

Heavy Metals Concentration and Spatial Variation of Groundwater in Isoko North-L.G.A., Delta of State Nigeria

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Abstract

This study examined water pollution substancesspatial variation, and conducted a comparative study for primarydata within ten spatially distributed boreholes' samples ofgroundwater reservoir heavy metals intrusion in Isoko North LGA, Delta State, Nigeria. The secondary data include acceptableWHO standards and published works Online,Textbooks, Journals etc. Samples are collected from productive boreholes into plastic Jerry-cans (2 liters), labeled and immediately covered with lids to minimize oxygen contamination and escape of dissolved gasses. Parameters tested for include Ph, Temperature, Total Dissolved Solid, Total hardness, Bicarbonate, Nitrate, Sulphate, Ca, Fe, Pub, Cd, Cu, Zn, Mg and total coliform count.. The analyses show that water in the area has high Iron oxide and Calcium Chloride concentration than any other heavy metals and other contaminants found in the water samples. Moreover there is differences in water quality in dry and rainy seasons to establish a significant relationship between the heavy metals from the host rocks and the groundwater resources in the area. Apart from high Iron and calcium contents, none of the parameters examined exceed the stipulated acceptableWHO standards to indicate that the water in the area is potable "if and if" (iff) well treated of the predominantly high iron and calcium concentrations.

Keywords: 1.Concentrations, 2.Heavy Metals, 3.Spatial Variation, 4.Groundwater, 5.Intrusion And Pollution.

Introduction

Plummer, McGeary and Calson, (2001) described groundwater as lies directly beneath the ground surface, filling pore spaces. between porous grains in bodies of sediments in detrital or clastic sedimentary rocks, and filling cracks, fissures, joints and crevices in all rock types, The sources of groundwater is rain and snow that the precipitation, percolates the ground as groundwater. Generally, about 15% of the total precipitation ends up as groundwater but could vary locally and regionally from 1% to about 20% (Plummer, McGeary and Calson 2001). The groundwater within 1km of the surface of the earth is more than 100 times the volume of the fresh. When the chemical composition of groundwater is not within prescribed About 2 billion people (approximately one-third of the world's population) depend on groundwater for domestic, industrial and other uses and an estimated 700m³ of water is withdrawal, mostly from shallow and easily polluted aquifers (Cunningham & Cunningham, 2006).

World Health Organization (WHO) standards for drinking, irrigation, industrial and agricultural use, it becomes unsuitable for use. Arsenic, Fluoride, Nitrate, Iron, Manganese and Boron are the most suspected heavy metals, radio nuclides with few other contaminants are of great concern if not within permissible limits (Metcalf & Eddy, 2003). Groundwater is the world's most important source of freshwater resources, originating from precipitation that falls on the earth surface and percolates into layers of soil and faults in rocks and therefore make up the largest compartment of freshwater - Water in lakes, rivers

and reservoirs inclusive (Cunningham & Cunningham, 2006). Plants get moisture from a relatively shallow layer of soil zone of aeration saturation and water containing both air and water. Depending on the amount of rainfall, soil type, and surface topography, the zones may vary from few centimeters to several meters deep. The lower soil layers where soil pores are filled with water, make up the zone of saturation constitutes the source of water of most wells. Aquifers are water bearing beds that may consist of porous layers of soil with sand or gravel and also found in rock's cracks, crevices

Groundwater is advantageous as it is comparatively fresh, well filtered within the soil pores spaces and widely distributed unlike most polluted surface water (Agunwamba, 2000). The threat to groundwater has increased due to increased population and increased demand for domestic, industrial, and agricultural needs has become enormous with improper management that led to various contaminations of the resource. The contaminated water supply endangers standard of living of the people to cause low wellbeing of inhabitants in affected areas. Moreover, the contamination of groundwater may result from natural due to degradation of parent's rock or anthropogenic processes of inherent geological conditions while anthropogenic factors may be due to wastewater from sewage treatment plants, discharge from industries, improper solid waste disposal, agrochemicals, runoff from agricultural fields, leakage from underground storage tanks amongst others (Oyegun, 2000).

The inadequate public water supply schemes (government or community) in most urban and rural towns in Nigeria have led to emerging privately owned borehole and well schemes in Isoko North LGA. The area is not supplied water by Delta State Water Board and therefore, households resorted to digging wells or drill boreholes. Some commercialized their products for public consumption as these vendors sell water in buckets, jerry cans and sachets irrespective of the quality of the water being sold (Hutton & Haller, 2004).

Water supply in Isoko North Local Government Area has certain problems as the Delta State Water Board located in Ozoro provided non-sufficient water for the teeming town's population and environs as increased human population and growth in size of the area resulting from high birth rate and low death rate, migration sitting of the State Polytechnic now upgraded to varsity status. Water supply from the Board could not cater for the high demand for water with some parts of the area completely at zero level of supply. The government water scheme in the new layouts constructed was never a solution the area has no surface water bodies (rivers, streams etc.) though endowed with very rich aquifer. The inhabitants take advantage of this to drill boreholes, aimed at alleviating the problems of water shortages experienced. These boreholes are however drilled by unprofessional persons with little or no knowledge about the hydraulics and hydrogeology of the area. Thus, no geophysical survey was conducted for data on the formation before drilling. The people worked on with rudimentary knowledge of the shallow water table in the area and the drilling is stopped a little after the water table is struck. The stratigraphic units in Isoko sub soil is such that, the water table lies within the clay belt in the sub-soil horizons (where water reacts with the rocks to produce heavy metal) and rather far below it as observed during the field work in the area. Observations made on water stored in plastic containers indicated reddish color particles that settled, have raised suspicion of possible intrusions of contaminants suspected to be iron oxide and other minerals within the sub soil in the area. These physical observations suspect iron oxide from the soil formation in the study area to have been leached down into the ground water saturation zone. Also, literatures of previous studies of the soil and aquifer in the area and environs attest to it. Anomoharan (2014), observed the presence of four geoelectric strata, with a thick clay bed as one of them. The red stained clay bed is the source of the suspected iron oxide in the groundwater resources in the study area. Therefore, there is the need to further examine this anomaly to improve the quality of borehole water supply in the area. This is to prevent health related diseases, resulting from consumed polluted groundwater. Hence, this research study is needed in this regard to address this anomaly.

