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LONGITUDINAL CONDUCTANCE AND PROTECTIVE CAPACITY OF GROUNDWATER FLOW OF UNYENGE AND ITAKIFAIN AKWA IBOM STATE

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Abstract: *Ground water exist sintheintersticesofsoils or weathered/fractured rocks (geologic formation) knownasaquifers. Geophysical investigation to determine post impact assessment was carried out in the subsurface stratigraphy using vertical Electric Sounding (VES). This investigate resistivity in relationship with depth and soil environmental properties. The resistivity measurementsb were made by using Terca 3 earth resistivity meter. The protective Capacity were determined through the calculated Longitudinal Conductance, which shows a moIt was discovered that the Near Surfaderate at a layer Resistivity of 2.85 ohm.m and the thickness of 0.85 where th Longitudinal Conductance is 0.65 which is less thsn one.This implied that the sediments are averagely very loose and unlithified.*

Keywords: *Longitudinal Coductance, Pretective Cpacity, Groundwater, Vertical Electrical Sounding*

Any community's potential to thrive depends on the accessibility of necessities like electricity, excellent roads, and water. Since it is essential to each community's development, the quest for accessible, clean, and sustainable water will never end (Salako et al., 2009). Water is a gift from nature that is abundant, observable by its presence (on the surface, in the form of rain, and underground), and has the ability to change via repetition. According to Abdullahi et al. (2017), hydrological evaporation, condensation, and precipitation. One of the most crucial elements for community development is water. Planning and development of groundwater systems require a thorough understanding of an area's hydro-geological and hydro-chemical properties. For domestic, industrial, and agricultural purposes, groundwater has significantly increased in importance as a source of freshwater in urban and rural areas of both developed and developing countries (Duroway et al., 2014).For humans to live healthy, productive lives in any culture, they must have access to portable, clean drinking water. In the majority of our urban and rural populations, as well as for industrial and agricultural applications, ground water is a vital supply of portable drinking water. However, due to inadequate waste disposal and management methods, maintaining a portable ground water supply that is free of microbiological and chemical contamination is far from becoming a reality in most of our metropolitan areas (Chernicoff and Whitney, 2009).

Despite the fact that water is essential for survival, finding drinkable water can be difficult in many parts of the world, especially in developing nations like Ghana. Most rural communities have traditionally relied on a variety of surface water sources, including lakes, streams, dugouts, and impoundment ponds. Some of these surface water sources are highly contaminated, leading to illnesses that are water-borne or connected to water, like diarrhea, guinea worm, bilharzia, and so forth (Gyau Boakye et al., 2008). Rural populations in Nigeria and throughout Africa have made access to clean water their top priority. Because of the growing population, which is causing more industrialization and agricultural activity, it is getting more and harder to find a sufficient supply of potable water. As a result, there is a search for additional options to supplement surface water in order to meet the rising demand from population growth and industry activities. Because of this, the globe is dependent on groundwater, which is the largest source of high-quality fresh water that is underground. Nearly every location on the land surface has subsurface openings large enough to give water in a useable quantity to wells and springs, making groundwater one of the most readily accessible natural resources.

The pre-cambrian crystalline basement rock that covers more than half of Nigeria limits the development of groundwater resources there (Kazeem, 2007). The formation of secondary porosity and permeability by weathering and/or fracturing of the parent rocks is mostly responsible for the presence of groundwater in this environment(Olayinka et al., 1997).There is a need for thorough pre-drilling geophysical investigations since the crystalline basement complex terrain is frequently characterized by aquifers that are discontinuous, or localized, in nature (Dan-Hassan et al., 1999; Omosuyi et al., 2008). Groundwater is the liquid that fills the moist spaces beneath the surface of the earth. Groundwater is mostly derived from air moisture that has precipitated and seeped into the subsurface layers of the soil. The porosity and permeability of the host rocks affect the quantity, accessibility, and exploitability of groundwater (Obiora et al., 2015).In the transport and recovery of ground water, both characteristics are crucial. The volume of fluid that a geologic material can contain depends on its porosity (Abdullahi et al., 2017). According to Obiora et al. (2017), it is the volume ratio of pore spaces to the overall volume of soil, rock, or silt.

