Groundwater characterization and impacts on health and environment in Abakaliki area and environs, Southeastern Nigeria.

[1]Rock Onwe Mkpuma
[2]Nwankwo G. I.
[3]Ema Michael Abraham

ABSTRACT- Water quality and availability is a consequence of the natural physical, chemical and biological state as well as any other alterations that may have occurred as a result of biotic and abiotic activities. The usefulness of water for a particular purpose is determined by the status of these parameters. In view of this, an understanding of these factors influencing livelihood is pertinent. In this study, hydrologic and hydrogeological characteristics as well as chemical and biological status of both surface and groundwater were evaluated. World Health Organization (WHO) standard were used as the yardstick to characterize the chemical and biotic status. Further, the Piper's Trilinear technique is employed. A questionnaire approach was also used to simulate water status impact on livelihood.

Results expected to indicate water status mainly in terms of quality and impact on livelihood in the area. Analysis of responses from the questionnaire further indicates that the water situation is associated with health problems, poverty and environmental issues.

Keywords: abiotic, availability, biotic, environmental, health, hydrogeological, hydrologic, livelihood status, water quality

1. BACKGROUND AND RATIONALE

Water is the hub on which life is anchored. It plays a major role in livelihood (healthcare, poverty and environment) hence its deterioration is always a severe problem to mankind, [14]. Water is still a limiting factor towards achieving the UN MDGs. Millions of people still live in areas where finding potable water resources is difficult [13] and in Nigeria, problems associated with lack of adequate water resources threaten to place the health of over 40 million people at risk [1]. Aina (1996), stated that less than 30% of the Nigerian population has access to safe drinking water and in most cases get about 25 liters/person/day available compared to WHO's standard of 120 liters/person/day for total domestic use and about 3 liters/day to maintain essential body metabolism. This therefore suggests a situation of serious water shortages. Water deterioration leads to over exploitation of groundwater. This in turn sometimes leads to intrusion of sea water into the aquifer and further deterioration of the water quality and exacerbates health risks, poverty and natural ecosystem degradation.

Earlier, poverty was only measured and linked to food insecurity but presently the importance and growing need for water, its scarcity relative to food has nullified using food scarcity as yardstick to measure poverty level. Nowadays, the number of water taps per thousand persons is a better indication of healthcare than number of hospital beds. Consequently, comprehensive strategy is needed to improve water security and accessibility. Development of water resources is a major factor for economic growth, as well as human and environmental health and poverty reduction. Agriculture and civilization can flourish with the development of reliable water supplies- and collapses as the water supply fail. In this study, potability of water in Abakaliki is assessed to help formulate strategies that will enhance water security for the affected class.

1.1 Location and Accessibility

Abakaliki is in Ebonyi State, Southeastern Nigeria. The study area lies between latitudes 06^0 05′ and 06^0 25′ and longitudes 008^0 00′ and 008^0 18′ (fig 1). It has a good internal road network, (Fig 1).

1.2 Physiography and Climate.

Abakaliki area lies within Ebonyi *(Aboine)* River Basin and the Cross river plains. It is characterized by gentle to moderate and in some isolated sub-areas, a rugged topography. The isolated highlands are occupied by igneous intrusives while the lowland areas are overlain by shally

[1,3] Department of Physics/Geology/Geophysics, Federal University Ndufu-Alike Ikwo Nigeria.
[2] Geosciences Department, Federal University of Technology Owerri, Nigeria.

members of Eze-aku Formation. The region lies on an elevation ranging from 125m to 245m above mean sea level.

1.2.1 Weather and Climate:- Two main seasons dominate the climate of the area– rainy (late April-October) and dry (November-April). Annual rainfall is 1000 to 2000mm and monthly rainfalls vary from 50 to 300mm while August has 180 to 200mm of rain [11].

