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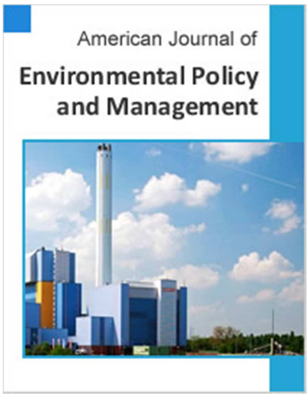

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Application of Geographic Information System in the Hydrochemical Evaluation of Groundwater in Parts of Eastern Niger Delta Nigeria

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Abstract
Application of Geographic Information System (GIS) in the hydrochemical evaluation of groundwater in parts of Eastern Niger Delta Nigeria has been done to ascertain the spatial distribution of pollutants and the hydrogeochemical character of the available water sources in the area. Fifty eight (58) water samples were collected within the study area and were subjected to chemical analyses. The result of the analyses revealed that Calcium concentration (mg/l) ranged between 0-0.22 and 0–1.4, for wet and dry seasons respectively, Magnesium concentration (mg/l) ranged between 0.2-4.6 and 0.2–3.0, for wet and dry seasons respectively, Sodium concentration (mg/l) ranged between 1.2-7.3 and 1.12–6.13, for wet and dry seasons respectively, while Potassium concentration (mg/l) ranged between 1.0-5.3 and 1.02–4.2, for wet and dry seasons respectively. Chlorine concentration (mg/l) ranged between 6.0-17.0 and 5.0–14, for wet and dry seasons respectively, Bicarbonate concentration (mg/l) ranged between 17.9-56.3 and 17.9–52.2, for wet and dry seasons respectively, while Sulphate concentration (mg/l) ranged between 164.6-248.0 and 121.1–224.0, for wet and dry seasons respectively. Arsenic concentration (mg/l) ranged between 0-1.35 and 0–1.25, for wet and dry seasons respectively, Copper concentration (mg/l) ranged between 0 - 0. 95 and 0 – 0.08, for wet and dry seasons respectively, Iron concentration (mg/l) ranged between 0-0.09 and 0–0.08, for wet and dry seasons respectively, Mercury concentration (mg/l) ranged between 0-0.014 and 0–0.01, for wet and dry seasons respectively, while Lead concentration (mg/l) ranged between 0-0.4 for both wet and dry seasons. The hydrochemical characterization modeling result revealed that SO_4 and SO_4 –HCO_3 were the dominant ionic species in groundwater sources in the area, with a trend of $SO_4 > HCO_3 > Cl >$ Na+K > Mg > Ca. This study therefore, recommends among others that public enlightenment efforts need to be enhanced in the entire area, especially in densely populated urban area, to improve on personal and public hygienic lives of the people. Efforts in this direction can reduce the problems of public water supply sources.

1. Introduction

Groundwater constitutes over 90% of the world's readily available freshwater resources with remaining 10% in lakes, reservoirs, rivers and wetlands [2]. Water is an essential resource and forms the primary need of man in his environment. It is a vital component of life for both plants and animals. It is available in forms of rain and snow thereby making rivers, oceans, streams, lakes, springs etc. Water quality is extremely important because constant access to good quality water is necessary for life as well as the economy. Environmental concerns related to groundwater (GW) generally focus on the impact of pollution and quality degradation in relation to human uses, particularly domestic supply. Due to high population growth and industrialization, greater amounts of domestic and industrial effluents are discharged that lead to the pollution of GW in shallow aquifers. The presence of adequate supply of quality water for human consumption is essential for sustainable development program of any society. The chemical composition of groundwater is a measure of its suitability as a source of water for human consumption or for other usages like Agricultural and Industrial purposes. Water quality is of vital concern to mankind, since it is directly linked with human welfare [5]. It is regrettable that rapid urbanization, improper waste disposal and landfill, excessive application of fertilizers and unsanitary conditions have threatened groundwater quality. Consequently, human health in many parts of the world has been endangered by naturally occurring pollutants and anthropogenic pollutants [4].

