IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 6, Issue 3 Ver. II (May. – June. 2018), PP 35-43
www.iosrjournals.org

Aquifer Studies Using Well Test And Lithological Data Within Abakaliki And Afikpo Areas, South-Eastern Nigeria

Tochukwu Innocent Mgbeojedo[1], Latifa Shaheen Al-Naimi[2], Obioma Peter Nosiri[3], Chukwuebuka Nnamdi Onwubuariri[4]
[1](Professional Founder Geological Consulting, Qatar).
[2](Department of Chemistry and Earth Sciences, Qatar University, Qatar).
[3](Department of Geosciences, Federal University of Technology, Owerri, Nigeria).
[4](Department of Geosciences, Federal University of Technology, Owerri, Nigeria).
Corresponding Author: Tochukwu Innocent Mgbeojedo[1]

Abstract: *Aquifer studies within Abakaliki and Afikpo were carried out utilizing lithological and pumping test data. The study area falls under the Benue Trough with varying lithostratigraphy. Results of the study reveal that aquifers within the study area are mostly confined; the hydrostratigraphy ranges from fractured shales around Abakaliki area to sands/sandstones in some parts of Afikpo. Information from lithostratigraphic analysis reveals a regional groundwater divide. Aquifer depth varies from 20.8m to 52m with a mean value of 34.98m. It is also noted that the least aquifer thickness of the study area is 5m and the highest aquifer thickness is 36.8m. Analyses of the aquifer hydraulic characteristics of the study area show that the transmissivity varies from 0.14m^2/day to 9.3m^2/day with a regional mean value of 1.71m^2/day. Similarly, hydraulic conductivity varies from 8.0 x 10^{-4} m/day to 9.8 x 10^{-2} m/day with a mean value of 1.2 x 10^{-2} m/day. The study area has an aquifer storativity ranging from 1.05 x 10^{-5} to 1.56 x 10^{-4} with a mean value of 1.02 x 10^{-2}. The study area has a poor to fairly good ground water yield that can sustain rural water supply.*

Keywords: *Aquifer studies, hydrostratigraphy, storatativity, aquifer depth, pumping test*

Date of Submission: 08-05-2018 Date of acceptance: 24-05-2018

I. Introduction

Access to safe drinking water is a key ingredient for better health and poverty reduction. However, more than half of the rural people in Nigeria do not have access to a safe and reliable water supply. Faced with this reality, the international community has set Millennium Development Goals (MDGs) to help focus on activities that will address poverty and pursue sustainable development. Across much of the rural populace of Nigeria, the only realistic potable water supply option is groundwater. Alternative water resources are unreliable and expensive to develop and maintain. The understanding and management of groundwater in aquifer is still weak in many developing countries[6]. Therefore, understanding and developing groundwater resources is of critical importance if real progress is to be made towards the Millennium Development Goals (MDGs).

Most developing nations of the world like Nigeria, are challenged with acute shortage of water leading to serious inconveniences to the local people. Twenty percent (20%) of the population of the study area live in the urban and semi-urban areas, while the rest 80% live in the rural villages. An estimated total demand for water to meet the need of the people is 270,000m³/day but only about 25% is available(MICs report, UNICEF 2004).

This work is undertaken with the aim of providing a hydrogeological database for use in developing a sustainable groundwater resources management strategy for the study area.

This research is limited to the study of the aquifers of the study area with respect to the aquifer geometrics, aquifer hydraulic characteristics and hydrostratigraphy.

Location, Topography and Drainage of the Study Area

The study area is located within South-eastern Nigeria and lies within Longitude 7^0 00' - 8^0 00'E and Latitude 5° 50' - 6° 40'N. The study area is divided into two major hydrological provinces, with active flood plains of recent alluvium within the Abakaliki and Ikwo areas. The area has level to gently undulating sandstone and shale plain. The Cross River is the main river that drains the area; several of its tributaries, Asu River, Ebonyi River in the north, the Ubeyi, and Itara Rivers in the south and their numerous tributaries traverse the area in NE – SE direction. The drainage pattern is dendritic, some trellis thus indicating a degree of structural control.