According to Clair, (2004) and Moran, Morgan & Wiersman, (1980); water pollution causes approximately 14,000 deaths per day, mostly due to contamination of drinking water by natural and artificial processes imputing toxic materials in most developing countries. The pollutants concerned are the heavy metals which are toxic to human health. They are carcinogenic in nature and cause various illnesses to humans and animals. For instance, Lead is known to cause mental disorder, anemia, kidney

damage and constant fatigue. Cadmium causes kidney disorder, hypertension and genetic mutation. Mercury can cause memory loss, brain damage and loss of teeth, while chromium is known to cause lung tumor. These amongst other damages are inflicted on man if polluted water is not checked. Some other health problems associated with poor water quality arose from inadequate water management practices include typhoid fever, diarrhea, cholera, hepatitis, hook worm infestation, skin diseases, malaria, etc. (Chukwuekezie, 1998 & Ekugo, 1998). Therefore, if water management practice in this area is not improved, it could lead to continuous epidemical outbreaks which centered on one or most of the health associated problems. Example is cholera, which is an acute intestinal infection caused by ingestion of food or water contaminated with the bacterium *Vibrio cholerae*. According to the World Health Organization (WHO), it has a short incubation period, from less than one to two days and produces an enterotoxin which causes copious, painless, watery diarrhea that lead to severe dehydration and death if not treated immediately (Gambia News Community, 2008). Cholera causes vomiting and continuous stooling and painless diarrhea leads to severe dehydration and death within 24 hours if treatment is not promptly given. Health issues like these can stem up from drinking of contaminated water, but these diseases can be prevented by avoiding the consumption of the contaminated water or subjected it to adequate treatment. Therefore, this research tends to determine the impact of the heavy metals in the ground water resources of the study area, is to prevent health related water diseases.

Isoko North LGA lies between Latitude $5^{\circ} 15' N$ to Latitude $5^{\circ} 40' N$ of the equator and Longitude $6^{\circ} 15' E$ to Longitude $6^{\circ} 25' E$ of the Greenwich Meridian. It is bounded on the north by Ndokwa West Local Government Area, on the south by Bayelsa State and Patani Local Government Area, on the east by Ndokwa East Local Government Area and on the west by Ughelli North Local Government Area of Delta State Nigeria respectively (Olomo and Ejemeyovwi, 2008), Ozoro is the headquarters of Isoko North Local Government Area, a rapidly growing town and one of the two administrative units in the Isoko region of Delta State, Nigeria (Fig. 1.2). As the Administrative Center for the Local Government, it houses the Council Offices. Isoko North LGA has other smaller towns which put together makes it a Local Government Area, these towns include: Ozoro, Owheologbo, Aradhe, Emevor, Otibio, Ellu, Okpe-Isoko, Ofagbe, Otor-Iyede, Oyede, amongst others. The study area is discussed in details under the following sub headings:

Objectives of the study

The aim of this research is to examine seasonally heavy metals contaminations in the ground water in Isoko North LGA. To achieve this aim, the following objectives will be determined

- To identify the areas in Isoko North LGA where suspected heavy metal intrusion is predominant.
- To identify differences in water quality for dry and rainy seasons.

Conceptual Framework

For the purpose of understanding this study, the concept of hydrologic cycle,

Hydrologic cycle

The hydrological cycle involved water series of transformation and motions that involves endless repetitive cycle with constant amount of water involved although, individual molecules of water may never return to their original state. The cycle has no beginning nor end and explanation can start from any of the processes. Evaporated water from the ocean is chosen as a convenient and logical starting phase. By precipitation on land and sea: by percolation into the ground to become soil moisture and groundwater: by runoff in rivers from land to sea: by discharge of groundwater to rivers and lakes and directly to the seas from glaciers and ice caps (Oyebande, 1998). The cycle is much more complex as most parts involved are not captured (figure 2.1)

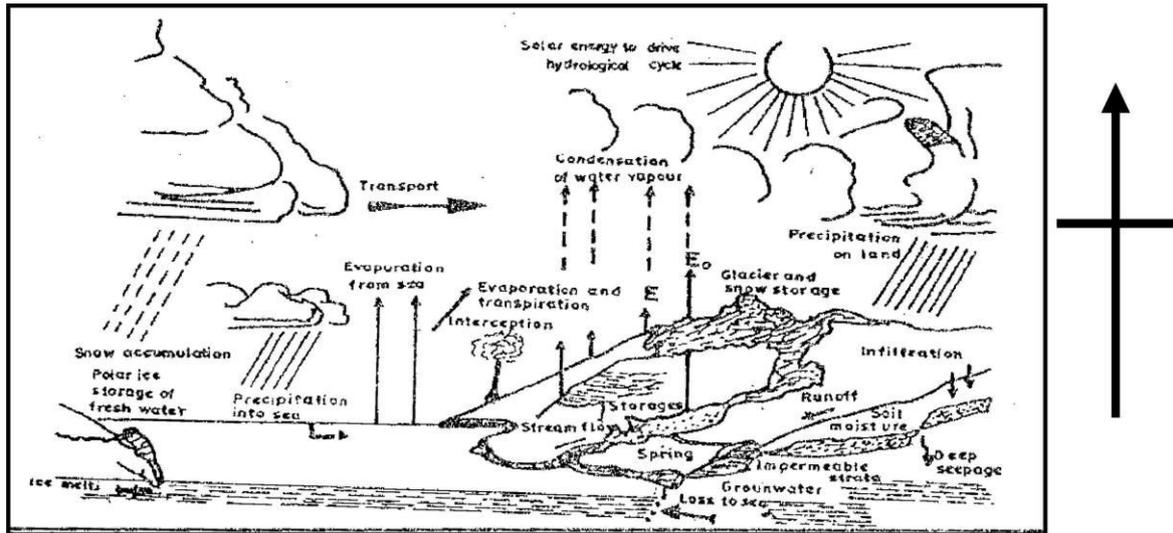


Fig 2.1. The hydrologic cycle.
source: Oyebande, (1998).

