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ASSESSMENT OF HEAVY METAL LEVELS AND MICROBIOLOGICAL PARAMETERS IN HAND DUG WELLS AND WATER BOREHOLES IN OGBA EGBEMA NDONI LOCAL GOVERNMENT AREA, RIVERS STATE, NIGERIA.

[1]Osigwe, Oke Wilson, [1]Abam, T. K. S., [1]Yondeowei P. O.
[1]Institute of Geosciences and Environmental Management,
Rivers State University, Port Harcourt, Nigeria

Email: *wilsonosigweoke@gmail.com*

ABSTRACT

This study assesses the heavy metals and the microbiological parameters of waters from hand dug wells and water boreholes in Ogba, Egbema, Ndoni Local Government Area, Rivers State, Nigeria. The study involves fifteen borehole water samples and fifteen water samples from hand dug wells, making a total of 30 groundwater samples collected from November to December, 2022. Heavy metals and biological parameters analysed includes Lead, Iron, Chromium, Copper, Cadmium, Mercury, Arsenic, Biological Oxygen Demand and E. coli and their quality characteristics evaluated by comparing them with WHO, 2012 water quality standards. The results from the analyses of boreholes samples yielded parameters that met the requirements provided by WHO, with exception of Pb, Cd, and E. coli. While Pb, Cd, as and E.coli in hand dug well water did not meet the recommended guideline. Heavy metals were found to have higher concentration in water boreholes than hand dug wells and could be as a result of the discharge of effluents from the oil companies and materials from anthropogenic sources. But samples of E.coli were higher in hand dug wells than water boreholes which could be attributed to poor sanitation causing water contamination from anthropogenic activities. It is therefore recommended that a proper waste management system should be provided and maintained for proper environmental sanitation in the study area, this will minimize indiscriminate dumping of waste and will reduce percolation of pollutant into groundwater.

Keywords: Groundwater, Parameter, Heavy Metals, Microbiological.

INTRODUCTION

Water is essential to people for drinking, irrigation, transportation and energy. It is needed in all aspects of life. Nothing can substitute for water; life is tied to water as it is tied to air and food. On the other hand, food is tied to water since plant growth; survival and sustenance depend on it. Providing water in the desired quantity and quality and at the right time and place has been an issue for all generation.

A large source of fresh water lies underground. Hence, there is a global recognition that groundwater quality is as important as its quantity. Currently, emphasis is not only on how abundant water is but also on whether its quality is good enough to sustain its various uses. Groundwater is the primary source of water for domestic, agricultural and industrial uses in many countries and its contamination has been recognized as one of the most serious problems (Belkhiri *et al*., 2010). Groundwater moves through pore spaces within rocks and reacts with minerals that make up the rocks in the course of migration (Amadi *et al*., 2012; Boateng *et al*., 2016). Groundwater quality in any locality takes after the chemical composition of the aquifer through which it migrates in accordance with the hydrological cycle and flow direction (Offodile 1983; Amadi *et al*., 2010; Boateng *et al.,* 2016). The intensive use of natural resources and increased human activities are posing great threat to groundwater quality (Foster, 1995).

Clean water supply is one of the key indicators for development in any country however; the situation of most African countries is not encouraging. For instance, eighteen African countries are expected to experience water shortage by 2025 while there are presently more than 300 million people in Africa living in water scarce environment. In Sub – Saharan African, the water requirements for major domestic and industrial purposes are usually not met. Even the available water resources keep dwindling as the amount of freshwater available for each person in Africa is about one – quarter of what it was in 1950 (Aba, 2001).

Nigeria as a nation is blessed with abundant surface and groundwater resources, in the southern, south-eastern and south-western regions of the country (Obatoyinbo & Oyedotun, 2011).

In Nigeria, the rate of urbanization characterized by high population concentration, increasing industrial and agricultural activities coupled with environmental pollution/degradation and indiscriminate disposal of all kinds of wastes are perceived to pose serious pollution threats with all its concomitant health hazards on groundwater quality especially in urban areas. The fact remains that the public and municipal water supply is inaccessible to a large proportion of urban and rural dwellers, even where it's available, the supply is highly inadequate, unreliable and irregular. Consequently, there is high dependency on untreated groundwater abstracted through hand dug wells and boreholes systems (Ocheri, 2006; Ocheri & Mile, 2010).