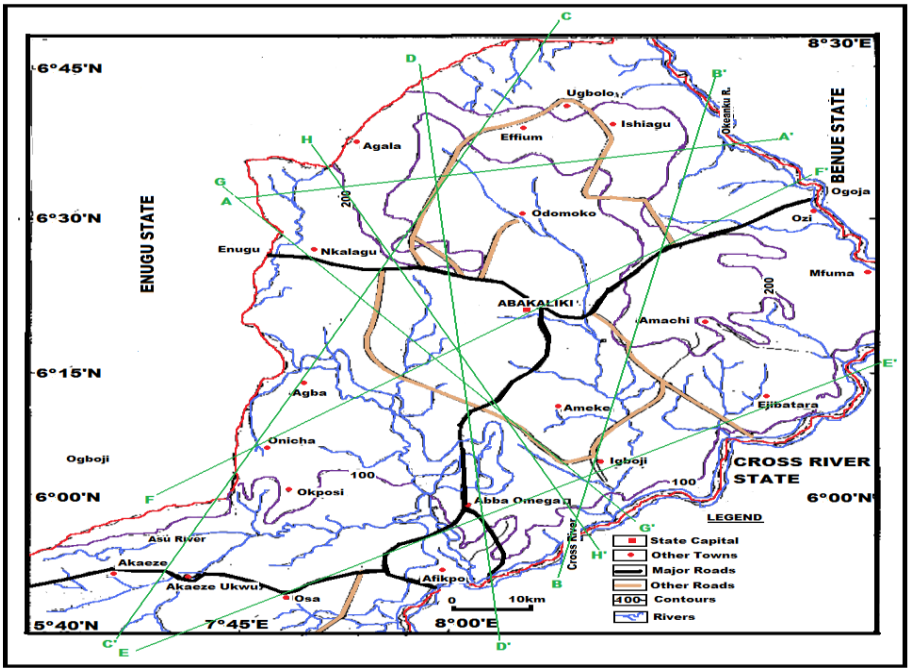

Figure no 1: Location/topographic map of the study area showing the interpretative cross-sections

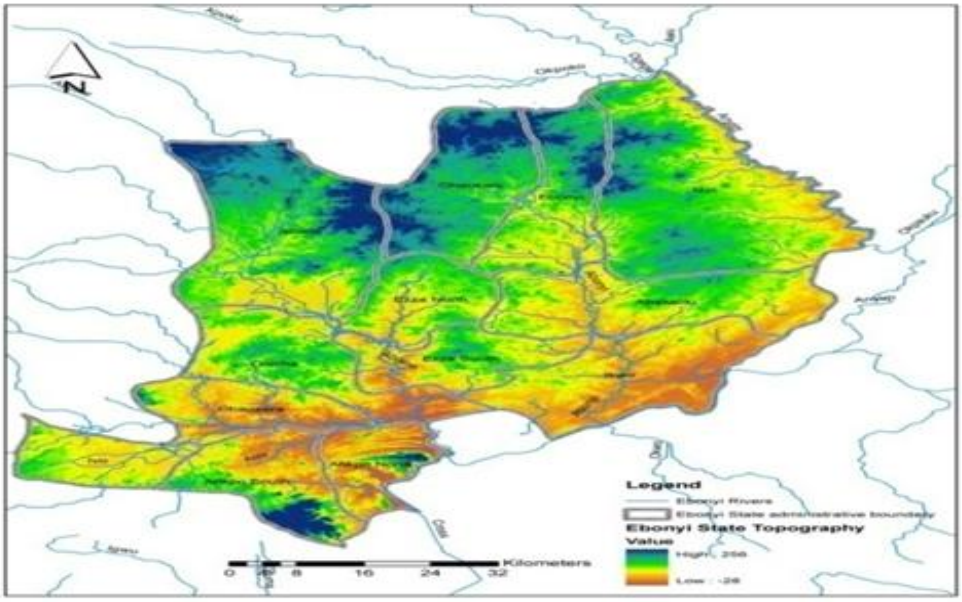

Figure no 2: Relief map of the study area showing the major rivers (Generated from ArcGIS)

Generalized Geology and Stratigraphy of the Study Area

The study area is within the Benue Trough. The general geology and stratigraphy of the southern portion of the Benue Trough has been described by several authors and is therefore sufficiently understood[6]. The oldest sediments in the study area belong to the Asu River group which uncomformably overlies the Precambrian basement complex that is made up of granitic and magmatic rocks. The Asu River Group, whose type section outcrops near Abakaliki, has an estimated thickness of 2000m and is of Albian age. It comprises of argillaceous sandy shales, laminated sandstones, and micaceous sandstones and limestones with an interfingering of mafic volcanics. It is associated with pyroclastic rocks especially around Abakaliki and Eziulor areas[6]. Deposited on top of the Asu River Group sediments in the area are the Upper Cretaceous sediments, comprising mostly of the Ezeaku shales which consist of nearly 1000m of calcareous flaggy shales and siltstones, thin sandy shaley limestones and calcareous sandstones[8]. They are of Turonian age and are overlain by the younger sediments of the Awgu shale (Coniacian). The Awgu shales consist of marine fossiliferous grey

blue shales, limestones and calcareous sandstones. They are overlain by the Nkporo shales (Campanian) which are also mainly marine in character and has sandstone members.

The Afikpo area consists of two major lithostratigraphic units of sandstone ridges and low-lying shales, each of which forms significant component of the Middle Albian Asu River Group and Turonian Ezeaku Formation. The major folds in the area have northeast-southwest trend, and comprise both anticlines and synclines. These mega-tectonic structures developed in response to crustal solidification processes linked to the opening of the South Atlantic and the post-Santonian structural framework as a result of these processes[12].