Critical evaluation of the existing climatic conditions is basic in the planning of water resources development of an area. The rainfall, temperature and evapotranspiration conditions are of great significance to water resources development. The study area is characterized by two major seasons: the wet (rainy) season, and the dry season. Mean annual rainfall of about 2152mm in the study area has been recorded by [8], which was recorded mostly between April and October. The rain is associated with moisture – laden maritime southwest winds from the Atlantic Ocean. A short period of momentary dryness (the August break) often occurs in the month of August. The dry season starts in November when the dry continental North-eastern wind from the Sahara desert blows over Nigeria. As observed by [6], Nigeria experiences high temperatures all year round because of its latitudinal location within the tropics. In the study area, a mean annual temperature of about 27°C has been recorded. The study area comprises parts of Osisioma Ngwa, Isiala Ngwa, Obio Ngwa, Aba North, Omumma LGAs (all in Abia State), Etche LGA (in Rivers State) and Ngor Okpala LGA (in Imo State). It lies between latitudes $5°07^1$ to $5°15^1$N, and longitudes $7°14^1$ to $7°22^1$E covering an area of about 169km^2. It is densely populated, with an average population density of five thousand, five hundred (5,500) inhabitants [1]. The area is a major settlement and commercial centre in a region that is surrounded by small villages and towns. The indigenous people of the area are well known for its craftsmen.

2. Method

Water sample collections were done in line with the guidelines of [10]. To reduce the risk of sample contamination, all water samples were collected in fresh sample containers (polyethylene plastic cans), which were acid – washed to reduce the effect of interferences between containers and sample. This was done by washing each container with a detergent and rinsing with tap water; re-rinsing with 1:1 nitric acid solution; rinsing with deionized water and air-dried. Before collection, each container was rinsed with the sample to be collected. Samples were labelled and transported to the laboratory in ice-pack cooler kit, samples collected were analyzed within 24 hours of collection. Fifty eight (58) groundwater samples within the study area were collected. Anions analysed included: Chloride, Bicarbonate, and Sulphate. Cations analyzed included: Calcium, Sodium, Potassium, and Magnesium. Heavy metals analyzed included: Arsenic, Copper, Iron, Mercury, and Lead. Heavy metal analyses were conducted using Varian AA240 Atomic Absorption Spectrophometer according to the method of [10]. ArcGIS software was used to plot the spatial distribution of the pollutants in the study area while the Piper Trilinear diagram and the Schoeller semi-logarithmic plot were used for the water classification to determine the dominant ionic specie.

3. Result and Discussion

Magnesium concentration (mg/l) ranged between 0.2-4.6 and 0.2–3.0, for wet and dry seasons respectively; it is worthy to note that all the samples were below the WHO standard of 50 for drinking water. Magnesium is present in large quantities in sea water. It causes most of the hardness and scale-forming properties of water. Figure 1 shows the spatial distribution of Mg in the study area.