A 1996 survey by the Ministry of Water Resources found only 63% of Nigerian boreholes was in working order, with many out of action due to pump failure, JICA (2014). Boreholes failure became common with increased number of individual borehole drilling. The Ministry of Water Resources ascribes these failures to the absence of management structure for boreholes most are meant to be managed by communities, but only around one fifth of rural communities were identified as having borehole management organizations, so not optimum. The problem of frequent abortive boreholes in the area cannot be blamed on the inability of the aquifer to yield enough water but on the incompetence of the drilling contractors Ngah and Eze (2017). The unprecedented demand for freshwater associated with high population growth and increased living standards has resulted in highly elevated groundwater drilling activities, which is now creating some concern over sustainability of the resources for the future.

Most of the Niger Delta relies on groundwater for both domestic and industrial uses. Hydrocarbon exploration/exploitation is one of the major anthropogenic activities which are liable for deteriorating the quality of water, soil as well as the environmental ecosystem in the surrounding area. Anthropogenic activities can adversely affect water quality by introducing contaminants such as, metals and metalloids. The availability of good quality water is vital for life, wellbeing, food and socio – economic development of mankind and it is generally obtained from two principal natural sources: surface water such as fresh water lakes, river, streams etc. and groundwater such as borehole water and well water (Boateng et al., 2016).

Studies in Nigeria have shown that water resources are easily contaminated from anthropogenic activities in most cities. Study of heavy metals pollution and physiochemical assessment of water quality of River Owo, Agbara, Nigeria was carried out by Shakirat et al, (2013). The study concluded that River Owo was slightly polluted with Cadmium, Chromium and Lead while the pollution was a result from the discharge of effluents by companies, factories and materials from other anthropogenic sources. Land use in areas that replenish groundwater is an important factor affecting water quality.

The physical landscape of Ogba/Egbema/Ndoni Local Government Area (ONELGA) has undergone and is still undergoing tremendous transformation consequent upon its agricultural economy as well as its urban industrial developments. Consequently, owing to the hydrocarbon exploration/exploitation activities in the area which may impact or degrade the water quality. As human activities increases, changes in the land cover and land management practices has been regarded as the key influencing factors behind the alteration of the hydrological system, which leads to changes in runoff as well as the water quality. ONELGA is one of the major activity areas of the multinational oil and gas companies such as Nigerian Agip Oil Company (NAOC), Shell Petroleum Development Company (SPDC) and Elf-Total, and other independent oil companies such as Saipem Construction and Services and other servicing companies.

Description of the Study Area

The study area is ONELGA, and is located between latitudes 5° 13'.92"N and 5° 19'.38"N and longitudes 6° 38'.10"E and 6°38'.75"E. ONELGA is 85km north of Port Harcourt, the capital of Rivers State of Nigeria. Omoku is the headquarters of Ogba/Egbema/Ndoni Local Government Area in Rivers State. The area can be found in the northern part of the Niger Delta Region within the Niger Delta flood plain. The area is within the coastal rain forest of Nigeria, which is characterized by a long wet and a short dry season.