Records show a mean annual temperature of 31.2^{0}C ranging from 33^{0}C in dry season to 28^{0}C in wet season. The seasonal climatic conditions are caused by "the North-South fluctuations of a zone of discontinuity between the dry continental (Saharan) air and the humid maritime (Atlantic) air. At the surface, it forms a boundary— Surface of Discontinuity [11]. Other minor climatic conditions in the area are the short dry season— August break and the harmattan patches of November to February. Meanwhile, the greenhouse effect of the climatic change is gradually eroding the cold harmattan patches and its occurrence sparingly noticed nowadays.

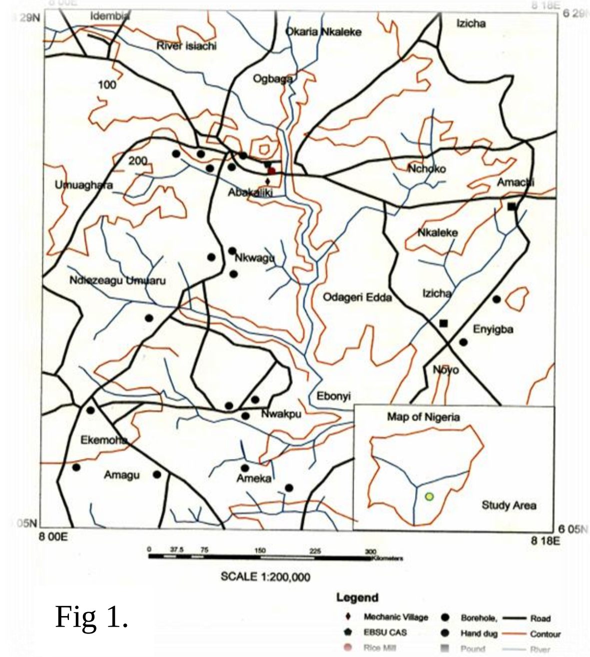

Fig 1.

1.3 Geology of the Study Area.

The study area falls within the Lower Benue Trough and composed of Cretaceous marine sediments in which carbonate rocks abound. The rock types are mainly shales, limestones, sandstones, pyroclasts and evaporites. There are Aptian mafic volcanics and volcanoclastics. The pyroclast underlie and interfinger with the transgressive sequence of marine argillites, limestone and evaporites of the Albian Asu River group. These rocks grade Northwards into shallow marine platform carbonates of the Middle Benue (Arufu and Gboko) Formation. There are emplacement of numerous mafic to intermediate intrusions of lavas and tuffs, [15] table 1. Generally the shale beds are massive, occasionally laminated, micaceous and fossiliferous.

TABLE 1: A section of Sedimentary Succession in Southeastern Nigeria, *Reyment, 1965*

	Age	Formation name	Thickness (≈ m)	Character
Upper cretaceous.	Turonian	Eze-aku shales	610	Flaggy calcareous shales, blue shales and mudstones subordinate shallylimestones and sandstones.
	Cenomanian	Odukpani Formation	1000	Arkosic, quartzose s/s, calcareous limestones, shales, limestones, sandy shales calcareous s/s and flaggy shales.
Lower Cretaceous.		***Abakaliki Formation Abakaliki Shales***	***1829***	***Bluish grey to Olive-brown and sandy shales, fine-grained micaceous s/s, mudstones and dense blue limestones.Weathers to rusty brown. Poorly fossiliferous.***
	Precambrian	Basement Complex	?	Granites, porphyritic granites, migmatilites, orthogneisses, paragneisses, granodiorities, rocks of charnockitic affinities, basic rocks, and ultra-basic rocks.

1.4 Soil types, Vegetation and Drainage

Two main soil types are found in Abakaliki area— silty clay hydromorphic soil and the grey sandy clay hydromorphic soil. They are moderately to imperfectly drained. The area falls within the rainforest/savannah belts. The lush vegetation is characterized by variety of tree shrubs, grasses and palms. The area is a gently sloping drainage basin. Run off is high during rainy season courtesy the lithology. Surface water bodies flourish during the rainy season and most of them dry up during the dry season being probably geologically controlled via the structures. The drainage system is dendritic.