The study area is however located within the Cross River Basin hydrological province The geology, geomorphology, sedimentology and hydrogeology of the Cross River basin have been extensively studied by several authors[4,2,3,1]. More than 90% of the Cross River basin is overlain by Cretaceous rocks of the Asu River, Ezeaku, Awgu, Nkporo and Mamu Formations, with the oldest, the Asu River Formation underlain by the basement complex rocks. With the exception of Awgu and Ezeaku Formations, all these rocks are very poor aquifers.

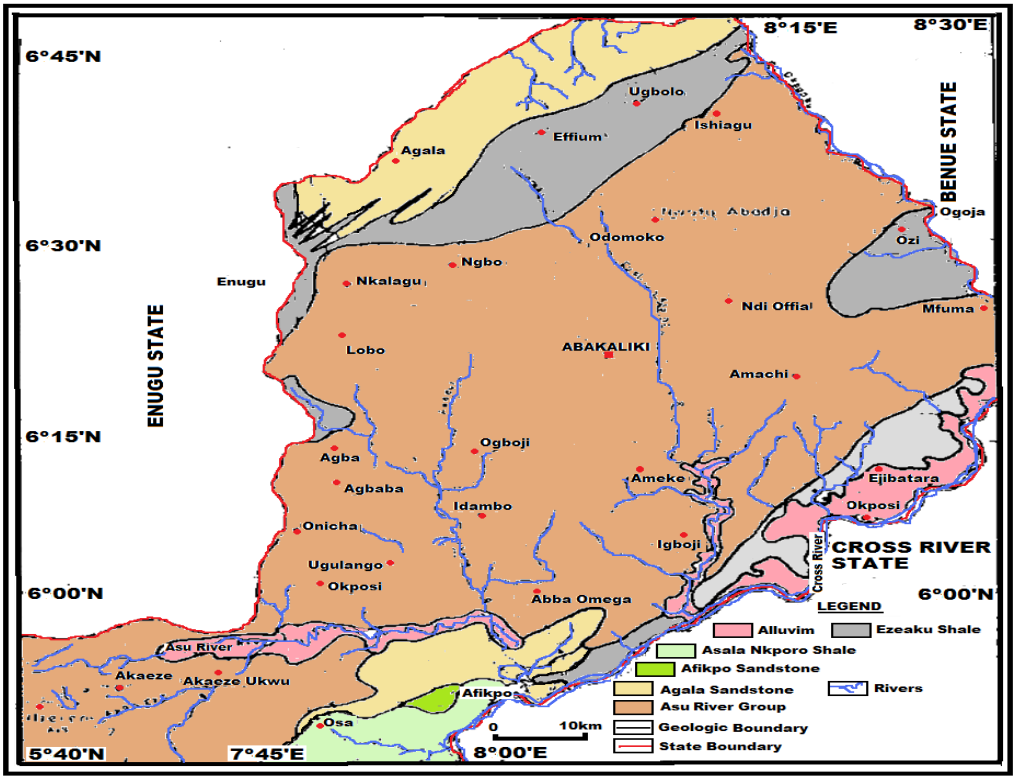

Figure no 3: Regional geology map of the study area (Adapted from NGSA)

II. Material And Methods

A detailed geological mapping of the study area was carried out followed by collation of data from selected hand dug wells and boreholes. These data include pumping test data and lithological information. A total of 44 hand dug and boreholes were selected for this study area. The methods outlined by Theis et al (1963) were helpful in analysing the pumping test data. However, interpretation of the data were carried along selected profiles for the purpose of interpretations and correlations. Eight profiles were used as shown in Figure no 1 above.

Several interpretations and correlations were carried out along the cross-sectioned boreholes .The following analyses were carried out:

1. Determination of aquifer geometric parameters - size/thickness, depth, etc.
2. Determination of aquifer hydraulic parameters – hydraulic conductivity, transmissivity, drawdown, static water level, etc.
3. Regional hydrostratigraphic analysis and correlation in the study area using borehole information.

III. Results

The aquifer geometrical parameters of the study area were interpreted from the litho- logs and other well information and are presented in table 1 below.

Table no 1: Summary of aquifer geometrical geometric parameters in the study area

S/N	BH. ID	Thickness (m)	Elevation (m)	Depth (m)
1	B65	17.5	69	40
2	B46	36.2	80	20.8
3	B56	15	52	49
4	B58	29	36	31
5	B87	22	60	45
6	B70	26	64	21
7	B85	13	64	43
8	B96	27.6	74	40
9	B77	33	85	28
10	B84	31	60	32
11	B42	20	45	26.8
12	B39	26.2	73	34
13	B67	34.6	68	23
14	B43	26.4	56	21.2
15	B47	36.8	92	23.2
16	B22	14.8	67	40
17	B21	30	64	26
18	B31	20	74	36
19	B15	12	65	45
20	B30	11	81	46
21	B68	30.8	76	27
22	B24	29	67	33
23	B38	32	65	32
24	B53	25.2	41	26
25	B17	14.8	70	42
26	B83	28	63	30
27	B100	20	78	38
28	B61	12	59	42
29	B94	32	59	35
30	B55	33	54	27
31	B59	26.6	70	31
32	B90	32.3	74	35
33	B97	13	92	46
34	B81	22	71	40
35	B28	5	69	52
36	B79	27	68	32
37	B86	26	83	39
38	B48	22.5	60	35.5
39	B60	22.2	64	33
40	B63	11.6	60	42
41	B62	19.6	58	29.8
42	B99	11	101	48
43	B89	35.7	44	31
44	B98	16	103	42

The summary of the results of the aquifer hydraulic parameters are presented in table 2 below.