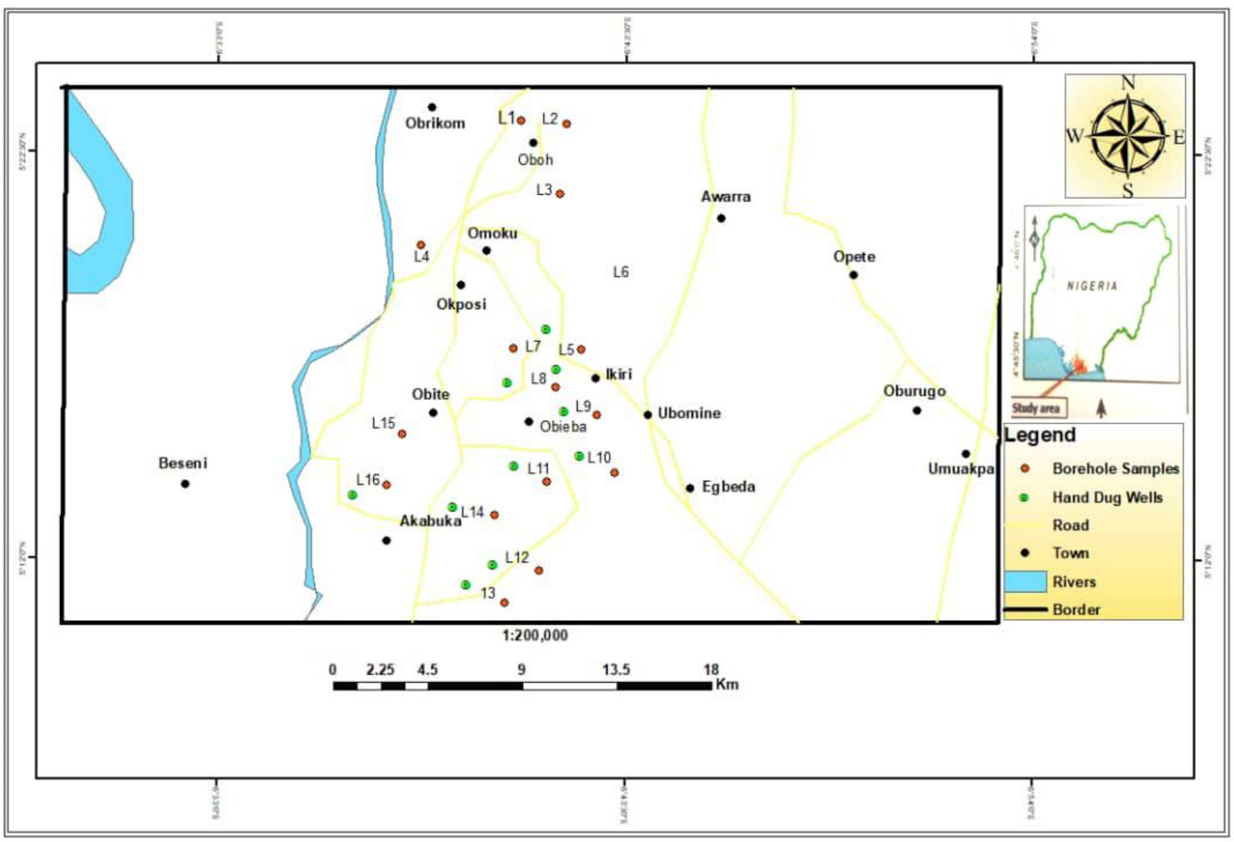

Fig 1: Map of the Study Area Showing Sampling Locations

Geology of the Study Area

The study area is Ogba, Egbema, Ndoni L.G.A of Rivers State (figure 1) located within the Niger Delta region of Nigeria, therefore has same geology as the Niger Delta. The Niger Delta Basin is perhaps the most prolific basin in Sub – Saharan Africa with respect to its petroleum resources (Short and Stauble, 1967). The Niger Delta is composed of marine shale as the base of its stratification, overlying it is an intercalation of sand and shale as the intermediate layer, then the topmost layer is sandstone (Etu–Efeotor & Akpokodje, 1990; Amajor, 1991). The groundwater occurrence is a multi – aquifer system because of the presence of certain clayey strata in formations of various thickness that acts as confining layer between two distinct aquiferous rock strata (Ngah, 1990; Nwankwoala, 2013; Nwankwoala and Ngah, 2014). The present-day Niger Delta was formed during the Tertiary period as a result of the interplay between subsidence and deposition arising from a succession of transgression and regression of the three – tertiary subsurface litho – stratigraphic units of Akata, Agbada and Benin formations (Short and Stauble, 1967). Further studies and evidence from deep wells drilled in the Niger Delta has also proven that the Niger Delta has a three litho – stratigraphic depositional succession (Akata, Agbada and Benin formations) with an approximate average thickness of over 5000m of sediment body (Amajor, 1991; Ngah, 2009).

