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GEOPHYSICAL INVESTIGATIONS AND GROUND-WATER QUALITY WITHIN CAMP VILLAGE, ABEOKUTA, SOUTH-WESTERN NIGERIA

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ABSTRACT

Ten vertical electrical soundings (VES) were carried out using Schlumberger electrode array at the locations where hand dug wells are situated within the village of Camp, Abeokuta, southwestern Nigeria. Eleven water samples were also collected from these wells and analysed. The geophysical study reveal that the depths of all the wells were below the standard recommended depth for deep wells in the basement complex area. The chemical analyses of the samples collected showed that the results when compared with the WHO/EPA standards were far below the recommended values for human consumption; which is suspected to have caused the water borne disease prevalent in this community.

***Key words*:** Groundwater, Contamination, Chemical and Physical Parameters, Lithology and Resistivity.

INTRODUCTION

Water is an essential resource for human survival and is used for various purposes, which includes domestic uses, irrigation, industrial, power generation and recreation. Many of our human activities have led to pollution of groundwater in our environment coupled with erratic supply of pipe-borne water, which has forced many people to resort to groundwater exploration in various forms (open wells, deep and shallow, boreholes in few cases). Groundwater contamination commonly results from four major sources: natural sources of contamination include dissolved salts, iron, manganese, fluoride, arsenic, radio-nuclides and trace metals; domestic sources of contamination include detergent, chloride, nitrate ions and viruses; industrial/commercial sources of contamination include mining waste, dissolved solids, metals and radioactive materials, toxic fluids and gasoline; agricultural sources of contamination include fertilizers and pesticides. The presence of these contaminants above World Health Organisation (WHO, 1997, 1998) and Environmental Protection Agency (EPA, 2005) standards can cause different kinds of diseases, typhoid fever, paratyphoid fever, dysentery, gastrosis, infectious hepatitis,

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sehistomeasis, Asiatic cholera, tuberculosis, drowsiness, lack of bladder control, pneumonia, nasal congestion, cancer and nose bleeding.

Electrical resistivity (ER) method is one of the most widely used means of carrying out geophysical investigation for groundwater exploration. It depicts the subsurface structure, determining the aquifer characteristics of the study area. Most surveys tend not to rely on the electrical resistivity survey alone but rather to integrate it with the lithology of the existing wells nearby. It is generally known that water is contained in the inner pores of subsurface formations. Water is a good conductor of electricity due to hydrogen bonding and dipole-dipole characteristics of water molecules. The success of geoelectrical resistivity methods for groundwater studies have been found recently to depend on the intelligent application of the methods used and good interpretation of data, which requires a careful correlation of all the geophysical data collected to known geology of the area, (Beck, 1981). Beeson and Jones (1988), Olayinka and Barker (1990), Hazel (1961), Hazel et al. (1988, 992), all have demonstrated the use of electrical technique for sitting borehole and wells in crystalline basement aquifer through out the sub-Saharan Africa. Geophysical investigation also involves the determination of lithological and facies changes to detail the aquifer correspondence of hydrogeological parameters and direction of regional flow, (Shemang and Likkason, 1997).

METHODOLOGY

Study Area

The study area, Camp village, Osiele Abeokuta, South-western Nigeria, falls within the basement complex of Nigeria where crystalline rocks (gneiss, schist, quartzite, older granites and dolomite dykes) are located, (Rahaman, 1989). The study area lies between latitude $7^o\ 7^lN$ and 7^o15^lN; longitude 3^o22^lE and 3^o30^lE (Fig. 1). Where the basement rocks are not exposed, the fresh bedrock is overlain by weathered residual overburden (regolith), which comprises clayey and sandy materials derived from the in-situ chemical weathering of parent rock formations. The landform of the study area is characterized by the extensive plains, which occur between river valleys and the residual hills. There is a paucity of basement exposure due to the presence of thick weathered mantle.

Experimental Field Procedure

A total of ten Schlumberger vertical electrical soundings (VES) were carried out in the study area near the existing shallow/ deep wells around the study area. The VES locations were located between 0.5 and 1 m from the wells. The current electrode (AB/2) spacing ranged from 1.0 to 100.0 m while the potential electrode (MN/2) varied between 0.25 and 5.0 m. The locations of the well/VES points were sectioned into three within the community as shown in the data acquisition map (Fig. 2). Twelve water samples were collected in all, each in a separate bottle for chemical analysis. Section one comprising samples 1, 2, 3 and 4; section two comprising samples 5A, 5B and 6, and section three comprising samples 7, 8A, 8B, 9 and 10. The total depths of all the wells were taken for comparative studies with the geophysical interpretation results (Table 1).

