Hydrochemistry of Groundwater in Obiga-Asa and its Environs, Abia State, Nigeria

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Abstract- The hydrochemistry of groundwater in Obiga-Asa and its environs has been carried out. The pH, conductivity, TDS, sulphate, carbonate (HCO_3), Iron (Fe^{2+}), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Sodium (Na^+) and Potassium (K^+) were analysed. pH, Conductivity and TDS were determined by meter method, Na, K, Mg, Ca by Atomic adsorption spectrophotometer (AAS), Carbonate and Chloride by titrimetric method and Suphate by turbidometric method. The result showed that the pH of the groundwater within the study area is generally acidic (3.98 – 4.61) and averaged 4.381. The values conductivity, Mg^{2+}, Ca^{2+}, Na^+, K^+, TDS, Chloride, sulphate and carbonate were below regulatory limits. The velues of pH were outside the regulatory limits in all the stations studied while the Fe^{2+} was slightly above the regulatory limit at Umuorie and Umukalu. This therefore suggests that the groundwater within the study area is fairly good for consumption however; they should be treated to bring the pH to regulatory limit of 6.5 – 8.5.

Index Terms- Hydrochemistry; Groundwater quality; contaminations; Obiga Asa; Abia State

1 INTRODUCTION

Land and water are precious natural resources on which rely the sustainability of agriculture, industrialization and the civilization of mankind. Unfortunately, they have been subjected to severe exploitation and contamination due to anthropogenic activities such as industrial effluent, solid waste landfills, gas flaring, oil spillage and petroleum refining leading to the release of heavy metals and other contaminants into the environment (Ahmad *et al.*, 2010; Bellos and Swaidis, 2005). Each source of contaminant has its own damaging effects to plants, animals and ultimately to human health, but those that add heavy metals to soils and waters are of serious concern due to their persistence in the environment and carcinogenicity of some of these heavy metals to human beings. Unlike the organic pollutants which are biodegradable (Ammann *et al.*, 2002; Adams, *et al.*, 2008), heavy metal ions are not biodegradable (Lee *et al.*, 2007), thus making them a source of great concern. These heavy metals can be bio-accumulated in living organisms through food chain toxic effects on them (Aktar, *et al.*, 2010). Human health, agricultural development and the ecosystem are all at risk unless soil and water systems are effectively managed (Akoto, *et al.*, 2008). Close relationship exist between groundwater quality and land use as various land use activities can result in groundwater contamination.

The people of Obiga-Asa and its Environs depend on borehole water for domestic and industrial activities. The majority of populate, if not all drink the underground water directly, without any form of treatment, oblivion of its chemical composition. Groundwater quality is

ISSN 2229-5518

influenced by the geology and geochemistry of the environment, rate of urbanization, industrialization, landfill/dumpsiteleachates, heavy metals, bacteriological pollution, and effect of seasons (Ocheri et al., 2014). Apart from the geology and seasonal effects, all other activities that result in the contamination of ground water is anthropogenic. Some of these activities take place in the geographical region Obiga-Asa and environs are located. Nwankwoala andUdom, (2011) acknowledged that the groundwater quality in the region is rapidly deteriorating due to increase in population and rapid urbanization resulting from petroleum exploration and production. Water is directly linked to human and animal health, and its suitability or potability for consumption depends on its characteristics (Adindu et al., 2012). Hence, it is very essential to understand the hydro-chemical properties of the groundwater in the study area. Therefore, the aim of this study is to analyze groundwater samples from Obiga-Asa and its environs and assess the suitability of the water for domestic and other uses by comparing it to World Health Organisation (WHO) (1971 and 2006) and National Agency for Food and Drug Administration and Control (NAFDAC) (2001) standards.

1.1 Study Area

The study area, Obiga-Asa, is located in Ukwa West Local Government Area of Abia State, Nigeria. It lies between the latitudes 04°54N to 04°57N and longitudes 007°110E to 007°16E (Figure 1). It is bounded to the north by Aba North, Aba South, Osisioma and Ugwunagbo Local Government Areas, to the east by Ukwa East, to the south and south west by Oyibo and Etche Local Government Areas of Rivers state respectively, and to the north west by Imo state. Within the study area are nine (9) communities, which include Obiga-Asa, Obibor-Asa, Umuelechi-Asa, Obehie-Asa, Umukalu-Asa, Umeorie-Asa, Ezendioma, Umuokwor and Umudiobia.

The study area is relatively flat in terrain with elevation above mean sea level that varies between 53 and 87m. Generally, Abia state, where the study area is located is mainly drained by the ImoRiver that flows from Imo state in the North through the eastern part of the state to the Atlantic Ocean in the south. Other rivers that drain the state include Aba River (a tributary of Imo River), lgwu, Azurnini Blue River and Kwalbo.