Methods of Study

A random sampling approach was adopted in groundwater sampling in Ogba, Egbema, Ndoni Local Government Area of Rivers State, Nigeria. Thirty groundwater samples were collected, fifteen borehole and fifteen hand dug well water samples. At each borehole where water samples were collected, the water was allowed to flow freely for about 5 minutes in order clear all dissolved solids that may be stuck to the walls of the pipes and well head. All sample containers for water sample collection were rinsed with water being sampled before putting the sample into the containers. Sample for heavy metals were collected in plastic bottles while samples for microbiological analysis were collected in sterile vials. All sampling containers were neatly labelled after sample collection and stored in an ice tight chest for onward transport to the laboratory for analysis. All sampling locations were noted with the aid of a global positioning system (GPS).

Table 1. Coordinates of Sampling Locations and Geographic References for Groundwater Sampling in ONELGA

Sampling Location	Easting	Northing	Village/Community
1.	E 6°41' 58.488"	N 5°18' 48.744"	Osiakpu
2.	E 6°42' 13.968"	N 5°17' 42.072"	Elieata
3.	E 6°41' 483.318"	N 5°17' 7.134"	Ikiri
4.	E 6°41' 58.026"	N 5°16' 31.836"	Elehia
5.	E 6°41' 51.672"	N 5°15' 37.566"	Ohiuga
6.	E 6°41' 58.05"	N 5°141' 16.698"	Akapta
7.	E 6°41' 10.722"	N 5°147' 974"	Obukaegi
8.	E 6°40' 18.132"	N 5°11' 26.304"	Odiemudi, Erema 1
9.	E 6°39' 53.928"	N 5°10' 54.606"	Erema 2
10.	E 6°38' 22.848"	N 5°12' 40.136"	Akabuka
11.	E 6°36' 46.74"	N 5°15' 11.34"	Obagi
12.	E 6°38' 57.51"	N 5°14' 2.994"	Ogbogwu
13.	E 6°38' 756"	N 5°19' 360"	Kreigani Road
14.	E 6°40' 411"	N 5°21' 872"	Omoku Ahoada Road
15.	E 6°40' 238"	N 5°23' 164"	Obiafu / Obrikom

Table 2. Equipment and Analytical Methods Used for Groundwater Samples Analysis

S/N	Parameters	Equipment/Analytical Method	Standards
1.	Heavy Metals	Atomic Absorption	APHA
2.	Pb, Fe, Cd, Cr, Hg, As.	Spectrophotometer (AAS)	2111B
3.	BOD	WTW Oxitop Kit	APHA 5210D

4.	E-Coliform	MPN Analysis	APHA 2008

Paramete	BH1	BH2	BH3	BH4	BH5	BH6	BH7	BH8	BH9	BH10	BH11	BH12	BH13	BH14	BH15	WHO (2012)
Pb mg/l	0.012	0.009	0.003	0.013	0.002	0.003	0.005	0.001	0.001	0.001	0.002	0.018	0.023	0.003	0.033	0.01
Fe mg/l	0.122	0.011	0.046	0.076	0.006	0.003	0.021	0.004	0.001	<0.001	0.001	0.022	0.104	0.011	0.044	0.3
Cr mg/l	<0.001	<0.001	0.001	<0.001	0.002	0.001	0.001	<0.001	<0.001	<0.001	0.003	0.001	0.001	<0.001	0.006	0.05
Cu mg/l	0.044	0.021	0.03	0.043	0.002	0.004	0.001	0.004	<0.001	<0.001	0.001	0.023	0.01	0.005	0.037	1.0
Cd mg/l	0.002	0.003	0.01	<0.001	<0.001	0.001	<0.001	<0.002	<0.001	<0.001	0.004	0.006	0.001	<0.001	0.014	0.003
Hg mg/l	<0.001	<0.001	0.002	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.004	<0.001	0.022	0.2
As mg/l	<0.001	<0.001	<0.001	<0.001	<0.032	<0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.001	N/A