The geophysical data acquired were analysed and interpreted using the usual manual curve matching method, the results of which served as initial parameters for the computer iteration technique using the commercially available software, Offix and Resist. The detailed results of the interpretation are presented in Table 1and this was compared with the total depths of all wells within the study area. In the case of chemical analysis, twelve cleaned water bottles were used to collect water samples from ten shallow/deep wells and two community boreholes. These water samples were taken to the laboratory for physical and chemical analyses within 24 hours of collection. The results of the analysis are presented in Table 2.

RESULTS AND DISCUSSION

Geophysical Investigation

The geophysical investigation was sectioned into three, section 1 consists of VES 01, 02, 03 and 04; section 2 consists of VES 05 and 06 while section 3 consists of VES 07, 08, 09 and 10. The locations investigated were very close to the existing wells, less than 0.5 m. In section 1, curve types QH ($r_1>r_2>r_3<r_4$), HA ($r_1>r_2<r_3<r_4$), AA ($r_1<r_2<r_3<r_4$) and HK ($r_1>r_2<r_3>r_4$) characterized the locations. The topsoil at these locations has resistivity values ranging between 47.6 Ωm and 305.1 Ωm and thickness between 0.7 m and 4.9 m. The second geo-electric layer revealed a clayey sandy formation with resistivity values between 23.2 Ωm and 77.0 Ωm; thickness range of between 1.1 m and 7.3 m. This layer is underlain as the third geo-electric layer, by sandy clay except at VES 01 where clayey sand is revealed. The current penetration terminated at the fourth geo-electric layer at these locations as shown in the geo-electric section (Figure 3). When the depths of penetration obtained from the field data were compared to the total depths of the shallow wells dug close to the VES points, the results reveal with clear distinction that all the wells at this section were not drilled to the aquifer level, the wells were terminated just slightly above the overburden (Table 1). The quality of the water from these wells should be subjected to standard laboratory analysis.

For section 2, where VES 05 and 06 are located, curve types QH ($r_1>r_2>r_3<r_4$) and HA ($r_1>r_2<r_3<r_4$) describe these locations with topsoil layer having resistivity values of 51.1 and 152.6 Ωm and thickness of 1.1 and 0.9 m, respectively (Table 1). The second and third geo-electric layers beneath these locations reveal clayey sand formation underlain by fine medium sand and sandstone at VES 05 and 06, respectively (Figure 4). VES 05 is seen to have a shallow aquifer depth, since the penetration terminated in sand and this accounts for the reason why the well was terminated at the overburden level, since sand aquifers are more water bearing. However, the comparison of the depths obtained from field data and the dug wells at this section showed that only overburden/surface water have been explored at these locations.

Section 3 of this study area is characterized by curve types AKH ($r_1<r_2<r_3>r_4<r_5$), AK ($r_1<r_2<r_3>r_4$), HA ($r_1>r_2<r_3<r_4$) and KH ($r_1<r_2>r_3<r_4$) with maximum of five geo-electric layers in VES07 (Table 1). The topsoil layer has resisitivity values ranging

between 31.7 and 197.5 Ωm, thickness range of 0.1 and 7.0 m. VES 07, at the second, third and fourth geo-electric layers is composed of clayey sand with resistivity values between 42.3 and 85.8 Ωm, thickness between 1.2 and 13.8 m. This layer is underlain by sandstone where the current penetration terminated. The second geo-electric layer at VES 09 and 10 reveal sandy clay formation while at VES08, clayey sand was delineated. The current penetration terminated at the fourth geo-electric layer at VES 08, 09 and 10 with resistivity values 17.5, 956.9 and 18866.4 Ωm (Figure 5). All the hand dug wells at this section show clear distinction of overburden water as described by the total depths when compared with the interpretations of the field data (Table 1).