Ozoro area is located within the humid tropical climate of tropical rain forest belt. The processes of hydrological cycle include the processes of evaporation, sublimation, overland flow and groundwater flow, evaporation, transpiration, condensation, and precipitation, run - off and percolation are involved in transporting pollutants in surface and underground water. The areas is marked with high and continuous rainfall within and along the Orogondo river watershed and attendant forested valley and high humidity is experienced with much water vapour is recorded than the hinterland. The cycle includes: evaporation, transpiration from plants, ground water flow, precipitation and run-off, evaporation from falling rain, infiltration and percolation. In the water cycle, the mean rate of flow of water or its equivalent in water vapour is of the order of $1.628 \times 10^{-3} \text{m}^3 \text{s}^{-1}$. Which is roughly 200 times the flood flow of the Mississippi River or 700 times that of the Niger River. The amount of water constantly moving through the hydrologic cycle corresponds to an average annual precipitation of about 825 mm per year. All water soluble elements are embedded in the water and follow the water cycle partially or completely. These elements in water flows into the soil through infiltration process, where it reacts with chemicals in the rocks to produce new compounds and rocks with new and different chemical compositions. It further percolates through the soil, and dissolves those chemical compounds into the aquifer, thereby influencing the aquifer with high content of compounds extracted from the rocks. The cycle is thus the integrating process for the fluxes of water, and chemical element

Empirical Literature

The review will be presented under the following sub-heading to give insights of existing literature for knowledge on the theme.

Groundwater Pollution

Chemical weathering is the decomposition of rocks from exposure to water and atmospheric gases principally carbon dioxide, oxygen and water vapor. As rock is decomposed by these agents, new chemical compounds including minerals are formed. These may be softer, more soluble or greater in volume than the original rocks. If rock is chemically weathered, some of the original minerals are chemically changed to different minerals. Feldspar for example will change to a clay mineral (with a crystal structure similar to mica). This process includes hydration and oxidation, where rock minerals absorb water and expand, thus adding stress within the rock structure, which bring along forces that breaks the rock into fragments. An example of such is ferric oxide, which absorb water to form new compounds. Most rocks (like feldspathic minerals) contain compounds that chemically react with oxygen

and water in the air to produce Iron oxide and feldspar, which is the most common rock forming mineral. The iron oxide which is softer is easily removed, thus weakening the rock structure to eventually break up into fragments in a process termed oxidation in chemical weathering process (Montgomery,2007). Varughese & Prasad (2012) identified groundwater as water contained in an aquifer matrix located below the surface in the saturated zone, which acts as the primary buffer against drought for both human requirements and plant production. Groundwater naturally contains mineral ions dissolved from soil particles, sediments and rocks as water flows along mineral surfaces of the aquifer. Factors like climate, slope, drainage conditions and residence time of groundwater contributes to the groundwater quality. But the monitoring of water quality is one of the major tools for sustainable development that provides important information for water management. This view is not farfetched from that of Oseji (2012) where he studied the surface and groundwater potential of Ernu-Kingdom. The study was initiated by a desire to determine the availability of sufficient and good quality water for a proposed expansion of the human and industrial establishments without jeopardizing the existing domestic water supply in the area. The quality of water is determined by its chemical composition and therefore its ultimate usability, assessment and the parameters examined depends on the envisaged usage. In some cases, water quality is far more important than its availability. It is almost impossible to set a rigid standard of chemical quality, however, a range of chemical values of some elements have been established for domestic and specialized industrial uses. The result of the analysis revealed that water in Emu-Kingdom is acidic, soft, and low in dissolved constituents. It also has high iron content when compared with the World Health Organization (WHO) Standard for drinking water. Apart from the acidic condition and the high iron content, none of the parameters studied exceeded the stipulated standards showing that the water is potable if treated for high iron concentration and acidity

Groundwater-Evaluation

Berkoff (2007) evaluated groundwater for vulnerability test of sample. The evaluation scheme results in a groundwater vulnerability map aimed at identifying areas of high, medium and low vulnerability, as necessary for the measurement and planning of the European Water Framework Directive (WFD). It considers exposure, sensitivity and the adaptive capacity of the region. The adaptive capacity is evaluated in an actors' platform, which was constituted for the region in the Partizip A (Participative modelling, Actor and Ecosystem Analysis in Regions with Intensive Agriculture) project. As a result of the vulnerability assessment, 21% of the catchment area was classified as being highly vulnerable, whereas 73% has medium vulnerability and 6% has low vulnerability. Thus, a groundwater vulnerability assessment approach was presented, which can be used in practice on a catchment scale for the WFD measurement planning. Sacco, Offi, De Maio & Gringnani (2007), in their study of groundwater contaminants, found out that: Nitrate contamination of the groundwater throughout the world is a source of rising concern that has been faced through the introduction of several regulations in different countries. The groundwater nitrate concentrations in Europe exceed the international recommendations for drinking water (50 mg N-N03- 1-1 (1), in 22% of cultivated land, similar concentrations have been found in the USA and China.

According to Pandey & Tiwari (2009), ground water is the most suitable fresh water resource, with a nearly balanced concentration of the salts for human consumption. But overburden due to population pressure, unplanned urbanization, unrestricted exploration policies and dumping of the polluted substances at inappropriate places enhance the infiltration of harmful compounds to the ground water.

