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Subsurface Investigation for Effective Water Resource Prospect: A Panacea to Problem of Water Supply Services in the Built Environment of the Newly Created Areas in Anambra, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author UFI designed the study, prepared the field work, wrote the protocol as well as the first draft of the manuscript. Author AAO managed the field work, interpreted the data and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The creation of new Local Government Areas (LGA) in Nigeria has brought about problem of water scarcity due to population increase and consequent increase in the construction of residential buildings; especially in the south east in the recent time . Ihiala LGA is a case under study. Since the creation of Ihiala local government area in Anambra State of Nigeria, there is the need for underground water resource development for effective water supply system towards sustainable housing in the area due to population increase, and development of more residential buildings. By using Vertical Electrical Sounding (VES) technique in geophysical survey of the subsurface, it was discovered that there are about six litho-logical units in the area. The subsurface litho-logy, aquifer depth and their dispositions, were probed using Abem Tetrameters 300 SAS and Geographic Information System equipments to identify the resistivity of the formations. In the area, sand stone

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deposit is prominent at the upper levels between 3 to 27 meters. Aquifer depth is located within 75 to 120 meters. The saturated sand stones significantly occur within the 3rd and 5th layers of the litho-logical horizons. The aquifer is mostly semi confined, and composed of sand, silty sand and sand-stone mineral aggregates. Subsurface water resources exploitation using borehole facility in the area therefore should reference these discoveries for easy and sustainable underground water resource development, to meet the people daily need for good water in the study area.

Keywords: Ihiala local government area; sedimentary basin; vertical electrical sounding; aquifer; water supply; residential buildings.

1. INTRODUCTION

Local government creation in Nigeria brought about attendant population increase which called for construction of more residential buildings and the consequent need for underground water resources development, for economic and domestic purposes in the built environment; since the available water is no longer enough in these areas. Water borehole drilling failures abound in most of these new local governments, due to lack of appropriate exploration information [1]; hence the need for geophysical investigation of their sub-surfaces. Besides, open channel and unconfined underground water sources in most of these areas in the south eastern Nigeria especially suffer pollution; characterized with objectionable test to food, and unsuitable for most industrial uses [2,3]. Hence, the need for effective geophysical investigation of their sub-surfaces for sustainable underground water resource development arises.

In this work, effort had been made to probe the sub-surface litho-logy, aquifer depth and dispositions, using Abem tetrameters 300 SAS and geographic information system equipments. It was observed that the success of the exploitation of underground water resources depends on the effective probing of the subsurface litho-logy, by identifying the resistivity of the formations; hence aquifer disposition [4]. The area is located within Anambra sedimentary basin of the south eastern Nigeria. It is Bounded by longitude 6º45 E to 7ºE and latitude 5º45 N to 6ºN. The drainage pattern is dendrites, typical of sedimentary rock with uniform resistance and homogeneous geology [5]. The area is of tropical climate and experience two air masses - Equatorial maritime air mass associated with the rain bearing wind which is a south west wind from the Atlantic ocean blowing around March to September [6]; while the dry season trade wind comes from Sahara desert around October to February to cause dryness. In another dimension, the area is overlain by Benin formation of Miocene age and underlain by Ameki formation of Paleocene age [7], as shown in Table 1.

2. RESEARCH METHODS AND MATERIALS

The study is an original field work investigation on aquifer litho-logical settings in the study area. Vertical electrical sounding technique (VES), using tetrameter 300 SAS was carried out in line with Schlumberger approach to identify the litho-logical variations, as well as deduce the aquifer types and depths in the built environment [8].

The Schlumberger approach in VES is usually carried out in probing the litho-logy of the earth with tetrameter by sending the electrical current down the earth, and measuring the potential drop and resistance, as well as the conductivity of the formation. The resistance signal shows the type of the litho-logic formation for easy prospect of the potential source in the investigation.