Chemical Analysis of Water Samples

Twelve water samples were collected and analysed in the laboratory of Lagos State Water Corporation, Lagos, Nigeria. The samples were also sectioned into three on the basis of the geophysical survey carried out near the hand dug wells. Section 1 consists of samples 1, 2, 3 and 4; section 2 consists of sample 5A, 5B (borehole water sample) and 6; while section 3 consists of samples 7, 8A, 8B (borehole sample), 9 and 10. It is observed that the water samples are slightly warmer, about 2^{o}C than the WHO/EPA recommended value. Detailed results of the analysis are shown in Table 2.

The physical parameters measured for samples of section 1 showed that all the wells are shallow with low turbidity; however, the water samples are colourless in appearance, tasteless and odourless. Although turbidity has no health effect, turbidity can interfere with disinfections and provide a medium for microbial growth. Turbidity may also indicate the presence of disease causing organisms, which include bacteria, viruses and parasites that can cause symptoms such as nausea, cramps, diarrhoea and associated headaches. The laboratory analyses of these samples show low iron content in samples 3 and 4 and very high content in sample 2 when compared with WHO/EPA standards for human consumption. High iron content can result in hardness, which causes discolouration of clothing as well as soap wastage in laundry. The total dissolved solids are found to be very low in all the water samples in this section when compared to WHO/EPA standards; this may result in anaemia in infant and growing children. It also causes skin irritation, which is prevalent in the study area. All other parameters analysed are found to be within permissible limits in the context of groundwater quality (Table 2).

For section 2, the physical parameters reveal that all the water samples are odourless, tasteless and colourless except in sample 5B where the colour is light brown. The water turbidity in the samples exceeds the recommended WHO/EPA values. The chemical analysis of the water samples at this section show very low chloride and magnesium contents. Sample 5B contains low total hardness and pH, which gives low alkalinity. Sample 6 has the lowest alkalinity as well as low iron content. All the samples at this section show lower values for total dissolved solids when compared with WHO/EPA standards. However, other chemical parameters are in the range of permissible values (Table 2).

In section 3, the physical parameters reveal all the water samples as odourless, tasteless and colourless in appearance except samples 7 and 8, which have light brown colour and higher turbidity when compared with WHO standard values. The results of chemical analysis show that all the water samples have low pH between 6.1 and 6.4 except sample 8A with pH of 7.2. The iron content of all the samples is very low and this may also result in anaemia as well as hardness of water. The water samples at this section reveal no traces of residual chlorine except at sample 8B (borehole). The analysis also shows very low chloride content and total dissolved solids in all the water samples at this section. However, water sample from the borehole (sample 8B) is suspected to be less susceptible to contamination, as shown by the chemical analysis.

CONCLUSION

The geophysical investigation carried out at the study area reveal that the wells are shallow, indicating that the total depths are lower than the standard depth of wells in basement complex area. This is responsible for the drying up of almost all the wells during the dry season; since most of the wells tapped only the overburden/ surface water. The chemical analysis of the water samples from these wells also reveal low quality as the laboratory results indicate a wide range of variation when compared with the WHO/EPA standards for water consumption.

Water from these wells is contaminated and should be subjected to adequate treatment before consumption. However, the water samples from borehole reveal less contamination as most of the chemical parameters are in agreement with the WHO/EPA standards. Thorough geophysical and hydrgeological investigation is required to be carried out in this community when exploring for groundwater development. Deep wells and boreholes should be drilled during the dry season when groundwater is minimal and all the overburden/ surface water would have been trapped in the aquifer.

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Table 1:Summary of Location Description, Layer Resistivity and Thickness, Depth of Current Penetration (Experimental), Depth of Hand Dug Wells and Lithology