2. METHOD OF STUDY

This investigation was carried out in phases as follows:

- Study of the drainage and aquifer characteristics,
- Assessment of the hydrologic and hydrogeologic characteristics with a view to understanding the factors influencing water situation in the area employing the following field works,

— Collection and analysis of surface and groundwater samples;
— geophysical probing via Vertical Electrical Sounding (VES) and results interpretation,

- Administration, retrieval and analysis of questionnaires.

Twenty (boreholes/hand dug) wells were sampled and analyzed for chemical constituents including Na, Ca, Mg, K, SO_3, HCO_3, NO_3, Cl, Pb, Zn, Cu, Cd and pH. Surface waters including Rivers Ebonyi and Iyiokwu were also sampled and analyzed for same chemical constituents. Water samples collected from these sources were also analyzed to determine the presence and level of biogenic parameters and physical properties especially for hardness.

Interview and structured questionnaire method were also adopted in this study as a means of obtaining direct information from stakeholders. The questionnaire was designed to get information on source, quantity, availability (consistency), safety, quality and community management approaches. Individual and focused group discussion was also held with target audience.

3. RESULTS and DISCUSSION.

3.1 Results.

Concentration levels of various chemical constituents from (a) boreholes, hand dug wells and (b) streams samples were analyzed. Table 2 presents the summary results of the physical parameters while table 3 presents the major ions concentration of the analyzed groundwater samples.

Table 2: Results of Physical Parameters of Ground water samples in the study area

S/N	Sample Location	Water Sources	pH	EC (µS/cm)	TDS (mg/l)	TSS (mg/l)	TS (mg/l)	Turbidity (NTU)	Temperature (^{o}C)
1	Ameka 1	BH	7.49	760	494	1	495	2	29
2	Amegu 1	BH	7.27	300	195	1	196	0	30
3	Ameri 1	HW	7.37	560	364	0	364	1	29
4	Enyigba 1	BH	6.00	80	52	0	52	1	30
5	Enyigba 2	BH	7.91	650	422.5	0	422.5	0	30
6	Abakaliki 9	BH	7.37	520	338	1	339	0	30
7	Abakaliki 8	BH	7.91	1130	734.5	0	734.5	0	30
8	Abakaliki 2	BH	8.10	420	273	3	276	0	31
9	Amegu 2	BH	7.35	690	448.5	0	448.5	0	29
10	Nkwagu	HW	6.92	280	186	3	189	8	27
11	Ameri 2	BH	6.54	620	403	0	403	0	30
12	Ameka 2	BH	7.74	650	422.5	5	427.5	0	29
13	Abakaliki 1	BH	7.27	300	195	0	195	0	30
14	Abakaliki 4	BH	7.21	920	598	2	600	3	30
15	Abakaliki 3	BH	8.10	420	273	7	280	0	30
16	Abakaliki 11	HW	6.68	880	572	4	576	45	28
17	Abakaliki 7	BH	7.09	290	188.5	25	213.5	5	29
18	Abakaliki 5	PW	5.28	100	65	2	67	1	30
19	Abakaliki 6	BH	7.16	500	325	1	326	0	28
20	Abakaliki 10	BH	7.48	950	617.5	0	617.5	2	29
Mean			7.26	583.5	373.35	2.75	376.1	3.4	29.40
Minimum			5.28	80	52.00	1.00	52.00	1.00	27.00
Maximum			8.10	1130	734.00	25.00	734.00	45.00	31.00
WHO (2004)			6.5-8.5	1400	500	5**	500**	5***	

BH =Bore hole; PW= pipe borne water; HW= Hand dug Well; ***= USEPA (1975); **= WHO (1993)

Comparison of obtained result mean concentration levels against the World Health Organization (WHO) standards (Table 3) for Highest Desirable Level (HDL) and Maximum Permissible Level (MPL) shows that:

- Color, CO_3 and Fe exceed the HDL in various wells but fall within the MPL.
- PO_4, Pb and Cd exceed the MPL
- Coliform is marginally above the MPL
- All other constituents are below the HDL indicating conformity with WHO standards. The potability of the water samples were summarily assessed using Piper's Trilinear technique. The results, figs 3, 4, 5 shows that for the ions considered by the Piper's technique, the water is potable but moderately hard. The opinion pool of the questionnaire confirms this.