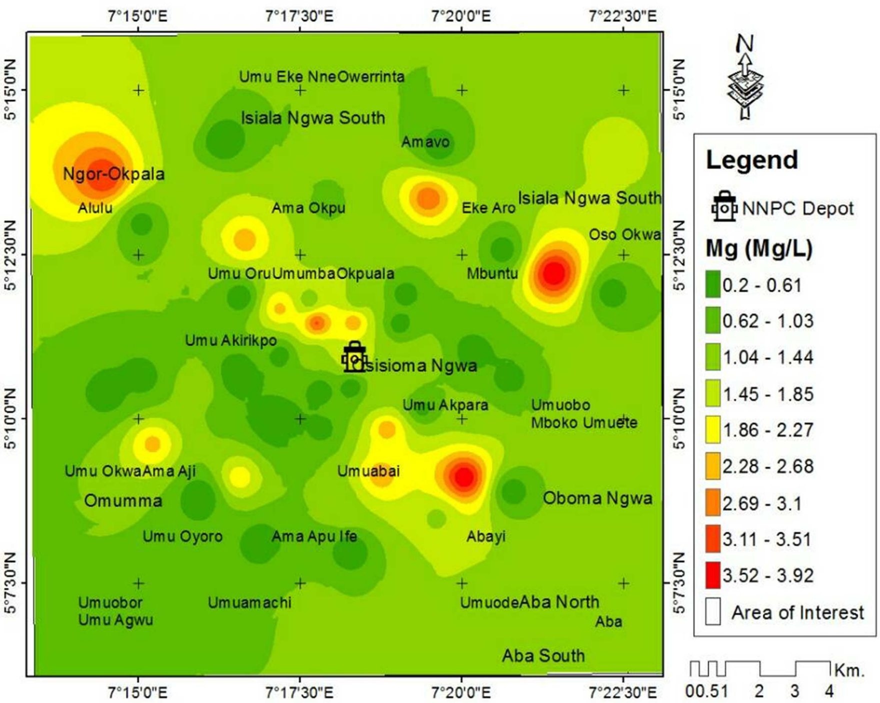

***Figure 1.** Spatial distribution of Mg in the study area.*

Chlorine concentration (mg/l) ranged between 6.0-17.0 and 5.0–14, for wet and dry seasons respectively, It is worthy to note that all the average result from the quadrants exceeded the WHO standard of 5.0 for drinking water. Chlorine is produced in large amounts and widely used both industrially and domestically as an important disinfectant and bleach. Figure 2 shows the spatial distribution of Cl in the study area.

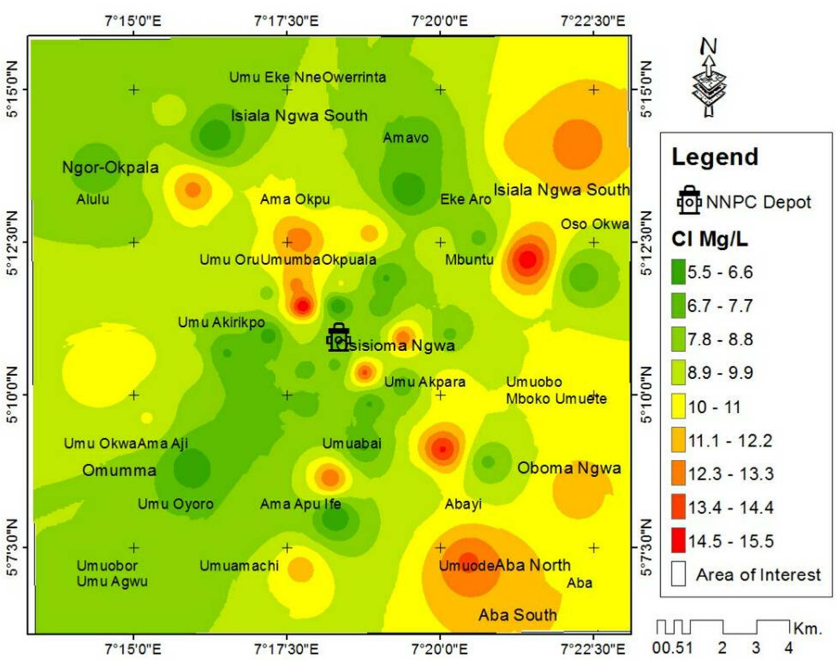

***Figure 2.** Spatial distribution of Cl in the study area.*

Bicarbonate concentration (mg/l) ranged between 17.9-56.3 and 17.9–52.2, for wet and dry seasons respectively, it is worthy to note that all the samples were below the WHO standard of 50 for drinking water. Bicarbonates are generated by the action of carbon dioxide in water on carbonate rocks such as limestone and dolomite, bicarbonate produces an alkaline environment. Figure 3 shows the spatial distribution of HCO_3 in the study area.