VES Locations & Curve Types	Layer 1		Layer 2		Layer 3		Layer 4		Layer 5		Depth of Current Penetration (Experimental)	Total Depths of Hand Dug Wells (m)
	Resisitivity	Thickness	Resistivity (Ω	Thickness	Resistivity (Ω	Thickness	Resistivity (Ωm)	Thickness	Resistivity	Thickness		
	(Ωm)	(m)	m)	(m)	m)	(m)		(m)	(Ωm)	(m)	(m)	
VES 01, QH	305.1	0.7	65.4	1.1	46.1	10.1	952.4	-			11.9	6.3
(r1>r2>r3<r4)	Topsoil		Clayey Sand		Clayey Sand		Sandstone					
VES 02, HA	96.0	1.3	77.0	7.3	117.3	10.5	4776.3	-			19.2	8.4
(r1>r2<r3<r4)	Topsoil		Clayey Sand		Sandy Clay		Basement Bedrock					
VES 03, AA	47.6	4.9	67.4	2.5	210.4	19.2	1475.3	-			26.5	15.5
(r1<r2<r3<r4)	Topsoil		Clayey Sand		Sand Clay		Sandstone					
VES04, HK	54.6	1.1	23.2	4.5	633.8	19.4	101.5	-			25.0	16.8
(r1>r2<r3>r4)	Topsoil		Clayey Sand		Sandy Clay		Fine Medium Sand					
VES 05, QH	51.1	1.1	42.9	3.1	29.3	0.9	299.5	-			5.0	4.4
(r1>r2>r3<r4)	Topsoil		Clayey Sand		Clayey Sand		Fine Medium Sand					
VES 06, HA	152.6	0.9	48.5	5.5	822.3	21.4	1423.4	-			27.8	14.8
(r1>r2<r3<r4)	Topsoil		Clayey Sand		Clayey Sand		Sandstone					
VES 07, AKH	31.7	1.0	63.3	1.2	85.8	5.9	42.3	13.8	1330.6	-	21.9	10.2
(r1<r2<r3>r4<r5)	Topsoil		Clayey Sand		Clayey Sand		Clayey Sand		Sandstone			
VES 08, AK	43.8	0.9	83.7	21.9	483.3	158.6	17.5	-			181.4	23.5
(r1<r2<r3>r4)	Topsoil		Clayey Sand		Sandy Clay		Shale/clay					
VES 09, HA	197.5	7.0	115.8	42.1	122.3	28.3	956.9	-			77.4	22.2
(r1>r2<r3<r4)	Topsoil		Sandy Clay		Fine Medium Sand		Sandstine					
VES 10, KH	67.5	0.1	210.7	3.5	66.6	11.7	1866.4	-			15.4	9.4
(r1<r2>r3<r4)	Topsoil		Sandy Clay		Clayey Sand		Sandstone					

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Table 2: Physical and Chemical Analysis of Well Water Samples

Parameters/Analysis	WHO/EPA Standard Values	SAMPLES											
		Section 1				Section 2			Section 3				
		1	2	3	4	5A	5B	6	7	8A	8B	9	10
Physical Parameters													
Water Temp. (oC)	25.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
Total Depth of Wells (m)	-	6.3	8.4	15.5	16.8	4.4	-	14.8	10.2	23.5	-	22.2	9.4
Appearance (Colour)	Colour-less	Colour-less	Colour-less	Colour-less	Colour-less	Colour-less	Light Brown	Colour less	Light Brown	Colour less	Colour Less	Colour less	Light Brown
Taste	Taste-less	Taste-less	Taste-less	Taste-less	Taste-less	Taste-less	Taste-less	Taste-less	Taste-less	Taste-less	Taste-Less	Taste-less	Taste-less
Odour	Odour-less	Odour-less	Odour-less	Odour-less	Odour-less	Odour-less	Odour-less	Odour-less	Odour-less	Odour-less	Odour-Less	Odour-less	Odour-less
Turbidity	5	0.24	0.56	0.32	3.72	7.8	14.6	0.28	12.4	0.24	0.264	3.6	8.2
Conductivity (Ωm)-1	1500.0	246.0	285.0	246.0	292.0	339.0	231.0	346.0	169.0	431.0	154.0	62.0	139.0
Chemical Parameters													
pH	6.5 - 8.5	6.8	6.2	7.1	6.9	6.6	6.4	6.9	6.4	7.2	6.0	6.1	6.1
Residual Chlorine	0.1 - 0.5	0.1	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	0.2	Nil	Nil
Iron (mg/l)	0.1 - 0.3	0.1	0.48	0.02	0.08	0.1	0.1	0.02	0.02	0.04	0.01	0.06	0.06
Total Alkalinity (mg/l)	30.0 -50.0	20.0	26.0	27.0	20.0	22.0	24.0	13.0	18.0	33.0	30.0	8.0	19.0
Acidity (mg/l)	-	16.0	56.0	12.0	14.0	36.0	40.0	20.0	38.0	10.0	100.0	42.0	40.0
Total Hardness (mg/l)	60.0 -300.0	100.0	80.0	142.0	86.0	114.0	78.0	130.0	96.0	156.0	42.0	34.0	50.0
Calcium Hardness (mg/l)	60.0 – 200.0	62.0	34.0	100.0	46.0	72.0	42.0	88.0	76.0	124.0	24.0	24.0	32.0
Magnesium Hardness (mg/l)	50.0 – 150.0	38.0	46.0	42.0	40.0	42.0	36.0	42.0	20.0	32.0	52.0	10.0	18.0
Free Carbon-dioxide (mg/l)	60.0	0.28	4.2	0.21	0.25	0.31	0.35	0.26	0.36	0.18	4.6	4.4	43.0
Chloride (mg/l)	200.0 – 250.0	20.0	14.0	18.0	22.0	24.0	18.0	23.0	13.0	24.0	15.0	5.0	14.0
Nitrite (mg/l)	0.0 – 1.0	0.15	0.05	0.05	0.05	0.15	0.15	0.1	0.15	0.05	0.05	0.15	0.05
Organic Matter	-	0.16	0.26	0.18	0.32	0.68	0.22	0.72	0.26	0.76	0.24	0.14	0.24
Silica (mg/l)	10.0 – 60.0	10.0	12.0	12.0	12.0	14.0	14.0	14.0	12.0	14.0	10.0	6.0	10.0
Salinity (m/l)	-	120.0	140.0	120.0	142.0	165.0	113.0	171.0	83.0	212.0	76.0	30.0	68.0
Total Dissolved Solids (mg/l)	500.0	160.0	185.0	160.0	190.0	220.0	150.0	225.0	110.0	280.0	100.0	40.0	90.0