Table no 2: Summary of aquifer hydraulic parameters in the study area

S/N	BH. Code	Transmissiviy (m^2/day)	DWL	Drawdown	SWL	Hydraulic Conductivity	Storativity
1	B65	0.72	NA	18.39	3.66	0.018	0.00012
2	B46	0.81	NA	18.7	6.08	0.0038	0.0000624
3	B56	0.52	NA	35.7	1.9	0.00106	0.000147
4	B58	1.23	NA	41	8.5	0.0039	0.000093
5	B87	0.48	NA	38.17	8.2	0.0106	0.000135
6	B70	0.82	NA	19.3	7.2	0.0039	0.000063
7	B85	0.94	NA	15.13	3.59	0.00218	0.000129
8	B96	0.48	18.72	15.24	3.48	0.012	0.00012
9	B77	0.14	NA	39.04	6.01	0.005	0.000084
10	B84	1.78	NA	13.5	3.1	0.055	0.000096
11	B42	1.93	NA	20.79	2.04	0.0072	0.0000804
12	B39	5.14	NA	5.12	3.56	0.0151	0.000102
13	B67	0.59	NA	19.38	5.63	0.0025	0.000069

14	B43	0.81	NA	15.18	3.59	0.0382	0.000063
15	B47	0.93	NA	13.2	4.2	0.004	0.000069
16	B22	0.41	NA	40.39	4.68	0.0102	0.00012
17	B21	8.2	16.8	7.1	8.8	0.0315	0.000078
18	B31	0.38	NA	25	7.9	0.00105	0.000108
19	B15	7.9	20.6	17	8.4	0.0175	0.000135
20	B30	0.66	NA	34.38	5.31	0.0014	0.000138
21	B68	9.3	14.7	10	4.2	0.0344	0.000081
22	B24	1.03	21	19	2.8	0.00312	0.000099
23	B38	3.14	10.42	5.06	6.3	0.0981	0.000096
24	B53	1.07	13	9.3	4.6	0.0041	0.000078
25	B17	0.35	NA	27.2	3.6	0.0008	0.000126
26	B83	2.89	12.2	9.3	4.2	0.0096	0.00009
27	B100	2.43	NA	11.61	3.42	0.0063	0.000114
28	B61	1.16	18.72	38.17	4.08	0.0027	0.000126
29	B94	0.73	NA	16.8	4.9	0.002	0.000105
30	B55	0.94	NA	23.1	3.56	0.0034	0.000081
31	B59	0.86	NA	16.2	2.9	0.0027	0.000093
32	B90	2.08	NA	10.1	4.2	0.0059	0.0000105
33	B97	3.06	11.09	7.9	3.6	0.0066	0.000138
34	B81	1.04	17.2	14.9	5.2	0.026	0.00012
35	B28	1.07	NA	15.2	4.3	0.0021	0.000156
36	B79	2.03	13.1	12	3.9	0.063	0.000096
37	B86	0.98	NA	19.03	4.9	0.0025	0.000117
38	B48	1.07	18.1	14	3.6	0.00301	0.000106
39	B60	0.92	NA	19.1	4.04	0.0027	0.000099
40	B63	0.89	NA	18.3	3.4	0.0021	0.000126
41	B62	0.79	NA	17.6	2.9	0.0026	0.000089
42	B99	0.68	NA	20.4	4.8	0.0014	0.000144
43	B89	1.12	14.3	19.3	3.9	0.0036	0.000093
44	B98	0.93	NA	18.9	4.2	0.0022	0.000126

IV. Discussion

The geology of the study area is very variable with areas around Afikpo North showing a lithostratigraphy that is dominated by sand. The geology generally changes as we move towards Afikpo South where the Formation becomes more shaly. The shale is believed to be part of the Nkporo Shale. The shaly formation prevalent in Afikpo South is similar to the formation in Amasiri area where shales of the Nkporo and Ezeaku Formation are prevalent.

In the Abakaliki area, the hydrostratigraphy consists mainly of fractured shale. Most areas around Abakaliki share a similar stratigraphy. Generally, the hydrostratigraphy of the study area consists of fractured limestone/shales in Abakaliki area and sand/sandstones within Afikpo area. The lithological sections for profiles A-A^1 – F-F^1 are shown below.