ISSN 2229-5518

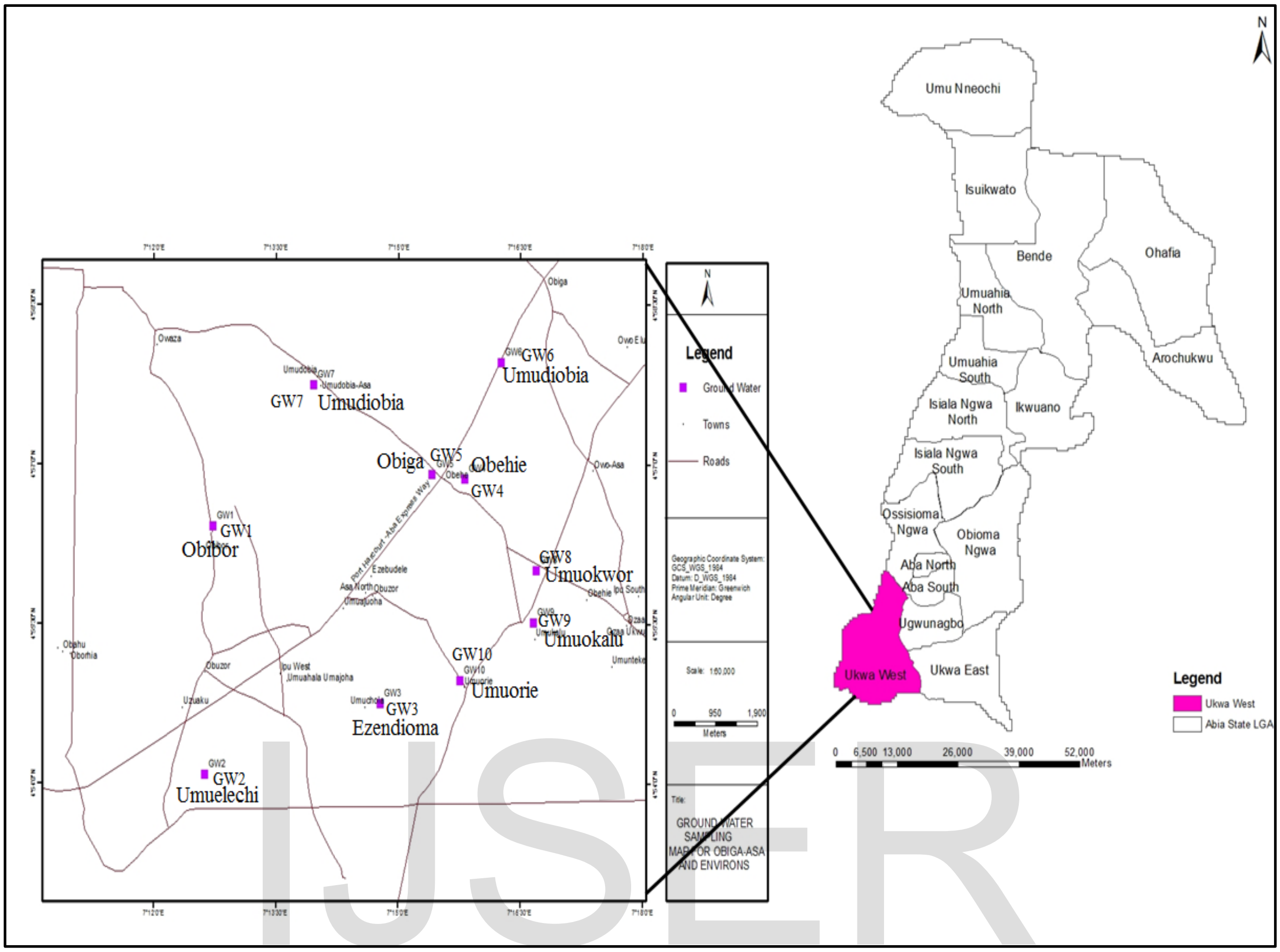


Figure 1 Showing location maps of the study area. The right side map is the map of Abia state of Nigeria showing the location of Ukwa West Local Government area, while the left side map is the map of Obiga Asa and environs showing groundwater (GW) sampling locations.

Obiga-Asa lies within the Niger delta basin which consists of three lithostratigraphic units – Benin, Agbada and Akata Formation (Short and Stauble, 1967). The top-most formation, Benin Formation, which can be impacted by human/industrial activities consist of continental and fluvial sands, gravel, and back swamp deposits. In the coastal areas and flood plains, the Benin Formation is overlain by the Quaternary alluvium deposits which consist of sand and gravel.

The aquifer in the study area is Benin Formations (Adelana, et al., 2008). It is either confined or unconfined aquifers. Depth to aquifers confined by shale or clay bed varies across Niger Delta. However, according to Adelana, et al. (2008), borehole data indicate a depthof approximately 100m and the specific capacity varies between 140 and 180m^3/d/m.

The unconfined aquifer closed to the ground surface is easily impacted by human and industrial activities. Most of the boreholes in the study area tap water from the top unconfined aquifer. It is recharged steadily through direct precipitation and major rivers. Depth to water table ranges between 3 and 15m below ground surface. It is sandy and highly permeable, with specific capacity 150 and 1400m^3/d/m.

2 METHODOLOGY

The materials used for this study include; pH, Conductivity and TDS meters, GPS, sample containers (1000ml for physic-chemical parameters and 100ml for heavy metal), cooler with ice blocks, masking tape, field notebook, e.t.c.

Water samples were collected from the boreholes shown in Fig. 1 and Table 1 in clean 1000ml plastic containers after pumping the wells for about 10 minutes to ensure stable conditions. Thereafter, water samples from the boreholes were collected into different sample containers for the different analysis. Immediately after sampling, containers containing the samples for physic-chemical parameter were placed in a cooler containing ice blocks for preservation while heavy metal samples were fixed with trioxonitrate (v) acid (HNO_3).

Table 1 Showing Location and Coordinate of sampling points

S/n	Location	Location Identity	Coordinates	
			Longitudes	Latitudes
1	Obibor	GW 1	04^{0}54' 10.7''	007^0 10' 56.0''
2	Umuelechi	GW 2	04^0 54' 04.8''	007^0 12' 38.1''
3	Ezendioma	GW 3	04^0 54' 44.8''	007^0 14' 47.5''
4	Obehie-Asa 1	GW 4	04^0 56' 51.8''	007^0 15' 49.4''
5	Obehie-Asa 2	GW 7	04^0 56' 54.1''	007^0 15' 25.5''
6	Obiga-Asa	GW 5	04^0 57' 57.4''	007^0 16' 16.0''
7	Umudiobia	GW 6	04^0 57' 43.1''	007^0 14' 06.0''
8	Umuokwor-Asa	GW 8	04^0 56' 00.2''	007^0 16' 42.2''
9	Umukalu-Asa	GW 9	04^0 55' 30.8''	007^0 16' 40.1''
10	Umuorie-Asa	GW 10	04^0 54' 57.9''	007^0 15' 46.0''

2.1Analytical Techniques

pH, conductivity and TDS were analysed by meter method in the field. The samples for Na, K, Mg, Ca were analysed in the laboratory using Atomic adsorption spectrophotometer (AAS) (AOAC, 2004) while Carbonate and Chloride were analysed using titrimetric method. Suphate were determined by turbidometric methods.