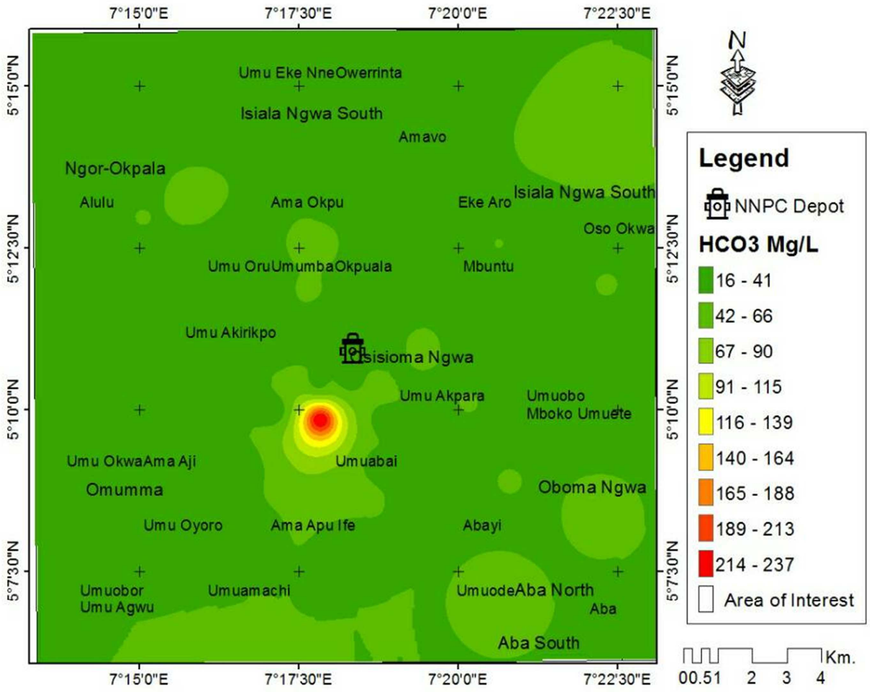

Figure 3. *Spatial distribution of HCO_3 in the study area.*

Sulphate concentration (mg/l) ranged between 164.6-248.0 and 121.1–224.0, for wet and dry seasons respectively. Sulphates occur naturally in numerous minerals and are used commercially, principally in the chemical industry. They are discharged into water in industrial wastes and through atmospheric deposition; however, the highest levels usually occur in groundwater and are from natural sources. However, in areas with drinking-water supplies containing high levels of sulphate, drinking-water may constitute the principal source of intake. Reason for not establishing a guideline value for sulphate is because it occurs in drinking-water at concentrations well below those of health concern [9]. Figure 4 shows the spatial distribution of SO_4 in the study area.