Urbanization, industrialization, and agricultural-related activities have put tremendous strain on groundwater, the primary source of potable water supply for home, industrial, and agricultural applications (Belmonte et al., 2004). The current social demands, therefore, include both finding new groundwater supplies and protecting them. Leachate from landfills, salt intrusion, oil spills, mining activities, and sewage (from latrines, buried petroleum pipelines, and septic tanks) can all contaminate groundwater and reduce its portability (Makeig, 1982). Dumpsites and latrines are built without taking into account the hydro-geological conditions of the area, endangering groundwater supplies in the future (Ugbaja et al., 2004).Groundwater pollution could be widely dispersed due to the widespread usage of chemical goods and the large-scale dumping of waste materials. Pesticides, herbicides, and solvents are just a few examples of dangerous chemicals that are frequently utilized in daily life. In urban, industrial, and agricultural environments, a large variety of chemicals are widely used.Some of these chemicals can eventually get into the groundwater and contaminate it, whether they are purposefully disposed of, accidently spilled, or put to the ground for agricultural purposes. Such pollution can represent a major concern to public health due to the quantity of toxic wastes and their stability in groundwater.Almost all significant industrial and agricultural sites have historically disposed of their trash on-site, frequently in a discrete area of the land. Every municipality has been required to dispose of its waste at specific areas close by. The possibility of contaminating groundwater has not always been taken into account while dealing with spills and previous waste disposal methods.

The permeability, porosity, and overburden thickness of geologic formations all influence the rate of groundwater contamination. It is possible for polluting influent to escape into the subsurface and contaminate groundwater when the underlying geologic material is unconsolidated and uncompacted, such as coarse sand (Keswick et al.,1982). This makes the soil corrosive and creates a polluting plume that can extend hundreds of meters.(Dan-Hassan 2001) discovered that the aquifers of the basement complex rocks of north-central Nigeria are primarily weathered overburden aquifers using the electrical resistivity method and borehole lithologic logs. Groundwater is crucial for residential and industrial processes, food production, sanitation, and other essential human activities. Its significance to the survival of man is enormous. However, due to the overstretching of the aquifer caused by water milling, the movement of leachates from dumpsites into the aquifer, leaks from surface and underground storage, salt water intrusion, oil spills, mining activities, sewage from latrines, underlined petroleum pipes, and septic tanks, the quality of groundwater has gotten worse over time (Makeig, 1982). It is imperative to have systems for managing and safeguarding such important resources.

Groundwater supplies over 80% of residential water in Nigeria, partly because they are less expensive to develop (Offodile 2014) and maybe because they are located closer to the end users. Groundwater resources must be developed and safeguarded from contamination in order to fulfill the rising demand for water and guarantee sustainable access to safe and sufficient clean water.The permeability, porosity, and overburden thickness of geologic formations play a significant role in determining how susceptible groundwater is to contamination from other sources (Obiora et al. 2015).In the past ten years, there has been an upsurge in the use of geophysical technologies, particularly VES, for hydrogeological site assessment (Vereecken et al. 2004; Herckenrath et al. 2013, Mosuro et al. 2017). It has been used to solve hydrogeological-related problems (Faneca Sa'nchez et al. 2013; Burschil et al. 2012) and is widely used due to portable equipment, quick measurements, and less ambiguity in data interpretation. It is also an environmentally friendly (non-destructive) method (Todd and Mays 2005; Adeniji et al. 2014).

Using the electrical resistivity approach, Mosuro et al. (2017) evaluated the groundwater's susceptibility to leachate penetration and came to the conclusion that the aquifers surrounding the dumpsites have insufficient protective capacity and are vulnerable to leachate contamination. In Makurdi, Benue state, Obiora et al. (2015) employed the electrical resistivity method to assess the soil corrosivity and aquifer protective capability.In order to protect the hydrological settings, they chose locations for the placement of companies and the laying of iron pipes. Adeniji et al. (2014) classified the region into zones of good, moderate, weak, and poor aquifer protective capacity after evaluating soil corrosivity and aquifer protective capacity using geo-electrical investigation in the Bwari Basement Complex area of Abuja.However, research on aquifer protective capacity by Abiola et al. 2009, Atakpo and Ayolabi 2009, Ehirim and Nwankwo 2010 and Akana et al. 2016 found no correlation between an aquifer's rate of vulnerability and the quality of its groundwater for drinking. It is necessary to assess the groundwater quality in order to determine whether areas with a high APC correspond to areas with excellent or good water for drinking purposes, and vice versa. Aquifer protective capacity (APC) refers to the ability of the overburden unit to delay and filter percolating ground surface-polluting fluid into the aquifer units (Adeniji et al. 2014).

According to Ahmad et al. (2016), corrosion is the breakdown of a substance or its qualities as a result of a reaction with the environment. Almost all surface and subsurface materials contain it. However, metals are most frequently linked to it. According to Revie et al. (2008), soil corrosion is a process that can occur naturally or artificially in which the soil structure is oxidized or reduced to a corrosion product, such as "contaminated soil," by a chemical or electrochemical reaction with the environment.