For the determination of the pH of samples, the pH meter was stabilized for 15 minutes using the water samples. The electrode was then rinsed with distilled water. Thereafter, the meter was calibrated using buffer 4, 7 and 10. The electrode was further rinsed with distilled water, dipped into the water sample, allowed to stabilize and the reading on the meter recorded.

The conductivity and TDS of the water samples were measured by rinsing the conductivity meter electrode with distilled water. The electrode was dipped into the water samples, allowed to stabilize and the readings recorded.

Chloride was determined using titrimetric method in which 25ml of water sample was measured into 100ml conical flask, 2 drops of potassium dichromate added and titrated with standard silver nitrate until the appearance of a brick red colour as the end point. The titre value recorded and the amount of chloride calculated as follows:

$$\text{Amount of Chloride (mg/l)} = \frac{\text{Titre (ml) x 0.5 x1000}}{\text{Volume of Sample (ml)}}$$

3 RESULTS AND DISCUSSION

The results of the groundwater from the study area are shown in Table 2, while the results are summarized and compared with standards in Table 3. Generally, the range of values recorded for the different parameters analyzed include; pH (3.94 – 4.61), Conductivity (44.0 – 399.0 µS/cm), TDS (22.0 – 209.0 mg/l), Chloride (8.0 – 14.0 mg/l), Sulphate (0.58 – 0.72 mg/l), Carbonate (0.001 – 0.82 mg/l), Iron (<0.01 – 0.551 mg/l), Magnesium (0.247 – 1.306 mg/l), Calcium (<0.1 – 0.314 mg/l), Sodium (<0.1 – 1.792 mg/l) and Potassium (<0.1 – 3.688 mg/l).

Table 2 Shows the physic-chemical results of the groundwater studied

Location	Parameters										
	pH	Cond (µS/cm)	TDS (mg/l)	Chloride (mg/l)	Sulfate (mg/l)	HCO_3 (mg/l)	Fe^{2+} (mg/l)	Mg^{2+} (mg/l)	Ca^{2+} (mg/l)	Na^+ (mg/l)	K^+ (mg/l)
Obibor (GW-1)	4.48	86	42	12.0	0.69	0.78	0.000	0.405	0.000	0.026	0.028
Umuelechi (WG-2)	4.43	44	23	8.0	0.61	0.79	0.000	0.691	0.003	0.000	0.524
Ezendioma (GW-3)	4.42	97	47	12.8	0.72	0.8	0.205	0.702	0.025	0.628	0.000
Obehie-Asa 1 (GW-4)	3.94	93	49	12.0	0.64	0.81	0.000	0.247	0.000	1.298	0.733

Obiga-Asa (GW-5)	4.24	66	34	14.0	0.68	0.82	0.158	0.358	0.000	0.000	0.010
Umudiobia (GW-6)	4.22	399	209	14.0	0.67	0.81	0.183	1.306	0.314	1.676	3.688
Obehie-Asa 2 (GW-7)	4.44	63	34.5	8.0	0.58	0.78	0.063	0.575	0.000	1.792	0.000
Umuokwor-Asa (GW-8)	4.58	44	22	9.6	0.6	0.001	0.063	0.310	0.000	0.062	0.000
Umukalu-Asa (GW-9)	4.45	127	47	8.0	0.69	0.001	0.551	0.794	0.163	0.215	0.139
Umuorie- Asa (GW-10)	4.61	68	36	8.0	0.68	0.001	0.348	0.682	0.000	0.002	0.157

Table 3 Shows **s**ummary of the Physico-chemical parameters of groundwater studied compared with regulatory standards

Parameter	**Maximum**	**Minimum**	**Average**	**STD**	**NAFDAC, 2007**	**WHO, 2006**
pH	4.61	3.94	4.381	0.198	6.5 - 8.5	6.5
Conductivity (µS/cm)	399.0	44.0	108.7	105.12	1000	-
TDS (mg/l)	209.0	22.0	54.35	55.156	500	-
Chloride (mg/l)	14.0	8.0	10.64	2.58	250	250
Sulphate (mg/l)	0.72	0.58	0.656	0.046	200	250
HCO_3 (mg/l)	0.82	0.001	0.559	0.385	500	-
Fe^{2+} (mg/l)	0.551	BDL	0.157	0.178	0.3	-
Mg^{2+} (mg/l)	1.306	0.247	0.607	0.31	30	50
Ca^{2+} (mg/l)	0.314	BDL	0.051	0.106	7.5	7.5
Na^{+} (mg/l)	1.792	BDL	0.57	0.738	200	200
K^{+} (mg/l)	3.688	BDL	0.528	1.139	-	200

BDL = below detectable limit; **STD =** Standard deviation

3.1 pH

The pH of groundwater within the study area ranged from 3.94 – 4.61. This indicated that the groundwater is generally acidic (Table 2). The sample from Obehie-Asa (GW-4) was the most acidic while the sample from Umuorie–Asa (GW-10) was the least acidic. Though according to Ezeigbo(1988), the groundwater of Benin Formation is low in pH, the very low pH value recorded at Obehie can be possibly be attributed to pollution from leachate from waste and dumpsites around the area. Ground water within the vicinity of dumpsite is characterised by low pH (Amadi, 2010). The range of values recorded during this study was not within the regulatory limits (Table3; Fig. 2.). The WHO (2006) standard value for potable water is 6.5 - 8.5.