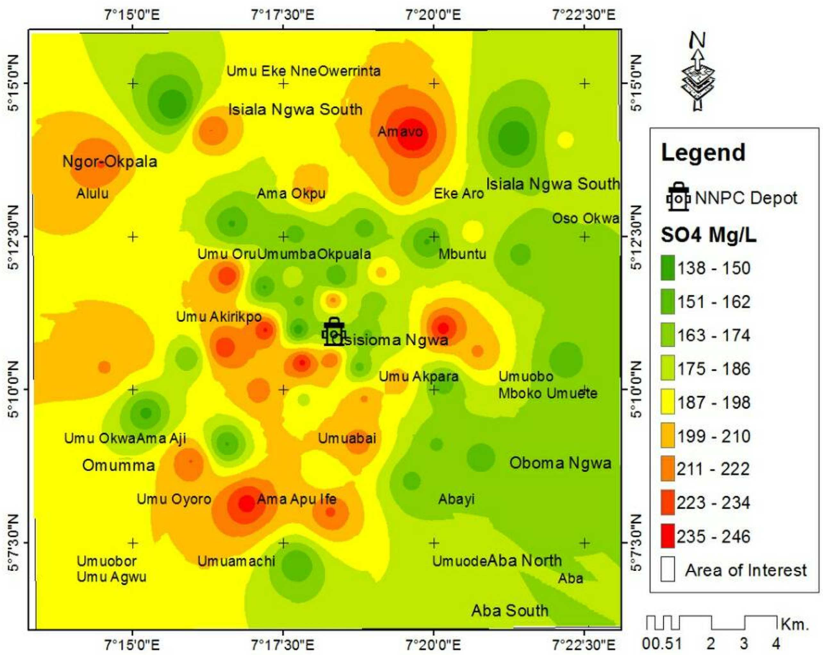

Figure 4. *Spatial distribution of SO_4 in the study area.*

Arsenic concentration (mg/l) ranged between 0-1.35 and 0–1.25, for wet and dry seasons respectively; Arsenic has not been demonstrated to be essential in humans. The acute toxicity of arsenic compounds in humans is predominantly a function of their rate of removal from the body. Acute arsenic intoxication associated with the ingestion of well water containing very high concentrations (21.0 mg/l) of arsenic has been reported [9]. Figure 5 shows the spatial distribution of as in the study area.

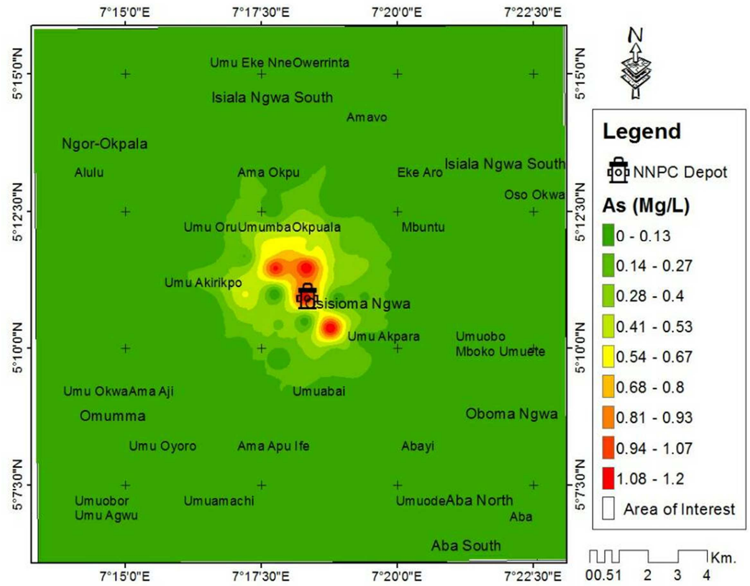

Figure 5. *Spatial distribution of As in the study area.*

Copper concentration (mg/l) ranged between 0 - 0. 95 and 0 – 0.08, for wet and dry seasons respectively, Iron concentration (mg/l) ranged between 0-0.09 and 0–0.08, for wet and dry seasons respectively, Copper is both an essential nutrient and a drinking-water contaminant. It is used to make pipes, valves and fittings and is present in alloys and coatings. Copper sulphate pentahydrate is sometimes added to surface water for the control of algae. Copper concentrations in drinking-water vary widely, with the primary source most often being the corrosion of interior copper plumbing. Levels in running or fully flushed water tend to be low, whereas those in standing or partially flushed water samples are more variable and can be substantially higher (frequently above 1 mg/l). Figure 6 shows the spatial distribution of Cu in the study area.