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Table 3: Results of chemical parameters

S/No.	Sample Location	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Na^{+} (ppm)	K (ppm)	Fe (ppm)	Cl^{-} (mg/l)	SO_4^{2} (mg/l)	HCO_3^{-} (mg/l)	NO_3^{-} (mg/l)	Total hardness (mg/l)	Ca hardness (mg/ l)
1	Ameka 1	37.8	13.67	12.151	26.198	0.12	12	4	110	55.00	150	94
2	Amegu 1	24	2.19	12.136	20.986	0.05	12	15	40	55.88	69	60
3	Ameri 1	20	1.70	13.775	24.198	0.01	14	21	42	62.04	57	50
4	Enyigba 1	8	0.24	8.25	10.216	0.64	2	10	20	44.22	21	20
5	Enyigba 2	32	4.64	9.741	18.741	0.81	24	13	70	85.67	99	80
6	Abakaliki 9	43.2	10.99	12.138	20.841	0.09	46	9	124	68.84	153	108
7	Abakaliki 8	24	1.47	9.981	9.216	0.02	98	21	28	35.20	66	60
8	Abakaliki 2	36	11.72	7.251	16.721	0.04	12	7	122	43.56	138	90
9	Amagu 2	40	8.55	9.081	31.081	0.67	24	58	92	35.64	135	100
10	Nkwagu	24	6.35	9.751	16.581	0.01	100	12	34	75.68	86	60
11	Ameri 2	32	9.77	11.241	27.341	0.98	16	15	82	66.08	120	80
12	Ameka 2	49.6	10.26	8.975	19.095	0.03	34	0	102	35.20	228	124
13	Abakaliki 1	27.2	0.24	12.136	27.986	0.18	12	7	38	31.68	69	68
14	Abakaliki 4	74.4	10.26	10.025	21.061	0.03	80	150	82	41.36	228	186
15	Abakaliki 3	40	2.44	10.841	24.181	0.12	8	3	100	28.60	110	100
16	Abakaliki 11	40	7.81	9.225	17.316	0.06	24	41	80	64.24	132	100
17	Abakaliki 7	32	9.77	10.986	25.097	0.78	20	21	68	38.28	120	80
18	Abakaliki 5	8	0.24	10.092	22.081	0.40	12	29	8	33.44	21	20
19	Abakaliki 6	60	12.21	9.981	27.198	0.02	8	20	20	51.48	200	150
20	Abakaliki 10	48.8	14.16	10.986	21.981	0.01	56	4	98	38.72	180	122
Mean		*35.05*	*6.93*	*10.45*	*23.11*	*0.264*	*30.70*	*23*	*62.0*	*47.84*	*119.10*	*87.60*
Minimum		*8*	*0.24*	*7.25*	*10.22*	*0.01*	*2.00*	*4.00*	*8.00*	*28.60*	*21.00*	*20.00*
Maximum		*74.4*	*14.16*	*13.78*	*31.08*	*0.98*	*80.00*	*150.00*	*124.0*	*85.00*	*228.00*	*186.00*
WHO (2004) limit		*75*	*50*	*200.00***	*12**	*0.30*	*250.00*	*250.00*		*50*	*100 ***	

*=Pratt, 1972 **=WHO, 1993

Table 4: Range of values of the measured physico-chemical parameters in comparison with WHO (1987)