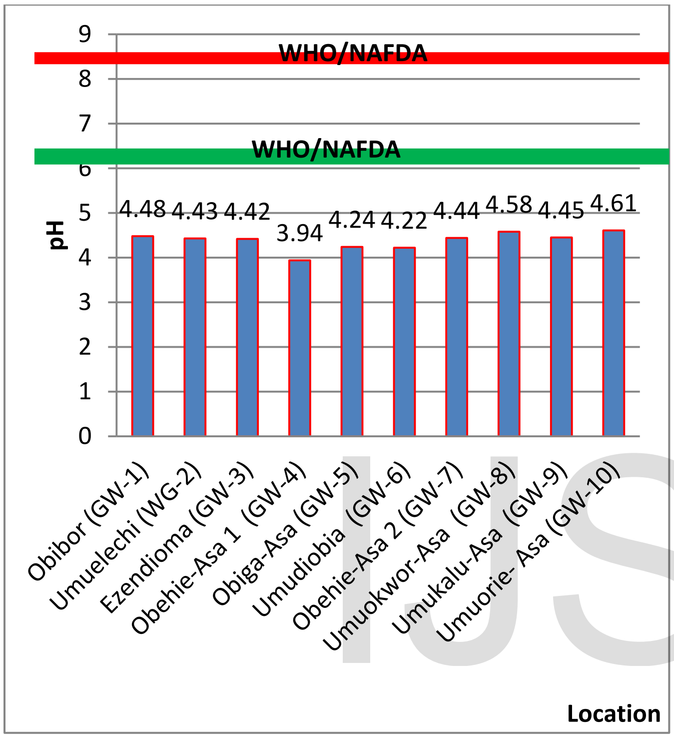


Figure 2 shows comparison between the pH of the groundwater with NAFDAC (2007) and WHO (2006) standards.

3.2 Conductivity

The Conductivity values varied from 44.0 – 399.0 µS/cm and it is the measure of the ability of water samples to conduct electric current. Among the samples collected, the sample from Umuokwor-Asa and Umuelechi-Asa had the lowest value 44.0 µS/cm (Table 2). These are followed by Obehie-Asa 2 (63.0 µS/cm), Obiga-Asa (66.0 µS/cm), Umuorie-Asa (68.0 µS/cm) and Obibor (86.0 µS/cm). These values are okay for drinking water and generally within Nigerian regulatory standard of 1000 µS/cm (Fig. 3). This range of values is in line with the previous study.

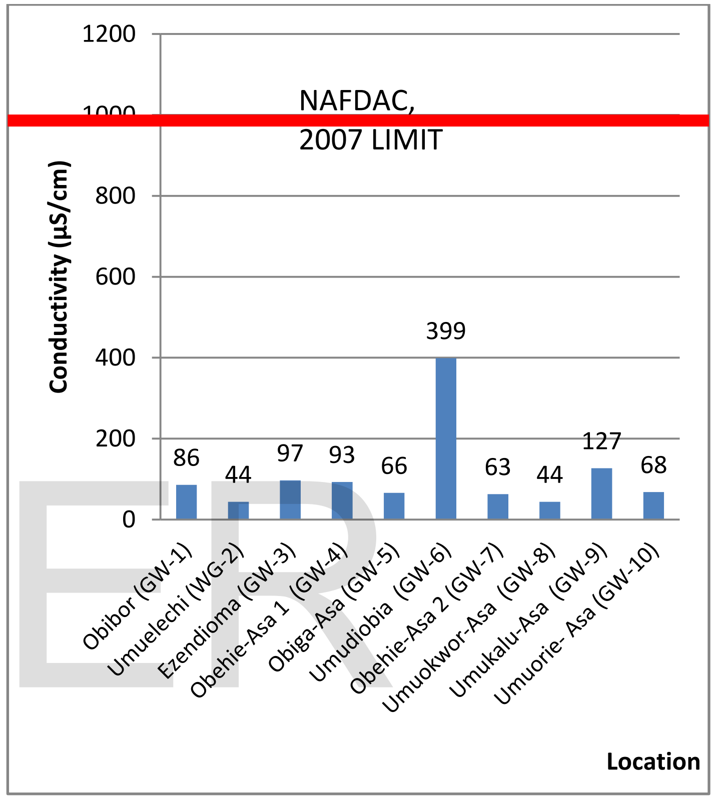


Figure 3 shows comparison between the Conductivity in the groundwater and NAFDAC (2007) standard.

3.3 Total Dissolved Solid (TDS)

This is the measure of the concentration of salts (organic and inorganic) in the water samples. Within the study area, the concentration recorded varied form 22.0 – 209.0 mg/l (Table 2). The maximum concentration was found in sample collected from Umudiobia (209.9mg/l) while the lowest value was in sample from Umuelechi-Asa. The different levels of TDS are attributed to different levels of anthropogenic activities. Umudiobia community has more of industrial activities than Umuelechi-Asa. The range of values however is within the permissible limit of 500mg/l (Fig.4; Table 3). According to World health Organisation (WHO, 1971), TDS < 500mg/l indicate excellent to good water.

3.4 Chloride

The chloride values of the study area were low compared to the regulatory standards. It can be attributed to absence of marine influences or salt water intrusion. For instance, Umuelechi-Asa, Obehie-Asa 2, Umukalu-Asa and Umuorie-Asa have chloride content of 8.0 mg/l each, Obibor and Obehie Asa-1 have 12.0 mg/l each, Umudiobia and Obiga-Asa 14.0 mg/l each while the concentration Umuokwor-Asa and Ezendioma are 9.6 mg/l and 12.8 mg/l respectively (Table 2). These concentrations are all within the NAFDAC (2007) and WHO (2006) limits of 250 mg/l (Table 3; Fig. 5).