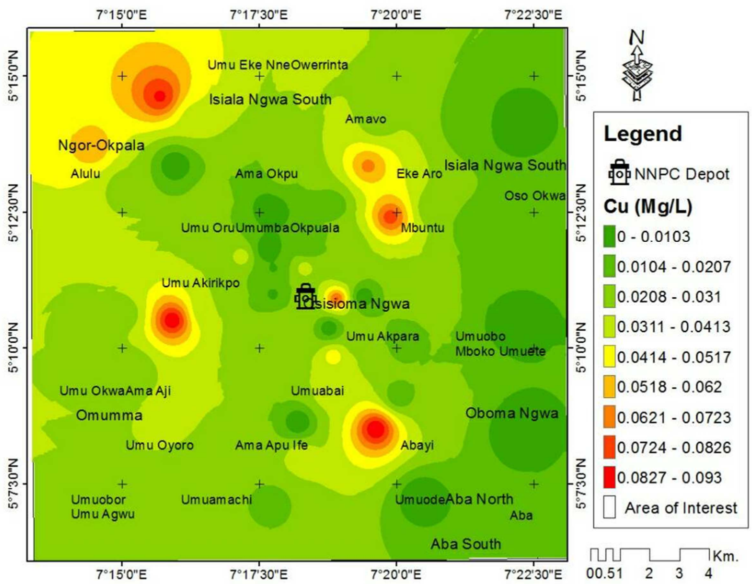

Figure 6. *Spatial distribution of Cu in the study area.*

Mercury concentration (mg/l) ranged between 0-0.014 and 0–0.01, for wet and dry seasons respectively, Mercury is used in the electrolytic production of chlorine, in electrical appliances, in dental amalgams and as a raw material for various mercury compounds. Methylation of inorganic mercury has been shown to occur in fresh water and in seawater. The toxic effects of inorganic mercury compounds are seen mainly in the kidney in both humans and laboratory animals following short-term and long-term exposure. Figure 7 shows the spatial distribution of Hg in the study area.

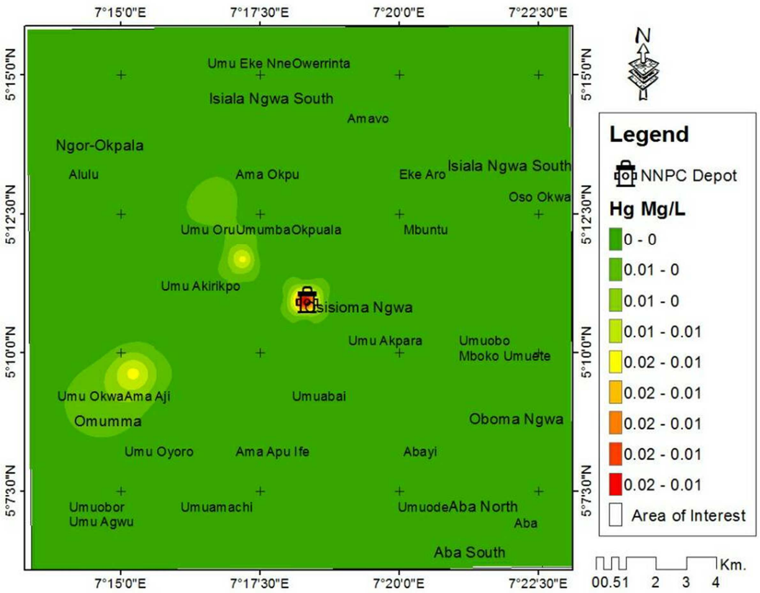

Figure 7. Spatial distribution of Hg in the study area.

Lead concentration (mg/l) ranged between 0-0.4 for both wet and dry seasons. Lead is used principally in the production of lead-acid batteries, solder and alloys. The organolead compounds tetraethyl and tetramethyl lead have also been used extensively as antiknock and lubricating agents in petrol, although their use for these purposes in many countries has largely been phased out. Lead is presence is primarily from corrosive water effects on household plumbing systems containing lead in pipes, solder, fittings or the service connections to homes. Figure 8 shows the spatial distribution of Pb in the study area.