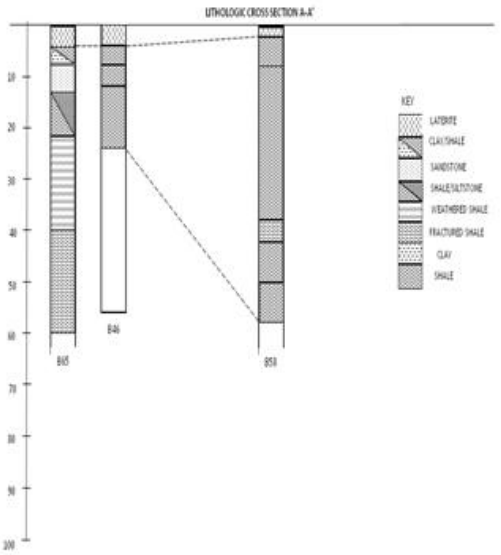

Figure no 4: Interpretation of the aquifer hydrostratigraphy along profile A-A^1

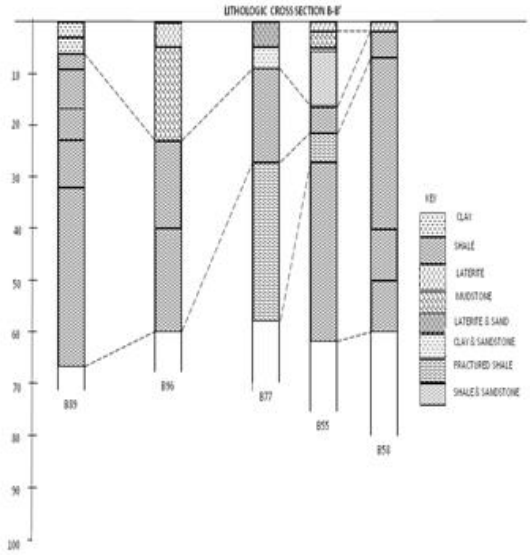

Figure no 5: Interpretation of the aquifer hydrostratigraphy along profile B-B^1

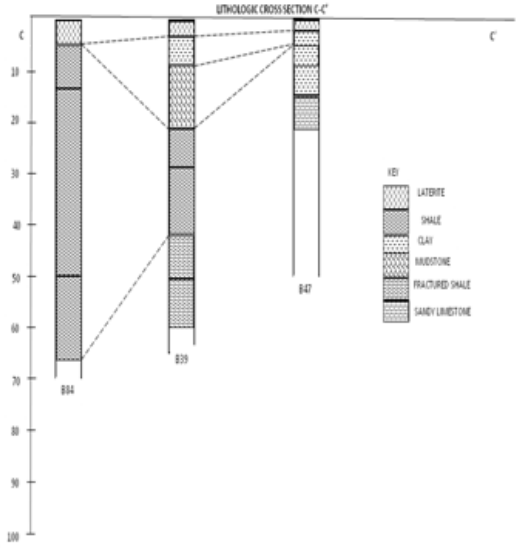

Figure no 6: Interpretation of the aquifer hydrostratigraphy along profile C-C[1]

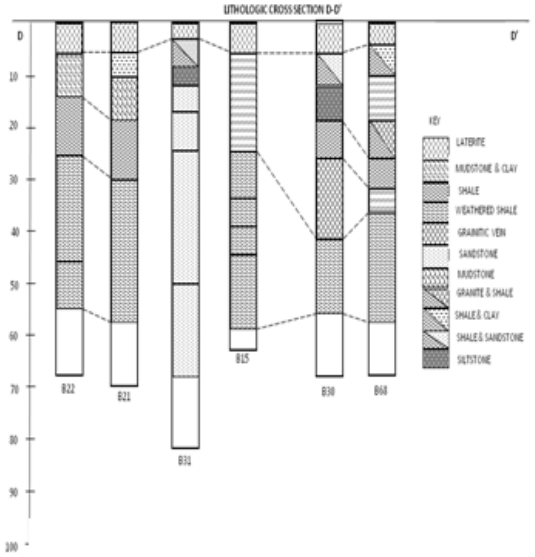

Figure no 7: Interpretation of the aquifer hydrostratigraphy along profile D-D[1]

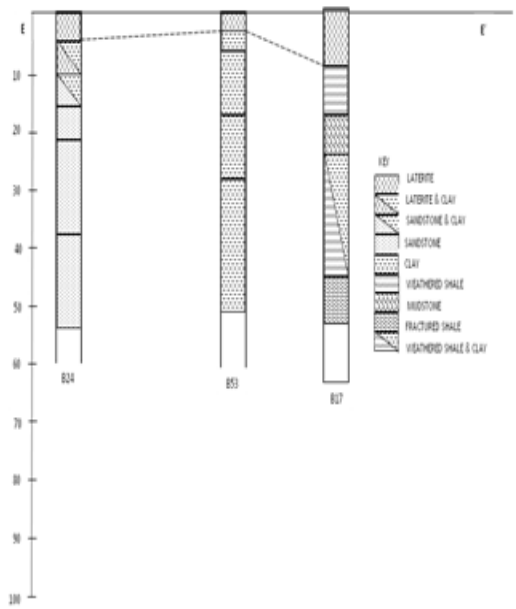

Figure no 8: Interpretation of the aquifer hydrostratigraphy along profileE-E[1]