3.5 Sulphate and Carbonate

The concentrations of sulphate and carbonate in the borehole samples were low (Table 3). For instance, the concentration of sulphate ranged from 0.58 to 0.72 mg/l, while that of carbonate ranged from 0.001 to 0.82 mg/l. These values are within the NAFDAC (2007) and WHO (2006) regulatory standards respectively (Figs. 6 and 7).

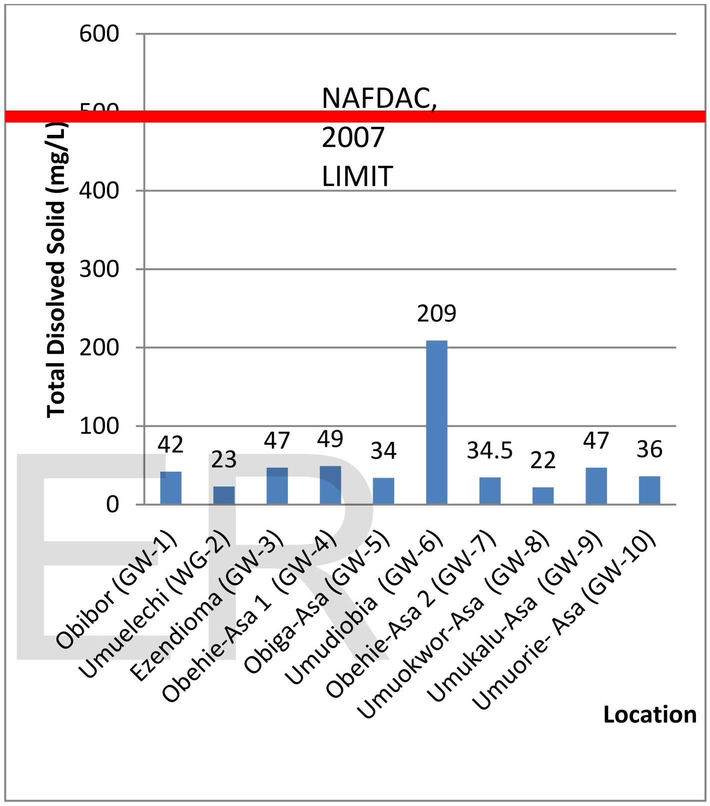


Figure 4 shows comparison between the total dissolve solids (TDS) with NAFDAC (2007) standards.

ISSN 2229-5518

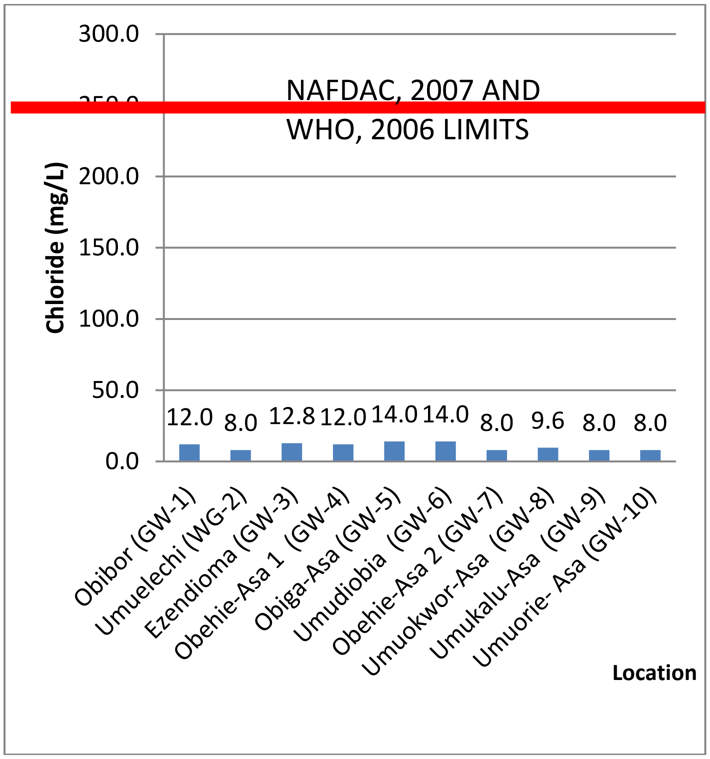


Figure 5 shows comparison between the Chloride in the groundwater and regulatory standards.

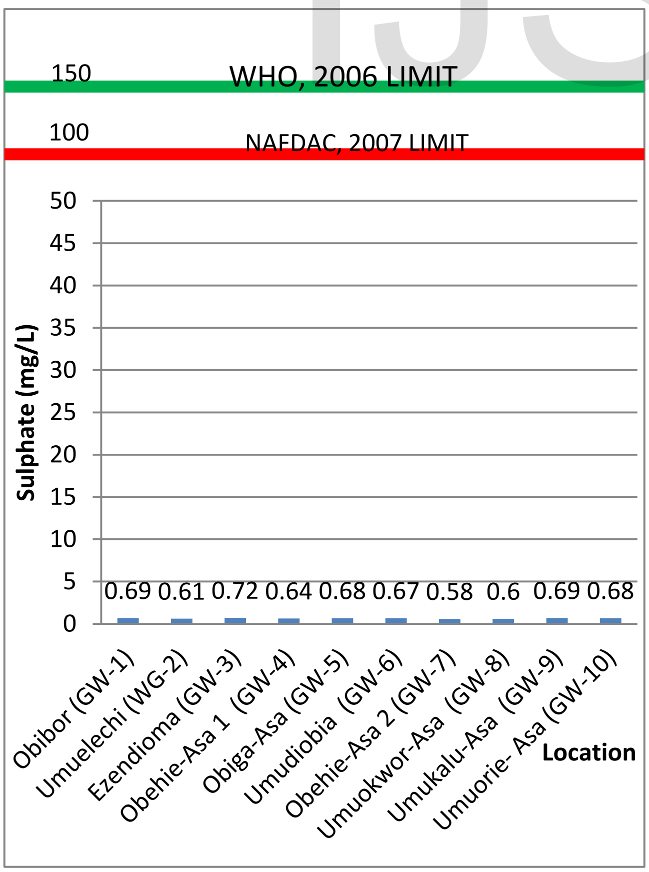


Figure 6 shows comparison between the Sulphate in the groundwater and regulatory standards.