Table 3. Results of Heavy Metal Levels and Microbiological Parameters in Borehole Water
Keys: BH = Borehole

Table 4: Results of Heavy Metal Levels and Microbiological Parameters in Hand Dug Well Water

Parameter	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W15	WHO (2012
Pb mg/l	0.026	0.008	0.001	0.004	0.007	0.007	0.001	0.002	0.002	0.005	0.003	0.003	0.020	0.007	<0.001	0.01
Fe mg/l	0.064	0.014	0.034	0.002	0.004	0.007	<0.001	0.003	0.64	0.031	0.002	0.002	0.017	0.013	<0.001	0.3
Cr mg/l	<0.001	<0.001	0.002	0.010	<0.001	<0.002	<0.001	0.003	0.002	<0.001	0.002	0.002	0.001	0.001	0.0013	0.05
Cu mg/l	0.065	0.016	0.021	0.001	0.003	0.004	0.002	0.003	<0.001	0.008	0.001	0.032	0.020	0.009	0.008	1.0
Cd mg/l	0.005	<0.001	0.006	<0.001	0.001	0.002	<0.005	0.001	<0.001	<0.001	0.002	<0.001	0.004	0.004	<0.001	0.003
Hg mg/l	<0.001	<0.001	<0.001	<0.031	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.001	0.012	0.2
As mg/l	<0.001	<0.001	<0.001	0.042	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001	0.002	0.003	N/A

Heavy Metals Analysis of Groundwater of Boreholes and Hand dug wells

Lead (Pb)

Lead is the commonest of the heavy metals, Lead interact with pH, alkalinity and hardness and is most soluble in acidic, soft waters. The concentration of Pb in groundwater of boreholes and hand dug wells for both wet and dry season are shown on (Tables 3) Pb values varies from <0.001 – 0.122mg /l (boreholes) to <0.001 – 0.026mg/l (hand dug wells), lead concentration in groundwater in the study area is slightly above WHO recommended guideline of 0.01mg/l for potable water thus making the water unsuitable for drinking. Lead concentration is higher in hand dug wells than in borehole water during dry seasons.

Iron (Fe)

The values of Iron in groundwater of borehole and hand dug wells ranges from <0.001 – 0.006mg/l and <0.001 – 0.64mg/l respectively, (Tables 3\4). The values of Fe in groundwater in the study area is above WHO standards of 0.3mg/l for drinking water. Iron concentration is higher in hand dug wells compared to water boreholes.

Chromium (Cr)

The values of Chromium in groundwater of boreholes and hand dug wells ranges from <0.001 – 0.006mg/l and <0.001 – 0.010mg/l respectively (Tables 3\4). Chromium in groundwater of the area fall within WHO recommended guideline of 0.05mg/l for drinking water. Chromium values are higher in hand dug wells compared to its values in borehole water.

Copper (Cu)

The concentration of Copper in groundwater varies from
WHO were all within the WHO acceptable limits (WHO 2012).

Cadmium (Cd)

The concentration of cadmium in groundwater varies from <0.001 – 0.014mg/l (borehole) and <0.001 – 0.016mg/l (hand dug wells), whereas the maximum allowable limits of WHO is 0.003mg/l for drinking water, thus, with respect to Cadmium the water is potable. Cadmium recorded slightly lower values in borehole water samples compared to that of hand dug wells.

Mercury (Hg)

Mercury in groundwater ranges from <0.001 – 0.022mg/l (boreholes) and from Nil – 0.012mg/l (hand dug wells) which conform to WHO standard for potable water of 0.2mg/l. With respect to Mercury, groundwater in the area is suitable for drinking. Higher values were recorded in boreholes compared to groundwater from hand dug wells.