Ground Water Quality

Studies regarding the ground water quality analysis has been made by many researchers like Gupta & Gupta (1999), Rajas, Banu, Kumar & Smila (2005), Rajan & Paneerselvam (2005), Thakare, Parvate & Rao (2005), Shika, Patra, Gupta, Saurabh & Singh (2007), concluded that, it is the high rate of exploration than its recharging, inappropriate dumping of solid as well as liquid wastes, lack of strict enforcement of law and loose governance are the causes of deterioration of ground water quality. A laboratory study was conducted to monitor the ground water quality of selected sites of Ghazipur city by examining the various

physico-chemical parameters like pH, T.D.S., D.O. and CO₂ etc. A comparison with ICMR (Indian Council of Medical Research) standard shows that the water is nearly suitable for drinking purpose, the DBPs (Disinfection by-products) analysis is required to corroborate the present study.

Kaira, Karnar, Yadav & Singh (2012) noted that water plays an essential role in human life. Though, the World Health Organization (WHO) reports that, approximately 36% of urban and 65% of rural Indian were without access to safe drinking water, fresh water is one of the most important resources crucial for the survival of all the living things. It is even more important for human beings as they depend upon it for food production, industrial and waste disposal, as well as cultural requirement. Human and ecological use of ground water depends upon ambient water quality; human alteration of the landscape has an extensive influence on watershed hydrology. Ground water plays a vital role in human life, the consequences of urbanization and industrialization leads to degrade the water for useful purposes. Ground water is explored in rural areas, especially in those areas where other sources of water like streams and river or a canal is not considerable. .

The assessment of groundwater potential in Ozoro, Delta State, Nigeria by Anornoharan (2014) using the Electrical Resistivity Method (ERM): Record of apparent resistivity and electrode spread were analyzed using curve matching and computer iteration technique and the outcome compared with record of existing boreholes. Result revealed the presence of four geoelectric strata which are topsoil, fine-medium grain sand, clay-clayey sand and coarse-medium coarse sand. The fourth layer with a resistivity range of 648-917m and depth range of 10.7-18.0m is identified as the aquifer layer. Result also revealed that the aquifer layer is overlaid by a clayey aquitard of 4.2m thick. It was recommended that the sourcing of water for domestic purpose by the people should be done in excess of 18.0m.

This research has a link with that of Anomoharan (2014), where it was established that Isoko North LGA has four geoelectric strata, with clay as one of them. This clay layer is believed to react with groundwater, producing substances suspected to be haematite and lironite, oxides of aluminum and iron. The possible intrusion of this substance in the groundwater of the area is what this research tends to study.

Methodology

The spatial sampling technique was adopted in this research. And the study adopted the point sampling method for data collection. According to Awaritefe (2007), point sampling is particularly relevant in situations where the phenomenon under study is spatially spread over a large area. These areas are: Ozoro, Owhelogbo, Ellu, Ofagbe, Emevor, Otor-Owhe, Iyede, Okpelisoko, Arade and Oyede. This pattern of distribution is aimed at ensuring equitable sourcing of groundwater sampling. A total of ten (10) groundwater samples were taken from the study area for possible heavy metal analyses.

Data Collection

The primary and secondary sources of data collection were employed to generate data for analyses in this research work. The primary source of data collection was based on groundwater sample data to ascertain the possible rate of intrusion from suspected heavy metals in the groundwater resources in the study area, the maps of Isoko North, Delta State and sketch map of Isoko North showing study area were generated using Arc GIS software for generated and designed maps. The secondary source of data includes written texts, existing maps, internet materials etc. Data on groundwater samples are collected from ten locations within the study area for analyses, using the study and interpretation of the characteristics of natural water as prescribed by Hem (1985). The samples were collected from existing and productive boreholes and where possible, the history and characteristics of the borehole was noted for record purpose. The samples were collected into ten (10) plastic Jerry cans of 2 liters each with covers. Once the jerry can was filled with water, it was covered and labeled to minimize oxygen contamination and the escape of dissolved gasses as described by Oseji (2012).

The equipment used for the collection of water samples and the analysis are sample jerry can containers, atomic absorption spectrophotometer (AAS) - Chinese Instruments, Model AA320N, China pH meter (Hannah Instruments Model H196107, England), Conductivity meter (Hannah Instruments Model EC215, England), Dr. 400 spectrophotometer (BScientific Instruments Model 721D, England), Dissolved Oxygen

meter (Swingfield Medicals, Model PHS-3E, England), Thermometer (Hannah Instruments, Centrig Model B2, England), Oven (SOL Instruments, Model 400 T LG, Korea), Hot Plat (SOL Instruments, Model NU-1 LG, Korea), Magnetic stirrer (Hannah Instruments Model HY-HS11, England), Desiccators (B. Scientific Instruments, Model BRC-1, England) and Weighing device/Evaporating dishes (OHAUS, Models AR223CN and CN-003V, USA.; Filter papers 9 12.50mm (Paper Filter Company, Lagos, Nigeria); Volumetric flasks (various capacity), Burettes 50cm, Pipette (various sizes), Conical flask (various sizes), measuring cylinder, separating funnel, Funnels Glass fiber paper 9 3.3cm diameters), Wash bottles, Glass rods, Drying dishes, White rubber kegs, Distilled, Deionized water, and Dissolved Oxygen bottles. These glasses and bottles are supplied by Nigeria Bottling Chemical Company, Lagos, Nigeria. The chemicals used are obtained from the following sources:

BD 1+ Chemical pole, England:

- $MnSO_4 \cdot H_2O$ — Magnesium Tetraoxosulphate (vi) monohydrate Na^+ - sodium hydroxide pellets, 36% HCl- Hydrogen chloride, 635 l- $[NO_3]$ — Nitric acid, Phenolphthalein indicator, $Na_2 S_2O_3 \cdot 5H_2O$ — Sodium the Osulate Pentahydrate, and $NaNO_3$ — Sodium Nitrite.