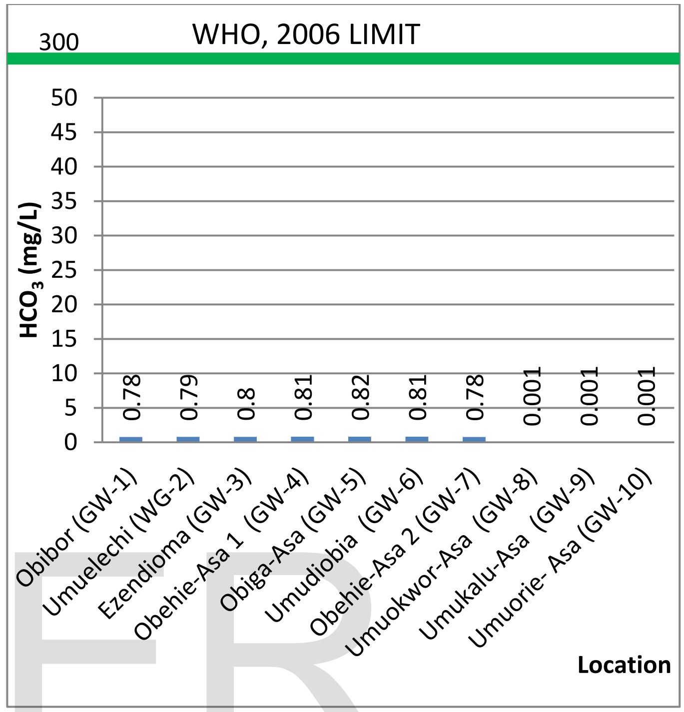
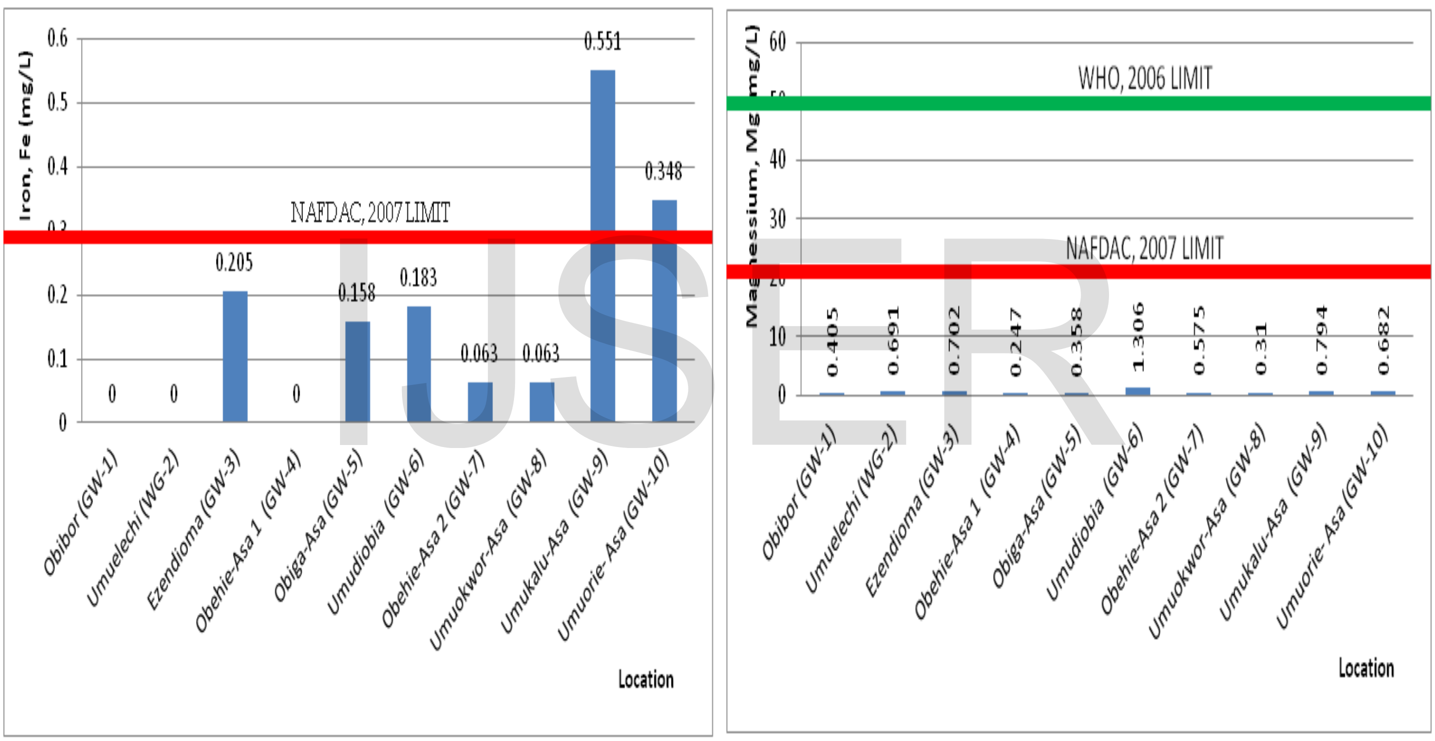


Figure 7 shows comparison between the Carbonate in the groundwater and regulatory standards.