	Parameter	Highest desirable level (WHO)	Max. permissible (WHO)	Result obtained
1	pH	7 – 8.5	6.5-9.2	5.8 - 7.5
2	Colour (°H)	5	50	20 – 40
3	TDS (mg/l)	500	500	4 - 120
4	TH (mg/l)	100	500	21 – 228
5	Na^{2+} (mg/l)	-	-	1.4 - 4.5
6	K^{2+} (mg/l)	-	-	0.4 - 1.5
7	Ca^{2+} (mg/l)	75	200	0.8 - 8.0
8	Mg^{2+} (mg/l)	50	150	4.8 - 19.5
9	PO^{-}_{4} (mg/l)	-	0.40	0 – 17.14
10	NO^{-}_{3} (mg/l)	45	50	0 – 5.65
11	SO^{2-}_{4} (mg/l)	200	200	0 – 10.20
12	Cl^{-} (mg/l)	200	250	0 – 63.20
13	CO^{2-}_{3} (mg/l)	1	120	0 – 14.16
14	HCO^{-}_{3} (mg/l)	1	-	2 – 25.68
15	Fe^{2+} (mg/l)	0.1	1.0	0.1 – 1.05
16	Pb (mg/l)	-	0.05	<0.01- 4.42
17	Cd (mg/l)	0.01	0.01	<0.01- 0.07
18	Zn (mg/l)		5.0	2.01
19	Cu (mg/l)		<1.0	0.09
20	Ni (mg/l)			0.19
21	Coliform MPN/100ml	0/100ml	0/100ml	0 - 0.5

* TDS = Total Dissolved Solids
* TH = Total Hardness.
* MPN = Most Probable Number