3. RESULTS AND DISCUSSION OF THE FINDINGS

The geological and location map of the study area is shown in Fig. 1 [9]; while the stratigraphic succession of the area is shown in Table 1 [10]. Results obtained from the field therefore are displayed for observation as shown in Tables 2 (a-h). Aquifer litho-logical units are also shown in Fig. 2, while the prospective aquifers natures are shown in Table 3.

3.1 Results the Investigation

In Tables 2 (A-H) are shown the varying range of the horizons of the successive litho-logic units of the various locations in Ihiala LGA.

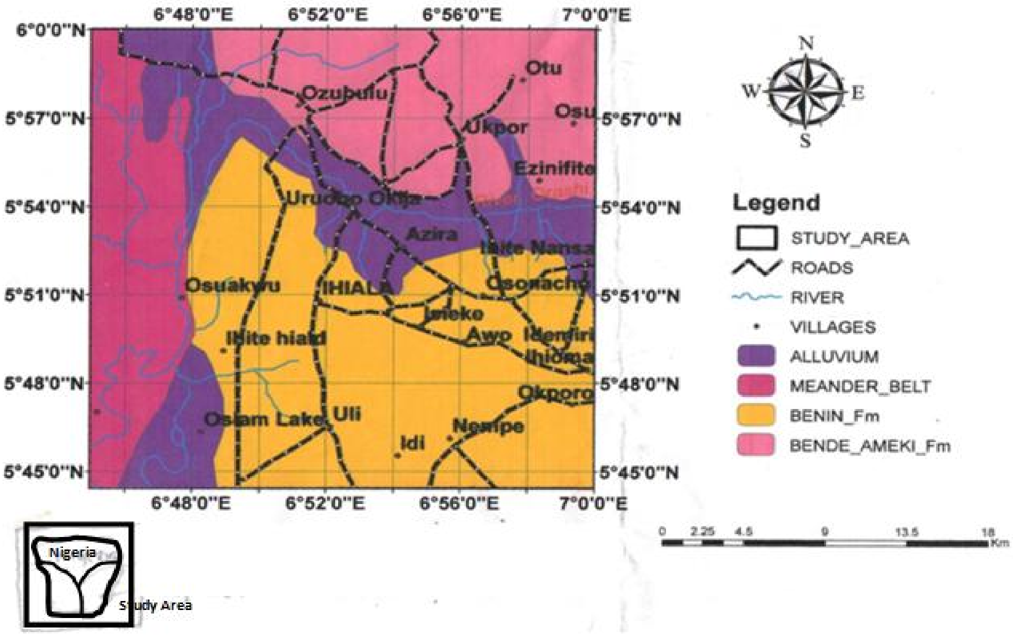

Fig 1. Geological and location map of the area

Source: Adopted from Elueze, (2002)

Table 1. The stratigraphic succession of the area

S/n	Age	Formation
1	Miocene	Benin formation
2	Paleocene	Ameki Formation

Source: Adopted from Ofodile, (2012)

Table 2. (A-H)

Okija (A)

Ves	Thickness (M) VES 1	Litho-logical description
1.	0-1.4	Sandy top soil
2.	1.5 - 57	Silty sand
3.	58 - 78	Sand
4.	79 - 90	Sand with clay lenses
5.	91 - 111	Sand stone
6.	112 - below	Silty sand

Source: Authors' field work, (2019)

Ezinifite (B)

Ves.	Thickness (M) VES 2	Litho-logical description
1.	0 - 6	Sandy top soil
2.	7 - 15	Slity sand
3.	16 -33	Sand
4.	34 - 70	Sand with clay lenses
5.	71 – 105	Sand stone
6.	105 – below	Silty sand

Source: Authors' field work, (2019)

Isieke (C)

Ves	Thickness (M) VES 8	Litho-logical description
1.	0 – 9	Top soil
2.	10 – 21	Sand
3.	22 - 27	Clayey sand
4.	28 – 75	Sand stone
5.	76 – 118	Sand stone
6.	119 – 128	Sand stone
7.	129 – below	Clayey shale.