Arsenic (As)

The values of Arsenic in groundwater for boreholes and hand dug wells during dry seasons varies from <0.001 – 0.001mg/l and <0.001 – 0.042mg/l. The concentration of Arsenic is slightly higher in hand dug well 0.042mg/l (W4) compared to 0.001mg/l (BH5). Arsenic concentrations in groundwater of boreholes and hand dug wells in the study area is above WHO 2012 recommended standard of NA not to be found in any 100mg/l sample.

Heavy Metals Parameter of Groundwater of Boreholes and Hand Dug Wells

The concentration of Cd, and Hg are higher in boreholes than hand dug wells while Pb, Cr, and As values are higher in hand dug wells. The values of mercury and copper were within the WHO acceptable limits except for Cu (BH1) which exceeded 1.0mg/l of WHO. While Pb, Fe, Cr, Cd and As did not meet the recommended guideline. This result shows that heavy metal concentration in groundwater of the study area is significantly high to render the groundwater unsuitable for oral ingestion. This is in line with the studies of Shakirat et al, (2013).

Microbiological Analysis of Groundwater of Boreholes and Hand Dug Wells
Biochemical Oxygen Demand (BOD)
The values for the BOD in groundwater of borehole and hand dug wells for both wet and dry seasons are shown in Tables 4.7, 4.8, 4.15, 4.16 above. The values ranges from 0.10 – 0.88mg/l for boreholes and 0.12 – 0.95mg/l for hand dug well samples. The values for all samples were within the WHO acceptable limits of 200mg/l (WHO 2012). The concentration of BOD in groundwater samples means that there is enough oxygen to support life and indicates less organic pollution. BOD concentration is slightly higher in hand dug wells during dry season 0.95mg/l (W12) compared to 0.88mg/l (B12) still during dry season.

E. coli
Results from groundwater samples of boreholes and hand dug wells during wet and dry seasons as shown in Table 4.7, 4.8, 4.15, 4.16 above indicates Fecal contamination with indicator organism *E.coli* present in all water samples. The values of *E.coli* varies from 0.8 – 12mg/l (boreholes) and 0.12 – 17mg/l (hand dug wells). These values exceeds the WHO stipulated standard of N/A (must not be detected in 100ml) WHO, 2012. Based on the WHO requirement of absence of *E.coli* cells in 100ml of drinking water, thus groundwater in the study area is not suitable for human consumption and it can be concluded that there is systematic pollution of groundwater in that study area. Despite the theoretically lower vulnerability of boreholes to microbial contamination, all wells and boreholes under this study area are contaminated*. E.coli* presence is higher in hand dug well samples 17mg/l (W14) during dry season compared to 12mg/l (BH15) of wet season samples. Furthermore, high *E.coli* values in groundwater of the studied area could be due to poor waste disposal and poor sanitation in the area, causing water contamination from anthropogenic activities (Ayoade, 1994, Obasi *et al.,* 2013).

SUMMARY AND CONCLUSION
This study has provided data on the level of Heavy Metals and Microbiological and properties of groundwater from Boreholes and Hand dug wells during Dry seasons in parts of Ogba, Egbema, Ndoni Local government Area (ONELGA) Rivers state. This study was set out to compare the level of these properties from the various sources with WHO standard for drinking water, (boreholes and hand dug wells) in parts of ONELGA studied. Considering the result obtained from the investigation of groundwater of fifteen (15) boreholes and fifteen (15) hand dug wells at 15 different sampling locations, the following conclusion are drawn;
1) Pb, Fe and as analyzed were slightly above the limits set by WHO.
2) Heavy metals concentration were higher in hand dug wells (Pb,Fe,Cu,Cr, and As) than in borehole water samples except for (Cd and Hg).
3) BOD concentration is slightly higher in hand dug wells compared to borehole samples. BOD met the WHO standard for potability.
4) *E.coli* concentration is higher in hand dug well samples compared to borehole water samples.
5) The values of *E.coli* in groundwater during the season, exceeded the WHO stipulated standard in all the sample locations.