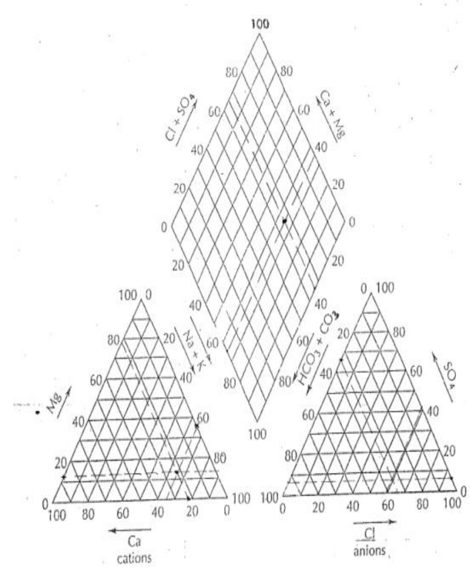

Fig 2

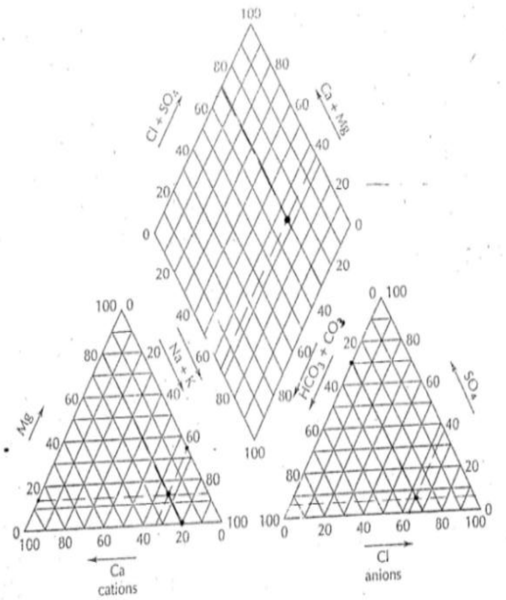

Fig 3

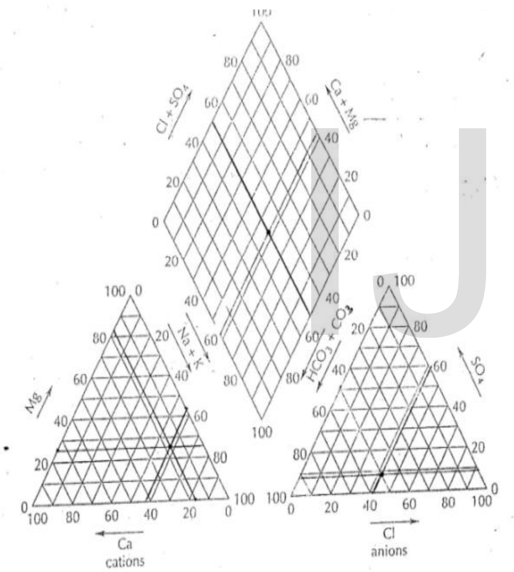

Fig 4

3.2 DISCUSSION

the water table and aquifer is expected. These are associated with low transmissivity values hence poor water potentials except for the fractured units which is also channel for biogenic pollution.

Using the mean value of the parameters, water quality especially the groundwater is generally admissible as shown by its compliance with WHO/FEPA standards. Nevertheless, consideration of the water quality in terms of hardness indicates that most of the places indicates objectionable qualities. This is clearly observed during this research field work and focused group discussions. For example, in the objectionable places their water does not lather with detergents, blurs or attacks colors when washed with water from such places, forms scales and defaces utensils, and makes foods cooked with it sour shortly when compared with foods cooked with potable water.

A striking feature of the groundwater quality data is their low microbial content even in the light of existing poor sanitation practices. The absence or low bacteriological content in the groundwater is most probably geologically controlled by the shale and clay which dominates the terrain. This literally filters out viruses and bacteria from infiltrating into the water, preventing them from reaching the water table. However, microbes, nematodes including Helicobacter pollute and contaminate surface water bodies. Helicobacter pyroli infection appears to be a major health issue in the area because its infection is associated with populations that have limited access to potable water. Such populations are associated with low-medium socio-economic class who live predominantly in the rural areas where ponds, rivers and other stagnant water bodies constitute the source of water supply. Majority of infected persons were of low socio-economic background and may have limited access to potable water. The Bacteriological contamination of surface waters may be associated with short distances between input points (random defecation points/latrines) and ponds/stream channels as well as ease of runoff generation during rainfall events.

The levels of phosphate, Iron, Zinc, Lead, and Copper respectively especially in surface waters in the area exceeded the Recommended Dietary Allowance (RDA) and the normal tolerable environmental levels (UNEP/ILO/WHO, 1995; Liu et al, 2005) while Nickel and Cadmium are within the accepted limit. The measured high concentrations of Zn and Pb in the area are not unexpected considering the Pb-Zn ore mineralization and mining activities in the area. The observable difference in the levels of these trace elements concentrations in surface and groundwater could also be as a result of hydrologic and hydrogeologic processes- rainfalls, run-offs, seepages, infiltration, percolation, exfiltration which are essential in trace elements distribution kinetic. Nevertheless, possibility of cadmium, lead, zinc particles from mines and Radioactivity concentration of quarry dust in Abakaliki indicate high radionuclide of $^{238}U/^{226}R$, ^{232}Th and ^{40}K, in Abakaliki area and probable contamination of groundwater.

The high levels of phosphate and trace metals in the area impose health risk to the inhabitants as well to other parts of the sub-region where foods and water from this area may be exported or flow to.

Analysis of the questionnaire response pattern indicates that health, poverty and environmental issues are related to the water distress level in the area. Time, finance and other resources which should have been directed to other economic productive use are diverted towards scouting and purchasing water. This, consequently further reduces the purchasing power of the local residents thereby aggravating poverty. Poverty in itself militates against the water security. An important consequence of the water distress level is that women and children undertake the responsibility of scouting water for household use. This exposes these vulnerable classes to risks of abuses such as kidnapping and rape probably contracting HIV/AIDs. The effects of water distress on human health and poverty exert cumulative negative effects on the total environmental health.