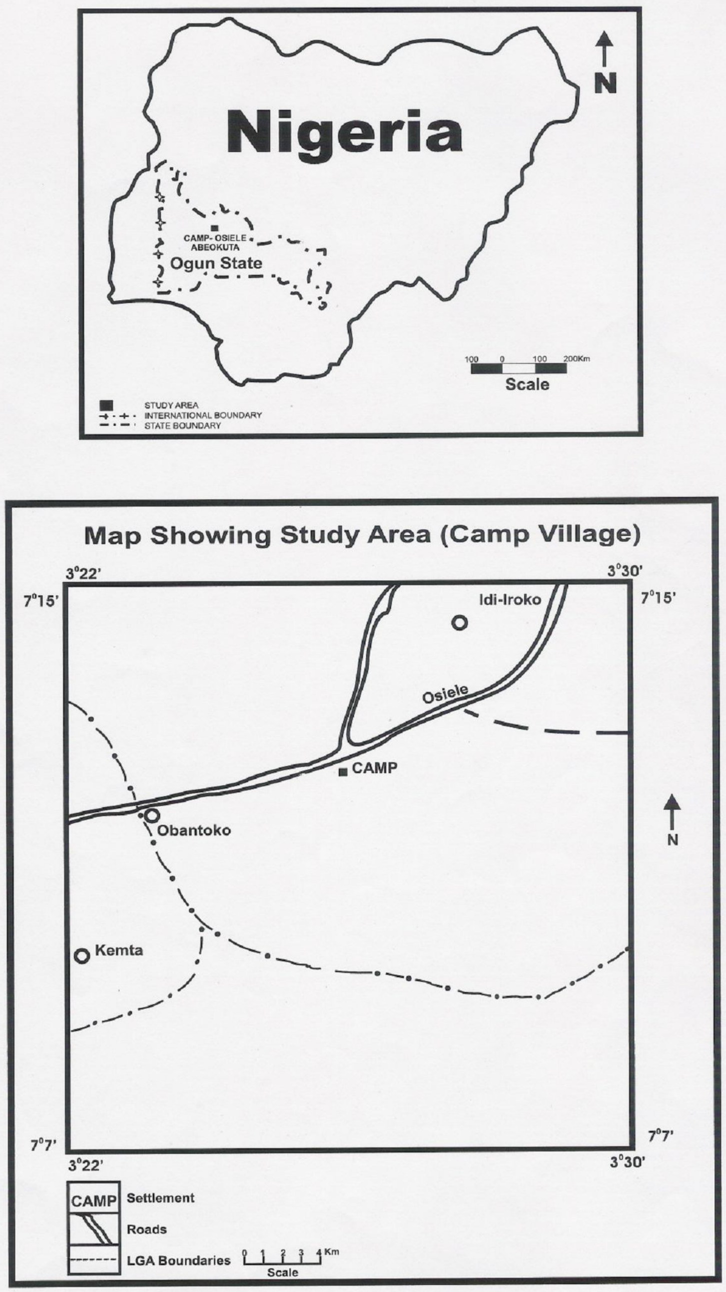

Fig. 1.0: Maps showing location of study area.