3.6 Heavy metals

Heavy metals are individual metals and metal compounds that can impact human health when ingested either by eating or drinking (Ocheri et al., 2014). The concentration of the analyzed heavy metals in the samples within the study area include: Iron (<0.01 – 0.551 mg/l), Magnesium (0.247 – 1.306 mg/l), Calcium (<0.1 – 0.314 mg/l), Sodium (<0.1 – 1.792 mg/l) and Potassium (<0.1 – 3.688 mg/l). These concentrations of the heavy metals were all within the regulatory limits except

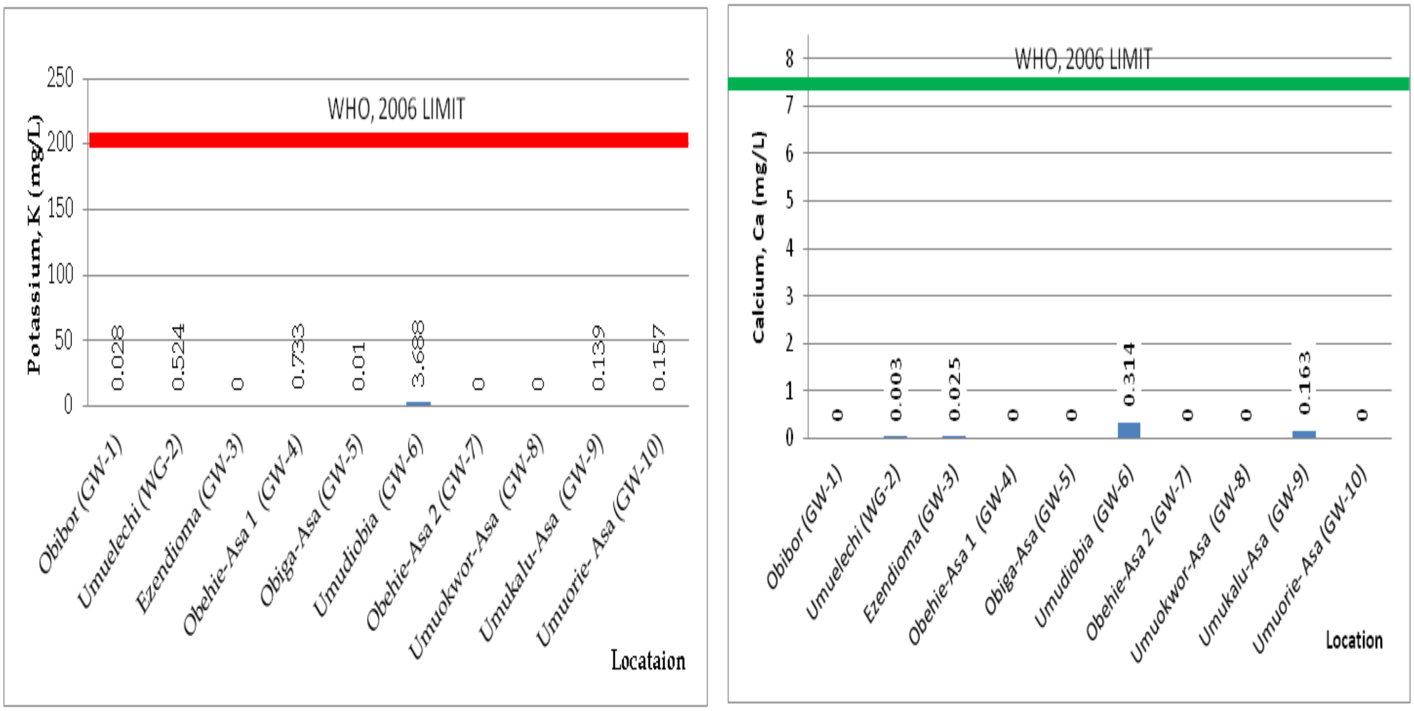
Iron that was slightly above the regulatory limit (Fig. 8a and b, 9a and b and 10). This is in line with the study of Edeth (1993). The high iron concentrations were observed in samples collected from Umukalu-Asa and Umuorie-Asa. This difference in concentration may be attributed to the anthropogenic activities (oil and gas exploration and exploitation) in and within these communities. The low concentrations of Ca and Mg ions and the carbonates discussed above indicate that the water is soft (Adindu et al., 2012). It suggests absence of calcium or magnesium carbonate minerals such as calcite or gypsum in the aquifer or soil in contact with percolating rainfall water that recharges the aquifer.



(a) **(b)**

Figure 8 shows comparison of Iron and magnesium in the groundwater withthe regulatory standards.

ISSN 2229-5518



(a) (b)

Figure 9 shows comparison between the Potassium and calcium in the groundwater with the regulatory standards. Figs. 9a and b show that potassium and calcium respectively, are far below the WHO (2006) limits.

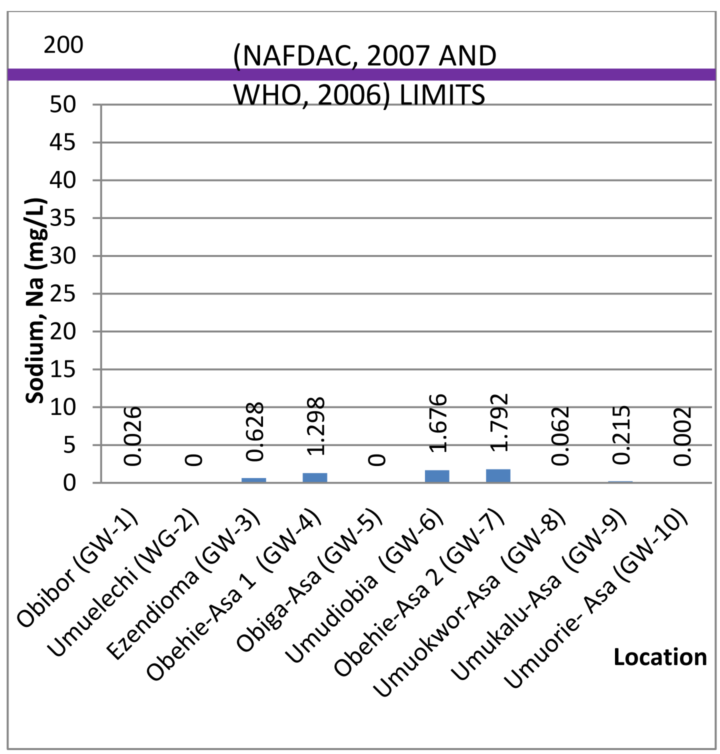


Figure 10 shows comparison between the Sodium in the groundwater and regulatory standards.