4. SUMMARY AND CONCLUSION

especially with respect to hardness and biogenic characterization. This however, has adverse consequences on the health, economy and environment, indirectly impoverishing them. Geologic factors are thought to be responsible for the water distress in the area. This is because hard water tends to originate in areas where thick top soils overlie carbonate rock formations. And biotic characterization thought to be controlled by the geological structure of faults in the area.

REFERENCES

[1]. *Anukam, L. C. (1997). Water Pollution Control – A Guide to the Use of Water Quality Management Principles Case Study iv – Nigeria. E & F. Spon on behalf of WHO/UNEP.*

[2]. *Barker, R., Vankoppen, B. and Shah, T. (2006). Water Scarcity and Poverty.*

[3]. *Bollenbach W. M. (1975). Groundwater and Wells. Johnson Division UOP Inc.*

[4]. *Chukwuma, C. (1993). Cadmium Lead and Zinc from terrestrial Plants in the Enyigba – Abakaliki Lead and Zinc mine: Search for a monitoring plant species in trace element distribution. Bulletin of Environmental Contamination and Toxicology, Vol. 51., No 5, Nov., 1993. Springer New York.*

[5] *Cleaver, F and Elson, D. (1995). Women and Water Resources: Continued Marginalization and New Policies. International Institute for Environment and Development.*

[6]. *Edeogu C. O. (2007). Nitrate, Sulphate, Phosphate and Chloride Status of Staple Food crops, Soils and Water as Indicator of Environmental Base Anion Pollution Load in Ebonyi State, Nigeria. Journal of Biological sciences, 7(5): 745-751.*

[7]. *Egboka, B.C.E., G. I. Nwankwo, I. P. Orajaka, and A. O. Ejifor (1989). Principles and problems of environmental pollution of groundwater resources with case examples from developing countries. Environmental Health perspective, 83; 39 – 68.*

[8]. *Evans, B., Rahman, A., Appasamy, P., Pittock, J., Classen, M., Ahmed, S. and Kerdany, A. (2008). Progress and Prospects on Water: For a clean and Healthy World. Bull of World Water Week. Aug. 2008. Stockholm.*

[9]. *Fetter, C. W. (1994). Applied Hydrogeology. Macmillan Publishing Company.*

[10]. *Handidu, J. A. (1990). National Growth, Water Demand and Supply, Strategies in Nigeria in the 1960s.*

[11]. *Iloeje, N. P. (1981). A New Geography of Nigeria. Longman Nigeria, Plc.*

[12]. *Liu, H., A. Probst and B. Liao. (2005) Metal Contamination of soils and crops affected by the Chenzhou Lead/zinc mine spill (Hunan China). Sci. Total Environ., 339; 153 -66.*

[13]. *Macdonald, A., Davies, J., Carlow, R. and Chilton, J. (2005). Developing Groundwater. Intermediate Technology Development Group.*

[14]. *Onwe M. R., Nwankwo G. I., and Ahiarakwem C. A.(2015), An Aspect of Water Distress Level Evaluation in Abakaliki Area and Environs Southeast Nigeria, International Journal of Scienceand Engineering Research, Vol. 6, Issue 2, pp 1561-1566*

[15] *Reyment, R. A. (1965). Aspects of the Geology of Nigeria. Ibadan. University Press.*

[16]. *Ugwuja, E. I. and Ugwu N. C. (2007). Helicobacter pylori in Uninvestigated Dyspepsia in Primary Health Cares in Abakaliki, Nigeria. Journal of Health and Allied Sciences, Vol 6, issue 1 (Jan – Mar, 2007). Mangalore, India., Pp 1-6*

[17]. *United States Environmental Protection Agency (USEPA). 2004 Edition of the Drinking Water Standards and Health Advisories. Washington DC, USA. US Environmental Protection Agency, EPA 822-R-04-005. Available at: www.FPA.gov/waterscience/criteria/drinking/standards/dwstandards.*