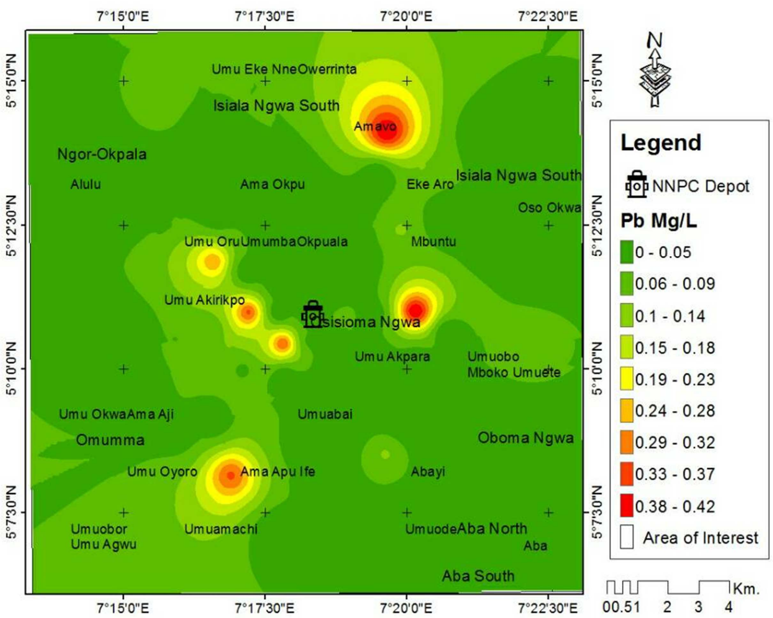

Figure 8. Spatial distribution of Pb in the study area.

The chemical characterization was done using AquaChem software; the results are presented in Figures 9 and 10. The result reveals that in the study area, 51.7% out of the samples had SO_4 as the dominant ionic specie, 46.5% of the samples had SO_4 –HCO_3 as their dominant ionic specie, while 1.7% of the sample had HCO_3- SO_4, as its dominant ionic specie, with a trend of SO_4 > HCO_3 > Cl > Na+K > Mg > Ca.