May and Belier chemicals, Dagenham, England:

- 98% H_2SO_4 — Sulphuric acid, H_2O_2 — Hydrogen peroxide, $K_2Cr_2O_7$ - potassium chromate dried at 103°C for 2 hours, Starch solution, K_2H_2O , potassium monohydrate, KOH — potassium hydroxide Chloroform, KI- Potassium Iodide. The parameters tested for include: PH, Temperature, Total Dissolved Solid, total use, total hardness, Bicarbonate, Nitrate, Sulphate, Calcium, Iron, Lead, Cadmium, Copper, Zinc, magnesium and total coliform count.

The samples are analyzed soon after collection, for heavy metal parameters (especially iron) to avoid degradation due to environmental factors using the analytical methods.

This presentation and analysis of samples obtained involve 2 liter jerry cans with stoppers used for storing the water with a cooler of ice block to preserve the sample before taking to the laboratory for test. Two samples used as control are collected from locations outside the study area were for the analyses of the spatial variation of heavy metals on ground water resources. The two areas selected are Oleh road and Irri road both in neighboring Isoko South LGA. Data collected was tested using the split-half and Cronbach Alpha Reliability test.

Results

The waters samples stored in plastic buckets, obtained from field are observed in relation to changes related to deposited iron oxide present and observations recorded and mapped (**Figure 1:**) water sample points from the field. They are shown in plates .1, 2, 3 and .4, and the plate 4 with the borehole filter stained red from suspected iron oxide deposits in the area..



Plate: 4.1. Yellowish particles of limonite as seen in the sub-soil from Owhelogbo, Isoko North LGA.



Plate: 4.3. A piece of clay soil with hematite and limonite from the sub soil in Ozoro, Delta State. Source: Field work.



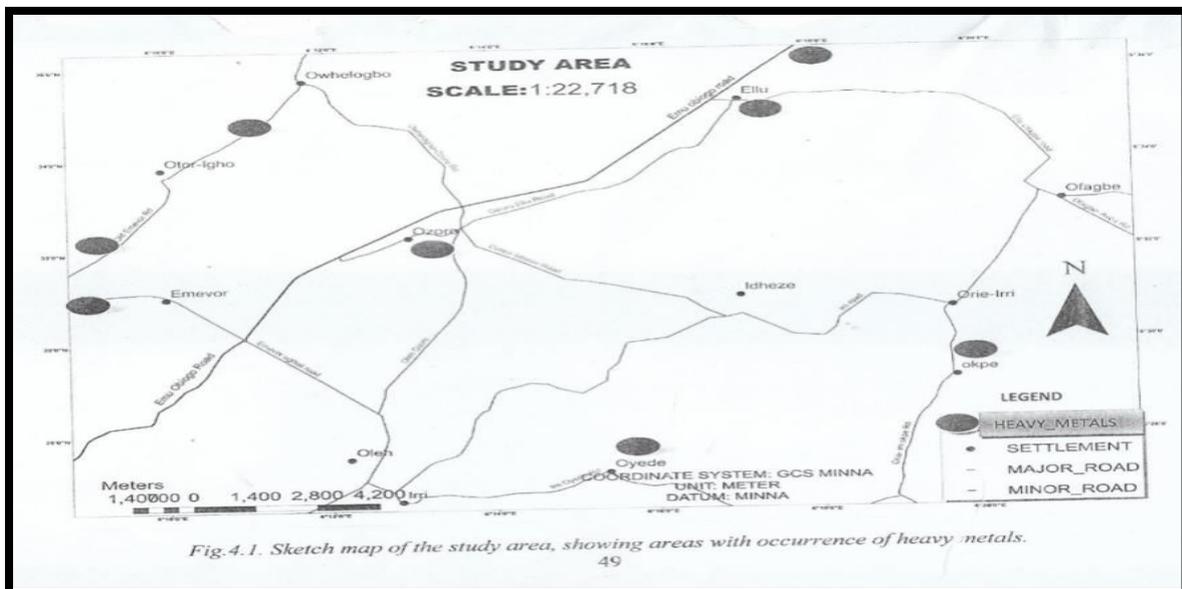
Source: Field work. Plate:4.2. A feldspar mineral metamorphosing into clay, with outer part already changed. Source: Field work.



Plate 4.4. A borehole filter stained red from suspected iron oxide in Ozoro. Source:Fieldwork.

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The water samples are analyzed to identify the zones of influence that is predominantly and prominently affected. These are mapped for the area(Figure 1) and a descriptive statistics employed to compute mean values for rainy and dry seasons respectively in the area Delta of State **Nigeria**



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. The identified zones with suspected heavy metal intrusion with their mean values computed and the results of the computations are shown in tables1, 2 and 3below and below are the results of the computations of field data in tables below:

Table.1. Data representation of values derived from water samples obtained during wet or rainy season.