According to Ahmad et al. (2016), corrosive soils typically include high concentrations of soluble salts, particularly in the form of sulfates, chlorides, and bicarbonates. As a result, they may have a high acidity (low pH) or high alkalinity (high pH). According to Bullard et al. (2004), soils with high clay and silt contents typically have a fine texture, a high water-holding capacity, and are consequently poorly aerated and drained.As a result, they are also more susceptible to corrosion than soils with a coarser texture, such as sands and gravel, where there is better air circulation (Bullard et al., 2004). In order to investigate Nigeria's soil corrosivity and aquifer protective capability, several researchers recently used the electrical resistivity approach (Adeniji et al., 2014).According to George et al. (2014), corrosive soils have chemical components that may react with building materials like concrete and ferrous metals to cause damage to foundations and underground pipelines. The groundwater that is in touch with the corroding structure is where the electrochemical corrosion processes that take place on metal surfaces in soils take place (Muraina et al., 2012).

Today, we see more and more boreholes being dug by the government, non-governmental groups, and private citizens. This demonstrates unequivocally how groundwater in Unyenge and Itakifaha Awa-Ibom State successfully complements other sources of water supply. This is a result of the rivers, lakes, and streams becoming contaminated at an unsafe pace. Due to its physical, biological, or chemical impurities, surface water is determined to have a severely diminished quality (Edet et al., 2009).

Due to the rising demand for the good for residential and agricultural purposes, there has been an increase in the need for water in the community. It has proven challenging to manage the current water supply to completely fulfill all requirements, especially during the dry season. Therefore, groundwater is likely to be the source that can help with the issue, necessitating the need to identify real and efficient ways to utilize it.In spite of this respite appearing to be significant, there may still be risks of groundwater pollution due to soil corrosivity and infiltration of contaminants from the surface through migratory pathways into the aquifers. We employed the VES approach to analyze the subsurface structure layering in Unyenge and Itakifain in the Mbo and Ibeno local government areas of Akwa-Ibom State with the goal of determining the protective capacity through Longitudinal Conductance as part of our effort to monitor the quality of groundwater.

Area of the Study

The poll was conducted throughout a number of Unyenge and Itakifain local government areas in Akwa Ibow state's Mbo and Ibeno local government regions. The location's local geology is made up of sediments that are typical of several depositional settings. Geologically speaking, deposits are young, dating from the Eocene to the most recent Pliocene. They consist of sediments from the open shelf, front platform of the delta, and river mouth.The sands and clays of the sub-horizontal delta front platform converge with the coarse-grained sands of the river mouth bar sediments in shallow water depths.Within the range of latitude 4°32′48.0″ N and longitude

8°06′03.1″ E are its geographic coordinates. Due to its subequatorial location, the region has alternate dry and wet seasons. The dry season begins in November and lasts until March, whereas the wet season lasts from March to October with a respite in August. With average yearly temperatures of roughly 23°C and relative humidity readings of more than 80%, the area experiences quite high temperatures and levels of humidity. A dense rainforest is more likely to exist in the area due to the overall climatic conditions. Alluvium is present overlying the area. The baseof the alluvium is slightly unconformable upon the underlying Benin Formation underlain AgbadaFormation and oil source rock of Akata shale as shown in Table1.

Table1:Stratigraphyofunderlyingsedimentsinthearea

Age	**Formation**	**Recognized aquifers**
Recent	Alluvium	**Aquifersunderarea**
Tertiary	BeninFormation	
	AgbadaFormation	
	Akatashales	

METHOD

Vertical Electrical Sounding (VES), a geophysical technique, was used to explore the subsurface strata. This study examines the effects of depth and the environmental characteristics of the soil on resistivity. Electrical potential that has been artificially produced between two positions is used to accomplish this.The Terca3 earth resistivity meter, model C.A 6470N, was used to measure the resistivity. A completely automated resistivity meter for DC electrical surveys is part of the equipment. Two current electrodes, P1 and P2, were used to inject current into the ground, and the potential electrodes, C1 and C2, were used to measure the voltage difference that resulted.Four electrodes in the Schlumberger configuration were used. Two electrodes that are external but in a direct line with the potential electrodes, the potential difference is detected. A deeper penetration of the electric field occurs and a different apparent resistivity is obtained as the distance between the electrodes is increased. The apparent specific resistance against half the distance between the current electrodes is presented in a depth graph to represent the measured apparent resistivity.At the location that the community designated for the drilling of the borehole, a vertical electrical sounding was conducted. The depth-point curve was interpreted using computer-aided interpretations software. The appendix displays both the interpreted model and the graphic of the measured data.