4 CONCLUSIONS

The analysis of pH, conductivity, TDS, sulphate, carbonate (HCO_3), Iron (Fe^{2+}), Magnesium (Mg^{2+}), Calcium (Ca^{2+}), Sodium (Na^+) and Potassium (K^+) of groundwater in Obiga-Asa and its environs showed that pH of the groundwater in the study area is generally low showing acidity (3.98 – 4.61) and iron concentration is only above the regulatory limit at Umukalu-Asa and Umuorie-Asa. Since the rest parameters are within the regulatory limits, it therefore suggests that the groundwater within the study area is fairly good for human consumption, though anthropogenic activities such as waste disposal and hydrocarbon exploration results in variations in quality. Therefore, generally groundwater for consumption should be treated to bring the pH to regulatory limit of 6.5 – 8.5. While Ground water at Umukalu-Asa and Umuorie-Asa, should be treated for Iron. Proper methods of waste disposal that will ensure the preservation of groundwater quality should be introduced by the authority. Also, it is recommended that the microbiological and other parameters should be analyzed to really authenticate the quality of groundwater in the study area.

ACKNOWLEDGEMENT

The authors are grateful to Dr. C. Ekeke for his assistance in samples collection and in-situ analysis. Gratitude is also extended to the laboratory staffs for their cooperation during the laboratory analysis of samples.

REFERENCES

Adams, R. H., Guzmán-Osorio, F. J., & Zavala, C. J. (2008). Water repellency in oil contaminated sandy and clayey soils. International Journal of Environmental Science and Technology, 5(4), 445-454.

Adelana, S.M.A., Olasehinde, P.I., Bale, R.B., Vrbka, P., Edet, A.E., & Goni, I.B., 2008. An overview of the geology and hydrogeology of Nigeria, in applied ground water studies in Africa, Publ. Taylor & Francis Group, London, UK, pp.171-197.

Adindu, R. U., Igboekwe, M. U. and Lebe Nnanna, 2012. Groundwater Mineralization Analysis of Osisioma Local Government Area of Aba, Abia State, Nigeria American Journal of Chemistry, 2(3): 121-125.

Ahmad, M. K., Islam, S., Rahman, S., Haque, M. R. & Islam, M. M., (2010). Heavy metals in water, sediment and some fishes of Buriganga River, Bangladesh. International

Journal of Environmental Resources, 4(2), 321-332.

Akoto, O., Bruce, T. N., & Darko, G., (2008). Heavy metals pollution profiles in streams serving the Owabi reservoir. African Journal of Environmental Science and Technology, 2(11), 354-359.

Aktar, M. W., Paramasivam. M., Ganguly, M., Purkait, S., & Sengupta, D., (2010). Assessment and occurrence of various heavy metals in surface water of Ganga river around Kolkata: a study for toxicity and ecological impact. Environmental Monitoring and Assessment, 160 (2), 207-213. doi.10.1007/s10661-008-0688-5.

Amadi, A.N., Ameh, M.I and P.I.Olasehinde.2010.Effect of urbanization on groundwater quality withinMakurdi Metropolis, Benue State. Proceedings,Annual Conference of the Nigerian Association ofHydrogeologists on Water Resources Developmentand Climate Change.p49.

Ammann, A. A., Michalke, B. & Schramel, P., (2002). Speciation of heavy metals in environmental water by ion chromatography coupled to ICP-MS. Analatia Bioanal Chemistry, 372(3), 448-452.

AOAC (2004). Official methods of analysis of Association of Official Analytical Chemists15th Edn., Washington D.C. USA. pp: 200-210.

Bellos, D. & Sawidis, T., (2005). Chemical pollution monitoring of the River Pinios Thessalia Greece. Journal of Environmental Management, 76, 282-292.

Ezeigbo, H.I.1988.Geological and hydrogeologicalinfluence on the Nigerian environment. Journal ofwater resources, Vol.2, pp.36-44.

Lee, C. L., Li, X. D., Zhang, G., Li, J., Ding, A. J. & Wang, T., (2007). Heavy metals and Pb isotopic composition of aerosols in urban and suburban areas of Hong Kong and Guangzhou, South China Evidence of the long-range transport of air contaminants. Environmental Pollution, 41(1), 432-447.

NAFDAC (2001). National Agency for Food and Drug Administration and Control, Ministry Safety bulletin, Volume 1. Recommendation, National agency for food, Drug, Administration and control. Lagos, Nigeria.

Nwankwoala, H. O. and Udom, G. J. (2011). Hydro-geochemical Evaluation of Groundwater In Parts of Eastern Niger Delta, Nigeria. *Journal of Academic and Applied Studies,* 1(2): 33-58.

Ocheri, M.I, L. A. Odoma and Umar. N.D., 2014. Groundwater Quality in Nigerian Urban Areas: A

Review. Global Journal of Science Frontier Research: (H) Environment & Earth Science, 14 (3) Version 1.0: 35-46

Short, K. C. and Stauble, A. J. (1967)" Outline of the geology of the Niger Delta". AAPG Bull.51:761-779.

WHO (World health Organisation) 1971. International Standard for drinking water. Geneva, World health organisation, 70p

WHO (World Health Organization), (2006) Guidelines for Drinking-Water Quality. First addendum to 3rd ed. 1, Recommendation. Geneva, WHO (World Health Organization), p. 595.