Thus, based on the level of Heavy Metals and Microbiological parameters of groundwater of Boreholes and Hand dug wells in parts of ONELGA studied, groundwater in its present state is not suitable as a source of drinking water because of its various health implication, notwithstanding the fact that some parameters were found to fall within the WHO permissible limits for drinking water. Deduction from the study indicates that the groundwater in the study area is generally suitable for irrigation purpose.

RECOMMENDATIONS

Sequel to this study, a few recommendations have been drawn up based on the results and findings. The result from this study shows that the socio – economic activities in the area did affect the groundwater quality and this could be a major threat to the health of the people.

Among the recommendation includes; proper town planning, creating awareness for groundwater quality protection, the need for improved regulations, among the identified needs are, improvements in drinking water standard, improved handling of special waste.

1) The relevant stakeholders have a task ahead in closing down open wells in the area for the sake of population likely to be affected through them, since they live near the area and make use of polluted groundwater. Unless we act, groundwater pollution growth is inevitable.
2) At the community level, public and school student should be educated/enlightened on groundwater quality and correct management through a seminar campaign, short films and other activities.
3) To improve groundwater quality, suitable management techniques such as regulating human activities, raising public awareness, as well as establishing a groundwater quality monitoring network are advised.
4) Human interference should be more effectively managed. Indiscriminate disposal of waste and uncontrolled use of agricultural pesticides should be controlled, as this is the most significant method for preventing groundwater contamination

REFERENCES

Abam, T.K.S. (2001), Regional hydrological research in the Niger Delta. *Journal of Hydrological Sciences*, 46(1).

Amajor, L.C (1991). Aquifers in the Benin Formation (Miocene Recent), Eastern Niger Delta, Nigeria: Lithostratigraphy, Hydraulics, and water quality. *Environment Geology and Water Sciences,* 17, 851-860.

Ayoade, J.O. (1994). Human impact on the Environment. In Fulani et al (eds) Ibadan region, Ibadan. Rex Charles Pub.

Etu-Efeotor, J.O. & Akpokodje, E.G. (1990). Aquifer System of the Niger Delta. *Journal of Mining and Geology*. 26(2), 279-284.

JICA (2014). The Project for Review and Update of Nigeria National Water Resources Master Plan Vol. 2. JICA, YE co. Ltd, CTI E I co. Ltd, SC Inc. Japan.

Ngah, S.A. (2009). Deep Aquifer Systems of Eastern Niger Delta; Their Hydrogeological Properties, Groundwater Chemistry and Vulnerability to Degradations. Unpublished Ph.D Thesis, Rivers State University of Science, Port Harcourt, 247.

Ngah, S.A. & Eze, C. (2017). Typical Hydralic Properties of Deep Aquifers of Niger Delta from Pumping Test Data. *Journal of Geoscience and Environment Protection*.5, 139-148.

Nwankwoala, H.O. (2013). Ionic Abundance and Distributions in Groundwater Systems: A case study. *Greener Journal of Physical Sciences*, 3(4). 115-130.

Nwankwoala H.O. & Ngah, S.A. (2014). Groundwater Resources of the Niger Delta: Quality Implications and Management Considerations. *International Journal of Water Resources and Environmental Engineering,* 6 (5), 155-163.

Obasi, A.I.; Okoro, A.U; Nweke, O.M. & Chukwu, A. (2013). Lithofacies and Paleo Depositional Environment of the rocks of Nkpuma – Akpatakpa, 1331, Southeast Nigeria. *African Journal of Environmental Science Technology*

Obatoyinbo, O. & Oyedotun, T.D.T (2011), Microbial/bacteriological analysis of water resources in Ikare and ArigidiAkoko of Ondo State, Nigeria. In: EIT International Conferences on Water Resources Engineering, 18th-19th Aug, Cha-Am. Proceedings, 1, 279-284.

Shakirat K.T. & Akinpelu, A.T. (2013). Study of heavy metals pollution and physico-chemical assessment of water quality of River Owo, Agbara, Nigeria. *International Journal of Water Resources and Environmental Engineering,* 5(7), 434-341

Short, K.C. & Stauble, A.J. (1967). Outline Geology of the Niger Delta. *AAPG Bulletin*, 54, 761-779.