RESISTIVITY FROM FIELD DATA

Resistivity were calculated from the data collected from the field according to the vertical electrical sounding position. These are shown in the Table 2 below

Table 2. Calaculated Resistivity from Vertical Electrical Sounding Data

	VES 1			
S/N	AB/2	MN/2	V/I(ohms)	R(ohms.M)
1	1.5	0.25	20.8	285.88
2	2.25		06.5	204.20
3	3		00.5	308.86
4	4.5		03.2	405.89
5	6	0.5	0.97	108.94
6	7.5		00.4	70.37
	VES 2			
1	1.5	0.25	19.7	270.266

2	2.25		04.0	125.664
3	3		02.3	101.473
4	4.5		00.8	67.388
5	6	0.5	00.6	70.37
6	7.5		0.7	241.903
	VES 3			
1	1.5	0.25	4.29	58.96
2	2.25		3.57	112.15
3	3		3.71	108.34
4	4.5		1.18	149.67
5	6	0.5	1.12	411.67
6	7.5			
	VES 4			
1	1.5	0.25	1.32	18.005
2	2.25		2.73	25.765
3	3		4.23	237.54
4	4.5		6.71	851.10
5	6	0.5	1.58	177.45
6	7.5		1.81	318.43
	VES 5			
1	1.5	0.25	26.0	357.356
2	2.25		15.0	471.239
3	3		13.0	730.028
4	4.5		07.7	976.682
5	6	0.5	05.0	561.560
6	7.5		06.0	1161.133
	VES 6			
1	1.5	0.25	13.0	178.68
2	2.25		05.3	163.363
3	3		03.5	196.55
4	4.5		01.8	228.315
5	6	0.5	01.7	190.930

LAYERS INTERPRETED FROM VES 1-10

The layers interpreted from VES 1-10 are shown in the table below. These show that VES 1,2,4 and 9 has four (4) layers, VES 3,5 and 10 has three (3) layers while VES 6,7 and 8 has two layers each.

Table 3.Laters Interpredate Data from VES Data

Layers	Depth	Thickness	Ohms.m
		VES 1	
1	0.82	0.82	218.38
2	1.88	1.07	454.38
3	2.31	0.43	295.45
4	4.13	1.82	2.8
		VES 2	
1	0.34	0.34	2551.46
2	2.28	1.95	138.65
3	4.33	2.01	22.14

4	5.78	1.45	742.20
VES 3			
1	0.53	0.53	29.69
2	0.74	0.22	52.03
3	4.13	3.39	2564.37
	VES 4		
1	0.54	0.54	90.43
2	1.56	1.02	258.68
3	1.85	0.29	87.70
4	4.13	2.28	36.55
	VES 5		
1	0.58	0.58	232.62
2	0.84	0.25	503.14
3	4.13	3.24	1006.71
VES 6			
1	0.44	0.44	130.36
2	4.13	3.69	202.50
VES 7			
1	0.51	0.51	106.16
2	4.13	3.62	230.18
VES 8			
1	0.40	0.40	170.72
2	4.13	3.73	276.44
VES 9			
1	0.48	0.48	169.64
2	0.60	0.12	5169.34
3	0.95	0.34	9694.25
4	4.13	3.18	31.7
VES 10			
1	0.35	0.35	183.70
2	0.42	0.07	667.81
3	4.13	3.71	827.47

The parameters (Hydraulic Conductivity, Transmissivity, Transverse Resistance and Longitudinal conductance were calculated through layers interpreted from the field data. These are shown in Table 4 below

Table 4: CALCULATED PARAMETERS (HYDRAULIC CONDUCTIVITY, TRANSMISSIVITY, TRANSVERSE RESISTANCE, LONGITUDINAL CONDUCTANCE)

VES	LAYER RESISTIVITY	THICKNESS	Ke-HYDRALIC COND.	Te-TRANSMISIVITY	Tr-TRANS. RESISTANCE	L.C-LONG. CONDUCTANCE	PROTECTIVE CAPACITY
VES 1	218.38	0.82	$4.6X10^{-3}$	$3.7X10^{-3}$	179.07	$3.7X10^{-3}$	Poor
	454.38	1.07	$2.2x10^{-3}$	$2.3x10^{-3}$	486.19	$2.3x10^{-3}$	Poor
	295.45	0.43	$3.4x10^{-3}$	$1.4x10^{-3}$	127.04	$1.4x10^{-3}$	Poor
	2.85	1.82	0.3	0.65	5.157	0.65	Moderate
VES 2	2551.46	6.34	$3.9x10^{-4}$	$2.5x10^{-3}$	$1.6x10^{4}$	$2.5x10^{-3}$	Poor
	138.65	1.95	$7.2x10^{-3}$	$1.4x10^{-2}$	270.36	$1.4x10^{-2}$	Poor

