71253, Victoria Island, Lagos, Nigeria
Tel. 08033551187, 08023430214
Suite 2, Mina Hotels Ltd., 23 Igbodo Street, Old GR, Port Harcourt
Tel. 084-236356, 236357
E-mail primeenergynigeria@yahoo.com

MECON GEOLOGY & ENGINEERING SERVICES LTD.

Consultants in Geology/Stratigraphy, Mineral Exploration & Water Resources Development

Plot 3317 Rantya Village, Off Miango Road
P.O. Box 6022, Jos, Nigeria
Telefax 073-462280 *E-mail* <mecon@bwave.net>

Getamme Geochem
GETAMME (NIGERIA) LIMITED

Specialists in Complete Geochemical Services for Petroleum Exploration, Development & Production

18 Peace Drive, Off 221 Okporo Road, Rumuodara, P.O. Box 6056, Port Harcourt, Nigeria
Tel. 084-230594 *Fax* 084-239514 *E-mail* ekweozor@infoweb.abs.net