S/NO	PARAMETER TESTED	UNITS	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	W.H.O STD
1.	Ph	-	5.7	6.6	4.2	5.8	5.7	4.9	6.0	3.3	5.5	6.2	6.5-8.5
2.	Temperature	00	24.5	25.4	26.8	22.1	23.2	24.9	25.7	26.0	24.6	23.8	Room Temp
3.	E/Conductivity	Us/cm	37.1	26.5	20.4	24.5	28.9	27.2	21.6	37.8	32.9	36.4	3000
4.	Colour	Mg/I	NI	Nil	4.Nil	Nil	Nil	Nil	Nil	3.000	1.000	2.000	200
5.	Total suspended solid (TSS)	Mg/I	Nil	Nil	Nil	2.000	0.000	1.000	2.000	8.000	8.000	6.000	5-25
6.	Co3	Mg/I	Nil	14.6	Nil	12.3	9.8	6.5	6.2	14.9	16.8	13.4	NJA
7.	HCo,	Mg/I	20.00	22.00	Nil	20.00	22.00	21.00	20.00	24.00	26.00	22.00	N/A
8.	Colilbrm	Mpn	Nil	Nil	1.8	0.5	2.6	Nil	1.6	9.6	11.4	8.6	0
9.	Cl	Mg/I	85.000	8.000	6.000	5.500	7.000	11.000	6.000	26.000	24.000	21.000	250
10.	SO	Mg/I	64.800	4.000	3.000	4.000	3.000	9.000	2.000	13.880	27.000	12.000	200-400
11.	DO	Mg/I	5.6	6.8	5.8	7.0	8.0	9.6	4.5	9.6	9.8	8.5	7.5
12.	BOD	MG/L	2.5	1.8	2.6	1.8	2.0	2.0	1.0	3.5	3.4	3.0	10
13.	TDS	Mg/I	66.77	61.07	10.3	46.13	63.54	42.98	31.03	186	113.4	11.99	1000
14.	Cu	Ppm mg/I	0.01	0.02	1.78	0.05	0.04	0.50	0.01	0.91	0.50	0.06	1.5
15.	Lead	Ppm or mg/I	<0.001	0.351	0.875	<0.001	<0.001	<0.001	<0.001	0.088	0.550	0.022	0.1
16.	Zinc	Ppm or mg/I	0.02	1.47	0.251	0.06	0.02	0.04	0.01	0.13	1.40	0.01	3

17.	Iron	Ppm or mg/I	1.30	1.01	0.25	0.80	0.55	1.0	0.3	2.412	6.65	1.11	0.3-1.0
18.	Ca	Ppm or mg/I	3.55	2.41	1.58	2.77	5.29	3.39	2.57	18.24	9.24	6.57	Nil
19.	Cr	Ppm or mg/I	<0.001	<0,001	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
20.	Hg	Ppm or mg/I	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.0
21.	Co	Ppm or mg/I	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	1.7
22.	Na	Ppm or mg/I	25.9	4.8	2.14	5.32	4.28	10.54	8.65	21.29	14.56	10.54	200
23.	K	Ppm or mg/I	14.58	3.21	1.89	10.33	6.14	10.33	10.25	14.55	23.41	11.37	5
24.	Mg	Ppm or mg/I	20.5	1.8	0.8	2.67	2.14	7.98	10.70	11.70	11.36	2.09	30-100

The table 1 is field data representing values derived from water samples obtained in rainy season together presented with WHO standard reference data used as control.

Table 2. Data representation of values derived from water samples obtained during the dry season.

S/N	PARAMETER TESTED	UNITS	Si	S2	S3	S4	S5	S6	S7	S8	S9	Sb	W.H.O STD
1.	Ph	-	6.2	5	5.3	6.1	6.0	5.5	6.0	6.8	5.8	6.9	6.5-8.5
2.	Temperature	00	24.1	24.8	26.1	21.7	22.8	24.3	24.9	25.6	24.1	23.3	Room Temp
3.	E/Conductivity	Us/cm	36.9	26.2	19.7	24.1	27.8	26.9	21.0	35.6	32.1	33.5	3000
4.	Colour	Mg/l	Nil	3.00	1.00	1.00	200						

		I								0	0	0	
5.	Total suspended solid (TSS)	Mg/I	Nil	Nil	Nil	1.000	0.000	1.000	2.000	7.000	8.000	5.000	5-25
6.	Co1	Mg/I	Nil	14.2	Nil	11.9	9.6	6.0	5.8	14.2	15.6	12.9	N/A
7.	HCo3	Mg/I	18.60	21.10	Nil	19.00	22.10	21.20	19.00	23.60	24.30	21.90	N/A
8.	Coliform	Mpn	Nil	Nil	1.1	0.5	1.9	Nil	1.3	8.1	9.4	6.3	0
9.	Cl	Mg/I	83.100	7.400	5.200	5.100	7.000	10.000	4.000	23.000	22.000	19.000	250
10.	SO4	Mg/I	62.600	3.500	3.100	3.900	2.800	7.600	1.800	12.780	26.500	11.000	200 - 400
11.	DO	Mg/I	5.3	5.7	5.2	6.9	7.8	9.3	4.1	9.2	9.8	8.3	7.5
12.	BOD	MG/L	2.3	1.5	2.1	1.5	1.9	1.6	1.0	3.3	3.1	2.6	10
13.	TDS	Mg/I	66.21	59.54	10.11	46.06	61.98	42.10	30.32	167.9	111.0	11.23	1000
14.	Cu	Ppm or mg/I	0.01	0.02	1.36	0.05	0.04	0.50	0.01	0.91	0.50	0.06	1.5
IS.	Lead	Ppm or mg/I	<0.001	0.331	0.812	<0.001	<0.001	<0.001	<0.001	0.080	0.449	0.012	0.1
16	Zinc	Ppm or mg/I	0.02	1.29	0.237	0.06	0.02	0.04	0.01	0.13	1.40	0.01	3
17.	Iron	Ppm or mg/I	0.91	0.89	0.22	0.67	0.35	1.00	0.3	1.87	5.32	1.01	0.3-1.0
18.	Ca	Ppm or mg/I	3.15	2.01	1.22	2.38	5.21	3.33	2.52	18.11	9.19	6.54	Nil
19	..Cr	Ppm or mg/I	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
20.	Hg	Ppm or	<0.001	<0.001	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	1.0
21.	Co	Ppm or mg/I	<0.001	<0.001	<0.005	<0.001	<0.001	<0.005	<0.005	<0.001	<0.001	<0.001	1.7

22	Na	Ppm or mg/l	25,5 11.2 8	4.2	2.08	5.13	4,22	10.0 9	8.43	20.6 8	14.0 1	10.1 9	200
23	1<	Ppm or mg/l		3.11	1.61	8.08	5.06	7.01	9.08	11.0 3	18.0 7	10.0 2	5
24	Mg	Ppm or mg/l	19.6	1.3	0.6	2.37	2.04	5.79	9.08	10.8 8	9.08	2.01	30- 100

The table 2 shows data representing values derived from water samples obtained during the dry season r presented together with WHO standard data used as control.