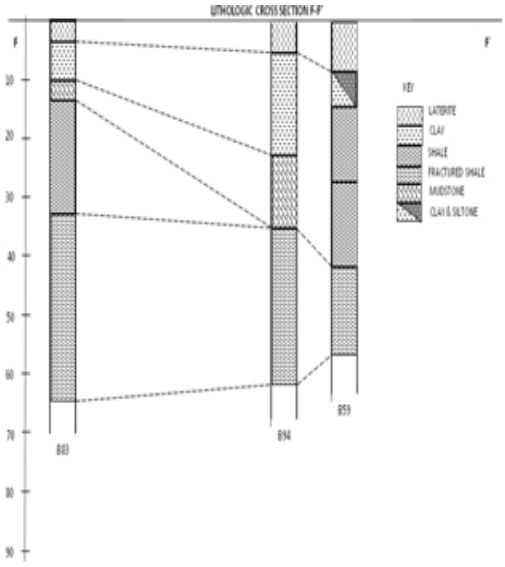

Figure no 9: Interpretation of the aquifer hydrostratigraphy alongprofileF-F[1]

The aquifer thickness in the study area varies from about 5m around Azuoge Umuoma to as high as 36.8m around Ndaegu Okpuruta with a regional mean of 23.67m across the study area as shown in Figure 10.

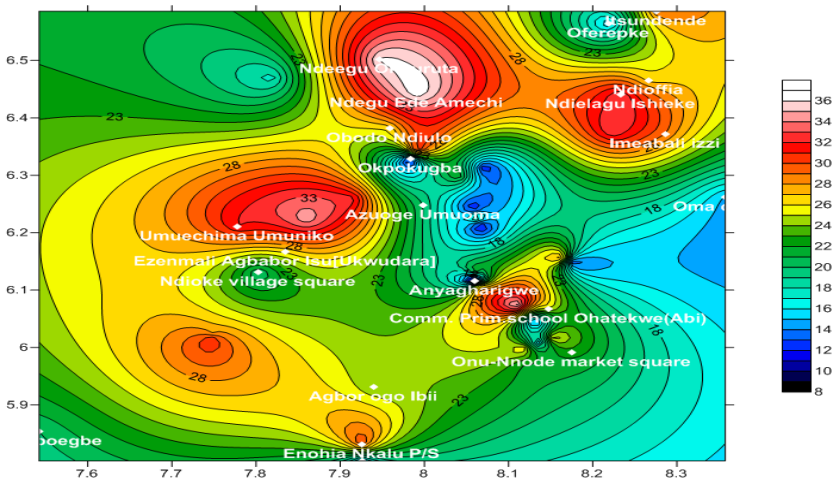

Figure no 10: Aquifer thickness (m) of the study area presented as a contour map

The aquifer depth across the study area varies between 20.8m around Ndaegu Okpuruta to 52m in the vicinity of Isundende, with a regional mean of 34.98m (Figure 11). Interpretation of the aquifer depth along the cross-sections revealed spatial variation of aquifer depth along the profiles.

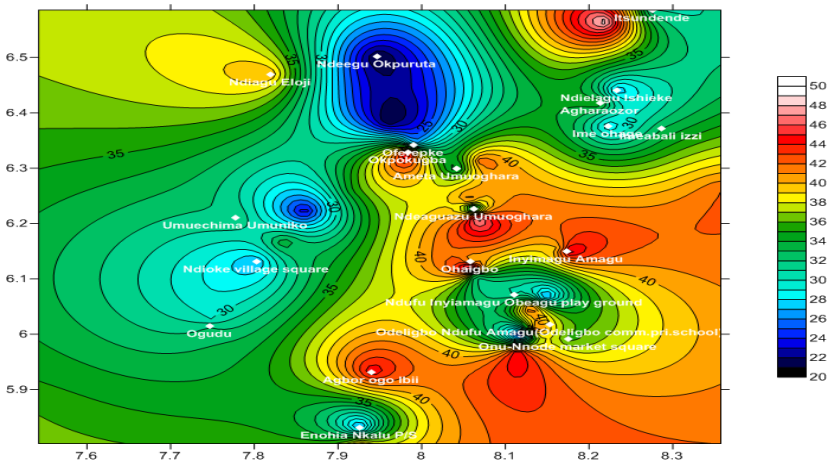

Figure no 11: Aquifer depth (m) of the study area presented as a contour map

The contour map of the static water level in the study area showed that the static water level in the study area varies from 2m at Ndioke Village Square to as high as 9m around Agbor Ogo Ibil and Onu-Nnode Market Square (Figure 12). The average static water level across the study area is given as 4.62m.