Source: Authors' field work, (2019)

Azira (Okija) (D)

Ves	Thickness (M) VES 3	Litho-logical description
1.	0 – 9	Top soil
2.	10 – 30	Sand stone
3.	30 - 55	Silty sand
4.	55 - 85	Sand
5.	85 – 113	Sand stone
6.	114 – 122	Transition
7.	123 –below	Clay base

Source: Authors' field work, (2019)

Ihiala (E)

Ves	Thickness (M) VES 4	Litho-logical description
1.	0 - 9	Sandy top soil
2.	10 – 24	Shaley sand stone
3.	24 – 61	Sandy clay
4.	61 – 75	Sand
5.	75 – 94	Sand
6.	94 –below	Clay

Source: Authors' field work, (2019)

Osaka (F)

Ves	Thickness (M) VES 5	Litho-logical description
1.	0 – 2.8	Sandy top soil
2.	2.9 – 46	Sand stone
3.	47 – 98	Sand
4.	98 – 107	Sand stone
5.	108 – 121	Sand
6.	122 –below	Shale

Source: Authors' field work, (2019)

Ihitte (G)

Ves	Thickness (M) VES 7	Litho-logical description
1.	0 – 5	Sandy top soil
2.	6- 40	Sand
3.	41 – 90	Sandy clay
4.	91 – 98	Sand
5.	99 – 119	Sand
6.	120 –below	Shale base

Source: Authors' Field Work, (2019)

Osuakwu (H)

Ves	Thickness (M) VES 6	Litho-logical description
1.	0 – 4	Sandy top soil
2.	5 -30	Sand
3.	31 – 57	Sandy clay
4.	58 – 90	Shaley sandstone
5.	91 – 110	Sand
6.	111 – below	Clay base

Source: Authors' field work, (2019)