Table 3: Showing mean values of suspected Heavy metals' intrusion in the study area.

Area	Ph	Temp	E/Conductivity	Colour	TSS	Co ₃	H Co ₃	Coliform	Cl	SO ₄	DO	BOD ₅	TDS	Cu	Lead	Zinc	Iron	Ca	Cr	Hg	Co	Na	K	Mg
Ozoro	5.95	24.30	37.00	0.00	0.00	0.00	19.30	0.00	84.05	63.70	5.45	2.40	66.49	0.01	0.00	0.02	1.11	3.35	0.00	0.00	0.00	25.70	12.93	15.05
Owhelogbo	7.05	25.10	26.35	0.00	0.00	14.40	21.55	0.00	7.70	3.75	6.25	1.65	60.31	0.02	0.34	1.38	0.95	2.21	0.00	0.00	0.00	4.50	3.16	1.55
Ellu	4.75	26.45	20.05	0.00	0.00	0.00	0.00	1.45	5.60	3.05	5.50	2.35	10.21	1.57	0.85	0.25	0.24	1.40	0.00	0.00	0.00	2.11	1.75	0.70
Ofagbe	5.95	21.90	24.30	0.00	1.50	12.10	19.50	0.50	5.30	3.95	6.95	1.65	46.10	0.05	0.00	0.06	0.74	2.58	0.00	0.00	0.00	5.23	9.21	2.52
Emevor	5.85	23.00	28.35	0.00	0.00	9.70	22.05	2.25	7.00	2.90	7.90	1.95	62.76	0.04	0.00	0.02	0.45	5.25	0.00	0.00	0.00	4.25	5.60	2.09
Oto-Owhe	5.20	24.60	27.05	0.00	1.00	6.25	21.10	0.00	10.50	8.30	9.45	1.80	42.54	0.50	0.00	0.04	1.00	3.36	0.00	0.00	0.00	10.32	8.67	6.89
Iyede	6.00	25.30	21.30	0.00	2.00	6.00	19.50	1.45	5.00	1.90	4.30	1.00	30.68	0.01	0.00	0.01	0.30	2.55	0.00	0.00	0.00	8.54	9.67	9.89
Ikpe Isoko	5.05	25.80	36.70	3.00	7.50	14.55	23.80	8.85	24.50	13.33	9.40	3.40	176.95	0.91	0.09	0.13	2.14	18.18	0.00	0.00	0.00	20.99	12.79	11.29
Arede	5.65	24.35	32.50	1.00	8.00	16.20	25.15	10.40	23.00	26.75	9.80	3.25	112.20	0.50	0.50	1.40	5.99	9.22	0.00	0.00	0.00	14.29	20.74	10.22
Oyede	6.55	23.55	34.95	1.50	5.50	13.15	21.95	7.45	20.00	11.50	8.40	2.80	11.61	0.06	0.02	0.01	1.06	6.56	0.00	0.00	0.00	10.37	10.70	2.05
Average	5.80	24.44	28.86	0.55	2.55	9.24	19.39	3.24	19.27	13.91	7.34	2.23	61.98	0.37	0.18	0.33	1.40	5.46	0.00	0.00	0.00	10.63	9.52	6.22

On pH, the mean value is 5.80. But areas like Ozoro (5.95), Owhelogbo (7.05), Ofagbe (5.95), Emevor (5.85), Iyede (6.00) and Oyede (6.55) have values higher than the mean value, while others such as Ellu, Aradhe, Otor – Owhe and Okpe-Isoko have less significant values.

Temperature (Q0), the mean value is 24.44, but areas like Owelogbo (25.10), Ellu (26.45), Oto-owhe 24.60), Iyede (25.30) and Okpe-Isoko (25.80) have significant values higher than the mean values, others such as Aradhe, Oyede, Emevor, Ofagbe and Ozoro have less significant values.

The mean value for E/conductivity (US/cm) is 28.86, but areas like Ozoro (37.00), Okpe-isoko (36.70), Aradeh (32.50) and Oyede (34.95) have higher values than others, while others like Owhelogbo, Ellu, Ofagbe, Emevor, Otor-Owhe and Iyede have less significant values.

The mean value for color (mg/i) is 0.55, but areas like Okpe-isoko (3.00), Aradeh (1.00) and Oyede have higher values than the others, while areas like Ozoro, Owhelogbo, Eliu, Oafgbe, Emevor, Otor-Owhe and Iyede have less significant values.

Total Suspended Solids (TSS) (mg/i), the mean value is 2.55, but areas like Okpe-isoko has (7.50), Aradhe (8.00) and Oyede with a value of 5.50, have higher values than the others. While others like Ozoro, Owhelogbo, Ellu, Ofagbe, Emevor, Otor-Owhe and Iyede have less significant values.

The mean value for CO₃ (mg/i) is 9.24, but areas like Owhelogbo (14.40), Ofagbe (12.10), Emevor (9.70), Okpe-isoko (14.55), Aradhe (16.20) and Oyede (13.15) have higher values. Others like Ozoro, Ellu, Otor-Owhe and Iyede have less significant values. HCO₃ (mg/i) has a mean value of 19.39, areas like Owhelogbo (21.55), Ofagbe. (19.50), Emevor (22.05), Otor-owhe (21.10), Okpe-isoko (23.80) Aradhe (25.15) and Oyede (21.95) have more significant values than others.