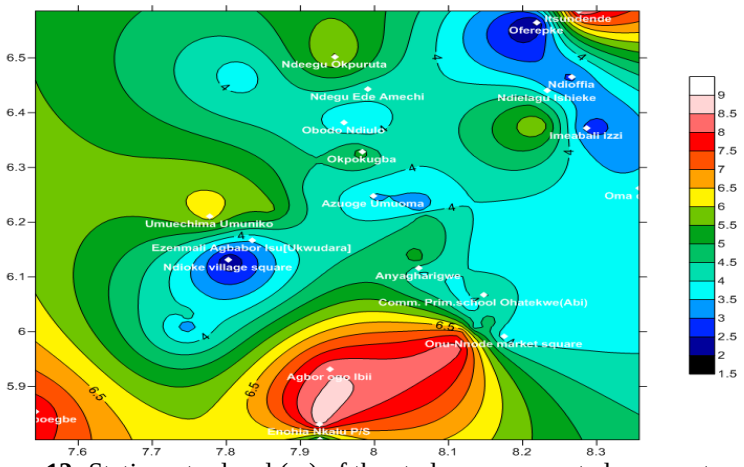

Figure no 12: Static water level (m) of the study area presented as a contour map

Similarly, the drawdown ranges from 4m around Umuechima Umuniko and Ezenmali Agbabor Isu area to as high as 42m around Itsundende area as shown in Figure 13. The regional average drawdown in the study area is about 19.19m.

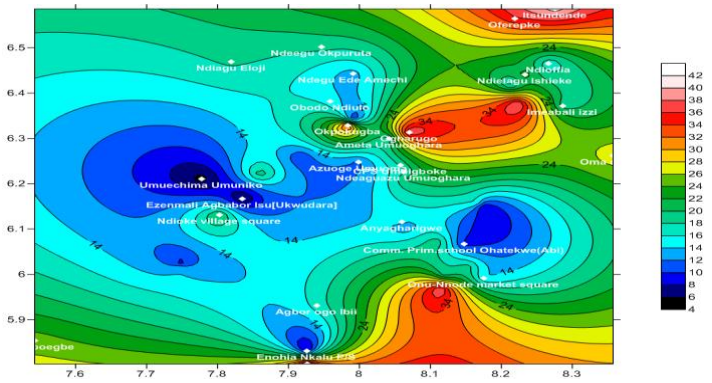

Figure no 13: Aquifer drawdown(m) of the study area presented as a contour map

The contour map of the aquifer storativity is shown in Figure 14 below.The study area revealed aquiferous horizons with aquifer storativity values of 1.05 $x10^{-5}$ around Auroge Umuoma to 1.56$x10^{-4}$ at Oferekpe with an average value of 1.03 $x10^{-4}$.

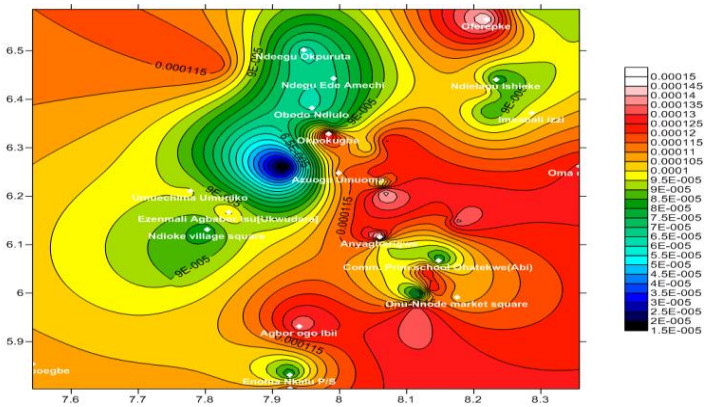

Figure no 14: Aquifer storativity (m) of the study area as a contour map

The hydraulic conductivity across the study area ranges from 8.0 $x10^{-4}$ m/day around Onu-Nnode Market Square to 9.8 $x10^{-2}$ m/day at Ndioke Village Square with a regional mean value of 1.2$x10^{-2}$ m/day.

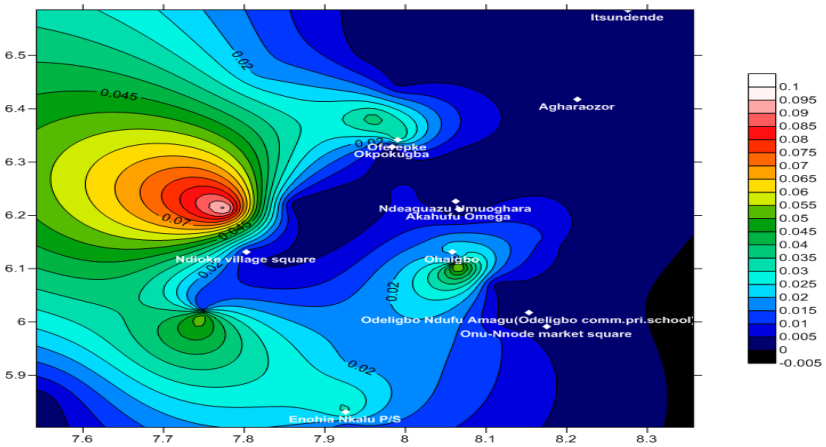

Figure no 15: Aquifer hydraulic conductivity (m/day) of the study area as a contour map

The transmissivity value varies from 0.14 m^2/day at Ndioffia to a maximum value of 9.3 m^2/day at Mac- Gregor Secondary School, Afikpo. The regional mean value of transmissivity in the study area is 1.71m^2/day.