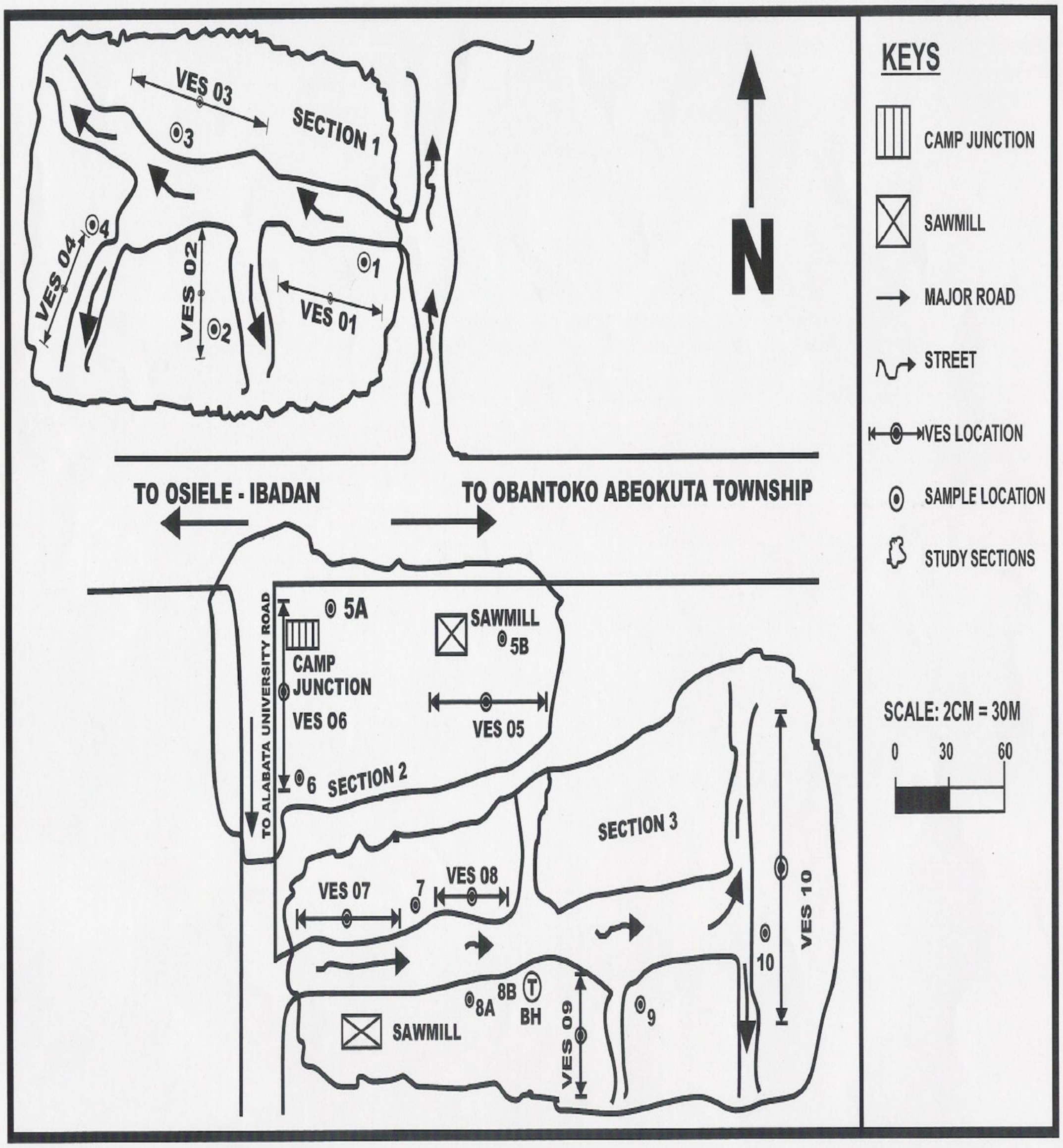

Fig. 2.0: Geographical Data Acquisition Map Showing VES Stations And Sample Locations