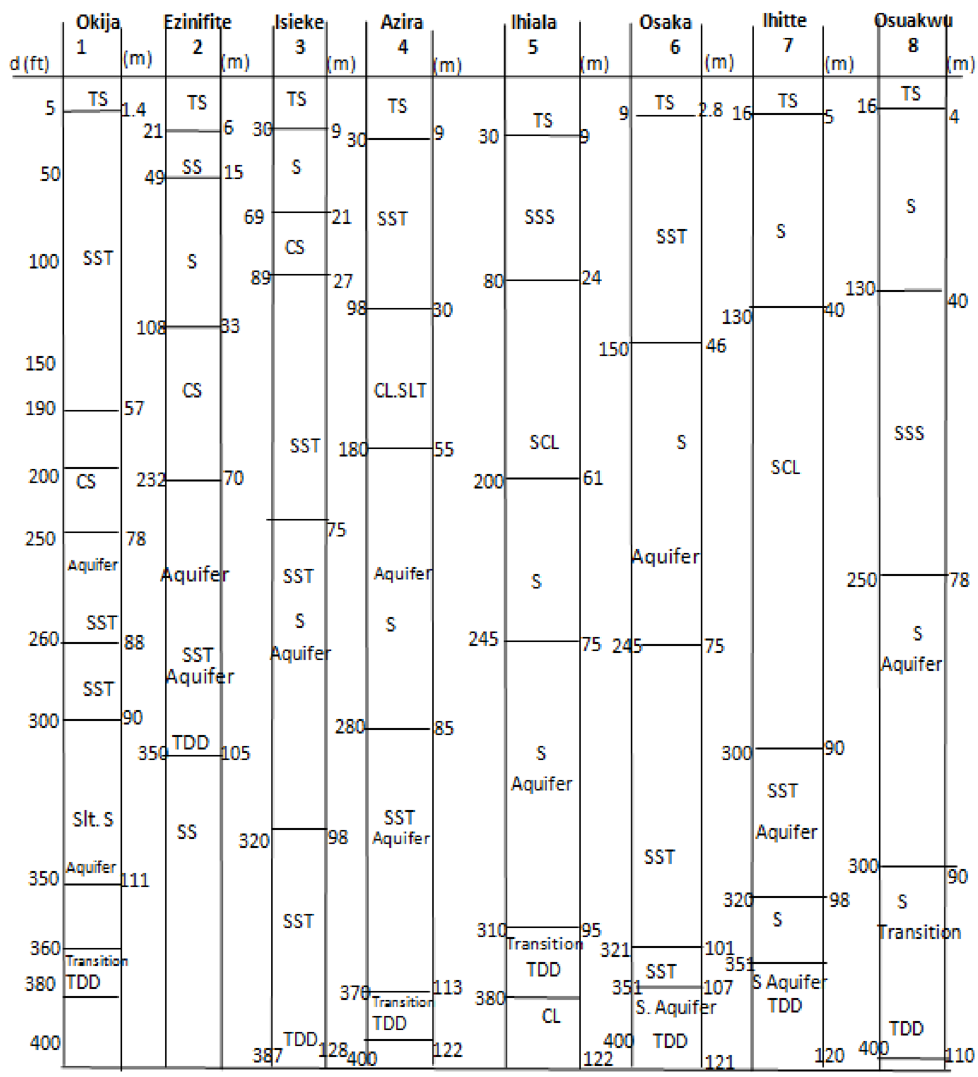

Fig. 2. Aquifer litho-logical units of different locations in the area

Source: Authors' field work investigations, (2019),

Legend: Slt.S – Silty Sand, S.Cl – Sandy Clay, Cl.Slt – Clayey Silt, S – Sand, Sst – Sandstone, SSS – Shaley Sandstone , CS – Clayey Sand, and TDD – Total Drill Depth

4. DISCUSSION OF FINDINGS

Borehole drilling practitioners in Ihiala area should observe that sand stone deposits are dominant at the shallow depth of about 3 to 27 meters. The range of aquifer depth is about 75 meters. Six to seven Litho-logical units abound in the area, and aquifer units significantly occur in

Table 3. Prospective aquifer nature (From VES results)

nUs1	Location	Depth to water table (M)	Number of layers	Aquifer materials	Overlying materials	Aguifer type
1	Okija	78	6	Sst & Slt.S	CS	Semi Confined
2.	Ezinifite	71	6	Sst	S.Cl	Semi confined
3.	Isieke	75	7	Sst	Sst	Confined
4.	Azira	55	7	S & Sst	Cl.Slt	Semi Confined
5.	Ihiala	75	6	S	S	Semi Unconfined
6.	Osaka	46 & 107	6	S & Sst	Sst	Confined
7.	Ihitte	90	6	S & Sst	S.Cl	Semi Confined
8.	Osuakwu	78	6	S	Sss	Semi Confined

Source: Authors' Field Work, (2019)

Legend: Slt.S – Silty Sand, S.Cl – Sandy Clay, Cl.Slt – Clayey Silt, S – Sand, Sst – Sandstone, Sss – Shaley Sandstone , CS – Clayey Sand, and TDD – Total Drill Depth

3rd to 5th litho-logical layers. The aquifer type is mainly of semi confined and is composed of sand, silt and sand stone. The semi confinement is marked at the upper level of the aquifer by sandy clay to sand stone, while the base is typically shale to clay layers. It is predominantly over laid by sandstone and sandy clay with little of sand, shaley sandstone, clayey sand and clayey silt; which explains the reason aquifer type is mainly of semi confined type in the area.

5. CONCLUSION

The average drill depth of the exploration in the area is 122 m as was observed in previous studies; and the aquifer units are observed to be mostly semi confined in nature. Unconfined aquifer is insignificant in the area, which suggests the potent of significant water supply from about 75 m depth as average depth of the aquifer in the study area. The work is helpful for effective subsurface water exploration in the built environment as it shows the aquifer dispositions and litho-logy of the area, as well as their respective depths for potential target of the water source in the study.

It is easy to drill in Ihiala – one of the newly created Local Government in Anambra State – where water is highly needed due to population increase in the recent time. Drilling in water prospect should stop at an average depth of 122 m. This is more reliable where the aquifer content is sand, silt to sandstone. The findings in this study therefore will facilitate aquifer identification for effective underground water exploration in the study area.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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