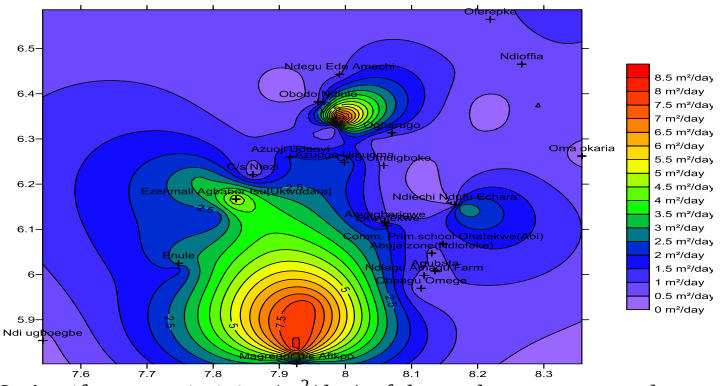

Figure no 16: Aquifer transmissivity (m^2/day) of the study area presented as a contour map

V. Conclusion

Forty- four boreholes and shallow hand dug wells were analyzed using pumpimg test and lithological information. Results of the study revealed that aquifers of the study area are mostly confined; the hydrostratigraphy ranging from fractured shales around Abakaliki area to sands/sandstones in some parts of Afikpo. Information from lithostratigraphic analysis revealed a regional groundwater divide. Aquifer depth and thickness showed variations within the study area. The transmissivity of the area has a regional mean value of 1.71m^2/day while hydraulic conductivity showed a mean value of 1.2 x 10^{-2}m/day.The study area revealed an aquifer storativity range of 1.05 x 10^{-5} to 1.56 x 10^{-4} with a mean value of 1.02 x 10^{-2}. The area has a poor to fairly good ground water yield that can sustain rural water supply.

Hydrogeochemical study of the area is recommended to assess the groundwater quality and its suitability for diverse purposes. Establishnment of monitoring wells to be equipped with sensitive instruments for measuring water level fluctuations is equally suggested.

Acknowledgement

Vani Vikram is highly appreciated for her dexterity in typesetting the manuscript. Big thanks to Mr. Ukeni for his immeasurable assistance.

References

[1] Amajor LC. Aquifers in the Benin Formation (Miocene Recent), Eastern Niger Delta, Nigeria:Lithostratigraphy, Hydraulics, and Water Quality. Environ Geol Water Sci. 1991;17(2):85-101.
[2] Edet AE, Okereke CS. Assessment of hydrogeological conditions in basement aquifers of the Precambrian Oban massif, south-eastern Nigeria. Journal of Applied Geophysics. 1997;36:195-204.
[3] Edet AE, Okekeke CS. Delineation of shallow groundwater aquifers in the coastal plain sands of Calabar area (Southern Nigeria) using surface resistivity and hydrogeological data. Journal of African Earth Sciences. 2002;35:433-443.
[4] Esu OE, Okereke CS, Edet AE.A regional hydrostratigraphic study of Akwa Ibom State, Southeastern Nigeria. Global Journal of Pure and Applied Sciences. 1999;5(1):89-96
[5] Okoro EI, Egboka BCE, Onwuemesi AG.Evaluation of the aquifer characteristic of Nanka Sands using hydrogeological method in combination with Vertical Electrical Sounding (VES). Journal of Applied Science and Environmental Management.2010;14 (2):5-9.
[6] Olade MA. Evolution of Nigeria's Benue trough (Aulacogen): a tectonic model. Geological Magazine. 1975;112:575-583.
[7] Onuoha KM, Ofoegbu CO. 1987. Subsidence and evolution of Nigeria's continental margin: implications of data from Afowo -1 well. Marine and Petroleum Geology. 1987;5:175-181.
[8] Reyment RA. Aspects of the geology of Nigeria. Ibadan University Press. 1965:133.
[9] Theis CV, Brown RH, Meyer RR. Estimating the transmissivity of aquifers from the specific capacity of wells: United States Geological Survey Water-Supply Paper. 1963;1536(I):331-340.
[10] Todd D.K. Groundwater Hydrology. John Wiley and Sons Inc., New York. 1980.
[11] Uma KO. The brine fields of the Benue Trough, Nigeria:a comparative study of geomorphic, tectonic and hydrochemical properties. Journal of African Earth Sciences. 1998;26(2):261-275.
[12] Whiteman AJ. 1982. Nigeria: its Petroleum Geology, Resources and Potential. Graham and Trotham, London. 1982;(I & II):394.

IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) is UGC approved Journal with Sl. No. 5021, Journal no. 49115.

Tochukwu Innocent Mgbeojedo1 "Aquifer Studies Using Well Test And Lithological Data Within Abakaliki And Afikpo Areas, South-Eastern Nigeria." IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG) 6.3 (2018): 35-43.