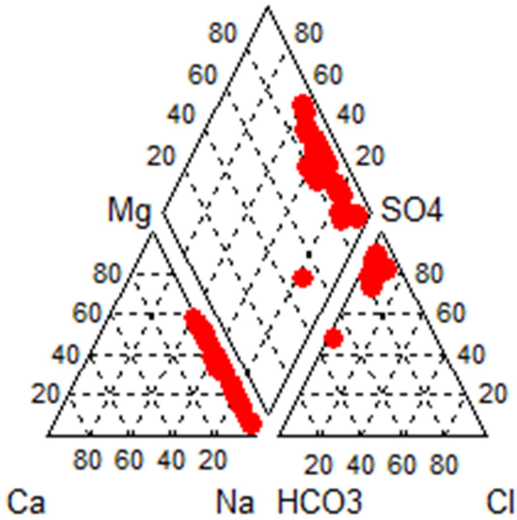

Figure 9. *Piper Trilinear diagram of water samples in the study area.*

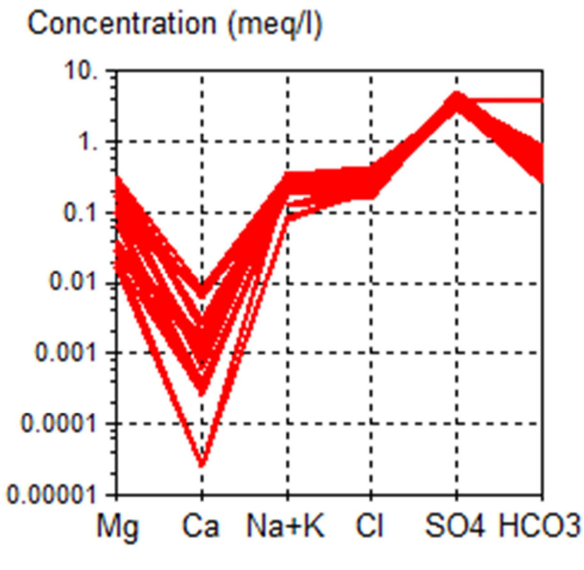

Figure 10. *Schoeller semi-logarithmic plot of water samples in the study are.*

4. Conclusion

Application of GIS in the hydrogeochemical evaluation of groundwater in parts of Eastern Niger Delta Nigeria has been done. The results of the investigation revealed certain attributes; the concentrations of Calcium, Magnesium, Sodium, Potassium, Bicarbonate and Sulphate in the study area were within the WHO standard and also, they are not of health concern at levels found in drinking water. Arsenic, Copper, Mercury and Lead concentrations were above the WHO standard values, and require pre-use treatment before use because of the associated health concerns. The result of the hydrochemical characterization revealed that 51.7% out of the samples had SO_4 as the dominant ionic specie, 46.5% sample had SO_4 - HCO_3 as their dominant ionic specie, while 1.7% sample had HCO_3 - SO_4 as its dominant ionic specie, with a trend of SO_4 > HCO_3 > Cl > Na+K > Mg > Ca. Public enlightenment efforts need to be enhanced in the entire area, especially in densely populated urban area, to improve on personal and public hygienic lives of the people. Efforts in this direction can reduce the problems of public water supply sources.

References

[1] Adindu et al. (2012). Groundwater Mineralization Analysis of Osisioma Local Government Area of Aba, Abia State, Nigeria. *Afr. J. Biotechnol.,* 11 (48), 10868-10873.

[2] Akakuru, O. C., Akudinobi, B. E. B., and Aniwetalu, E. U (2015) Qualitative evaluation and hydrogeochemical attributes of groundwater in Owerri Capital Territory, Southeastern Nigeria, IOSR journal of Applied Geology and Geophysics, 3 (2). www.iosrjournals.org. 12-18.

[3] Akpokodje EG (2005). Challenges of sustainable groundwater resources management in the Niger Delta. Paper presented at the National Stakeholders Workshop on Joint Management of Shared West African Coastal Aquifer Resources, Organized by the Federal Ministry of Water Resources in collaboration with UNESCO/IHP-IAH, held at the Hotel Presidential, Port Harcourt, 21-22.

[4] Akporido S. O (2008) Assessment of water, sediment and soil pollution arising from crude oil spillages in the vicinity of Esi River Western Niger Delta. PhD Thesis, Chemistry Department, University of Ibadan, 198.

[5] Balkrishnan, P Abdul Saleem and N. D. Mallikarjun (2011) Groundwater quality mapping using geographic information system (GIS): A case study of Gulbarga City, Karnataka, India. *African Journal of Environmental Science and Technology,* 5 (12), 19-1084.

[6] Ezeigbo, H. I. (1987). Quality of Water Resources in Anambra State. Nigeria. *Jour. Min. Geol.,* 23, 97 – 103.

[7] Foster, S. H., Garduno, K., Kemper, A., Tuinhof, M. N. and Dumars, C. (2005). *Sustainable Groundwater Management: Concepts and Tools.* World Bank Global Water Partnership Associate Program (www.worldbank.org/gwmate).

[8] Nnaji, A. O. and Duru, P. N. (2007). An Insight into the Role of Urbanisation in the Pollution of Nworie River, Owerri. *Proceeding of the 49th A. N. A. meeting, University of Abuja: 51-57.*

[9] WHO 2006. Guidelines for Drinking Water Quality. Geneva: World Health Organization, 130 – 185.

[10] APHA, (1995). Standard Methods for Examiantion of Water and Water, 18th Edition. American Public Health Association (APHA), American Water Works Association (AWWA), Washington D. C., 50-54.