	22.14	2.05	4.5x10^{-2}	9.26x10^{-2}	45.39	9.26x10^{-2}	Poor
	742.20	1.45	1.3x10^{-3}	1.9x10^{-3}	1.08x10^{3}	1.9x10^{-3}	Poor
VES 3	29.69	0.53	3.4x10^{-2}	1.8x10^{-2}	15.73	1.8x10^{-2}	Poor
	52.03	0.22	1.9x10^{-2}	4.2x10^{-3}	11.45	4.2x10^{-3}	Poor
	2564.37	3.39	3.9x10^{-4}	1.3x10^{-3}	8693.21	1.3x10^{-3}	Poor
VES 4	90.43	0.54	1.1x10^{-2}	5.9x10^{-3}	48.83	5.9x10^{-3}	Poor
	258.68	1.02	3.86x10^{-3}	3.94x10^{-3}	263.85	3.94x10^{-3}	Poor
	87.70	0.29	1.14x10^{-2}	3.3x10^{-3}	25.43	3.3x10^{-3}	Poor
	36.55	2.28	2.7x10^{-2}	6.2x10^{-2}	83.33	6.2x10^{-2}	Poor
VES 5	232.62	0.58	4.3x10^{-3}	2.4x10^{-3}	134.91	2.4x10^{-3}	Poor
	503.14	0.25	1.98x10^{-3}	4.97x10^{-4}	125.79	4.97x10^{-4}	Poor
	1004.71	3.24	9.9x10^{-4}	3.2x10^{-3}	3.2x10^{3}	3.2x10^{-3}	Poor
VES 6	130.36	0.44	7.67x10^{-3}	3.37x10^{-3}	57.35	3.37x10^{-3}	Poor
	202.50	3.69	4.9x10^{-3}	1.8x10^{-2}	747.22	1.8x10^{-2}	Poor
VES 7	106.16	0.51	9.4x10^{-3}	4.5x10^{-3}	54.14	4.5x10^{-3}	Poor
	230.18	3.62	4.34x10^{-3}	1.5x10^{-2}	833.25	1.5x10^{-2}	Poor
VES 8	170.72	0.40	5.8x10^{-3}	2.3x10^{-3}	68.29	2.3x10^{-3}	Poor
	276.44	3.73	3.6x10^{-3}	1.3x10^{-2}	1031.12	1.3x10^{-2}	Poor
VES 9	169.64	0.48	5.8x10^{-3}	2.8x10^{-3}	81.43	2.8x10^{-3}	Poor
	5169.34	0.12	1.9x10^{-4}	2.3x10^{-5}	620.32	2.3x10^{-5}	Poor
	9694.25	0.34	1.0x10^{-4}	3.5x10^{-5}	3296.0	3.5x10^{-5}	Poor
	31.7	3.18	3.1x10^{-2}	0.1	98.89	0.1	Poor
VES 10	183.70	0.35	5.44x10^{-3}	1.90x10^{-3}	64.29	1.90x10^{-3}	Poor
	667.81	0.07	1.49x10^{-3}	1.04x10^{-4}	46.746	1.04x10^{-4}	Poor
	827.47	3.71	1.2x10^{-3}	4.4x10^{-3}	3069.9	4.4x10^{-3}	Poor

Area considered as slightly too very strongly corrosive are area where the resistivity alues are less than 180Ωm table 4., the longitudinal conductance are between 0.000023 – 0.65. The area where the resistivity values are practically non corrosive, part of the study area characterized by materials of poor to weak protective capacity has longitudinal conductance values of less than 0.1Ωm. The aquifer are characterized by thick overburden , moderate to good protective capacity and exhibit moderate to relatively high values coefficients of anisotropy, and a transverse unit resistance which suggest that the materials above aquifers act as seal.

CONCLUSION

Near surface water regimes within the top layers. Average protective capacity is poor for all ten VES points, implied that the sediments are averagely very loose and unlithified. There is high tendency of having seeps to top surface and percolation from it thereby, increasing chances of pollution. This can be further investigated by collection of groundwater samples from boreholes (old or new) around VES points for chemical analysis.

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