The mean values for Coliform (mpn) is 3.24, but areas like Okpe-isoko (8.85), Aradhe (10.40) and Oyede (7.45) have higher values than. While others like Ozoro, Owhelogbo, Ellu, Ofagbe, Emevor, Otor-Owhe and Iyede have less significant values.

The mean value for Cl (mg/i) is 19.27, but areas like Ozoro (84.05), Okpeisoko (24.50), Aradhe(23.00) and Oyede (20.00) have more significant values than others. While others like Owhelogbo, Ellu, Ofagbe, Emevor, Otor-Owhe and Iyede have less significant values. SO₄ (mg/i) has a mean value of 13.91, but areas like Ozoro (63.70) and Aradhe (26.75) have higher values. Others such as Owheiogbo, Ellu, Emevor, Otor-Ohwe, Iyede and Okpe-Isoko have less significant values.

Dissolved Oxygen (DO) (mg/l), the mean value is 7.34. Areas like Emevor (7.90), Otor-owhe (9.45), Okpe-isoko (9.80), Aradhe (9.80) and Oyede (8.40), have higher values. Others such as Ozoro, Owhelogbo, Ellu, Ofagbe, and Iyede have less significant values.

Biological Oxygen Demand (BOD5) (mg/l), the maen value is 2.23, but areas like Ozoro (2.40), Ellu (2.35), Okpe-isoko (3.46), Aradhe (3.25) and Oyede (2.80), have higher values than others. While the others like Owhelogbo, Ofagbe, Emevor, Otor-Owhe and Iyede have less significant values. The value for Total Dissolved Solids (TDS) (mg/i) is 61.98, but areas like Ozoro (66.49) and Emevor (62.76), have higher values than

others. While others like Owhelogbo, Ellu, Ofagbe, Otor-Owhe, Iyede, Okpe-Isoko, Aradhe and Oyede have less significant values.

Cu (Ppm) has a mean value of 0.37, but areas like Ellu (1.57), Otor-owhe (0.50), Okpe-isoko (0.91) and Aradhe (0.50), have higher values as against others like Ozoro, Owhelogbo, Ofagbe, Ernevor, Iyede and oyede with less significant values. Lead (Ppm) has a mean value of 0.18, and areas like Owhelogbo (0.18), Ellu (0.85) and Aradhe (0.50), have higher values. Others such as Ozoro, Ofagbe, Ernevor, Otor-Owhe, IyedeOkpe-Isoko and Oyede have less significant values.

Zn (Ppm), the mean value is 0.33, but areas like Owhelogbo (1.34) and Aradhe (1 .40), have higher values than others. While areas such as Ozoro, Ellu, Ofagbe, Emevor, Otor-Owhe, Iyede, Okpe-Isoko and Oyede have less significant values.

The mean value for Fe (Ppm) is 1.40, but areas like Okpe-isoko (2.14) and Aradhe (5.99), have higher values. Others such as Ozoro, Owhelogbo, Ellu, Ofagbe, Emevor, Otor-Owhe, Iyede and Oyede have less significant values. Ca (Ppm), has a mean value of 5.46, areas like Okpe-isoko (18.18), Aradhe (9.22) and Oyede (6.56), have higher values. Others such as Ozoro, Owhelogbo, ElluOfagbe, Emevor, Otor-Owhe and Iyede have less significant values.

The mean value for Hg (Ppm), Co (Ppm) and Cr (ppm) are 0.00 respectively, with their corresponding values also at 0.00, having no significant values at all. Sodium chloride (Na) (Ppm), has a mean value of 10.63, but areas like Ozoro (25.70), Okpe-isoko (20.99) and Aradhe (14.29) have higher values than others such as Owhelogbo, Ellu, Ofagbe, EmevorOtor-Owhelyede and Oyede with less significant values. Potassium (k) (Ppm) has a mean value of 9.52, but Ozoro (12.93), Iyede (9.67), Okpe-isoko (12.79), Aradhe (20.74) and Oyede (10.70), have higher values, while others such as Owhelogbo, Ellu, Ofagbe, Emevor and OtorOwhe have less significant values. Magnesium (Ppm), has a mean value of 6.22, but areas like Ozoro (15.05), Otor-owhe (6.89), Iyede (9.89), Okpe-isoko (11.29) and Aradhe (10.22), have higher values, others such as Owhelogbo, Ellu, Ofagbe, Emevor, Iyede and Oyede have less significant values. This result implies that Okpe-Isoko, Aradhe, Ozoro, Ellu, Oyede, Iyede and Otor-Owhe are the areas having occurrence of heavy metals in Isoko North

L.G.A of Delta State more than others

Discussion of Findings

Findings from this study are discussed as follows:

Firstly, the study shows that in some areas in Isoko North LGA like Ozoro, Okpe-Isoko, Aradhe, Oyede, Elle, Iyede and Otor-Owhe, the heavy metal intrusion is predominant than others. This finding corroborates the study of Anomoharan (2014), which opined that due to the varied difference in the thickness of the clay bed in the study area, it was recommended that the sourcing of water for domestic purpose by the people should be done in excess of 1 8m in depth.

Secondly, the study shows that there is no significant variation in the quality of groundwater resources from the study area between the two seasons of the year. This was confirmed by the mean values of samples generated, revealing a significant value not more than 1%. By implication, the quality of groundwater between the rainy and dry season have no significant variation in the study area. This finding is in line with the study of the sedimentary environments and morphological features of the modern Niger Delta as described by Aweto and Akpoborie (2011).Here, they opined that, the Isoko region of Delta State is overlain by the paralic sequence consisting of interbedded sandstones and shales of the Agbada Formation, with summary of the geology and associated groundwater resources of Delta State also described in it, among many others. Thirdly, the study reveals that Iron and Calcium Chloride are considered to have stronger and

positive effects more on the quality of ground water resource than the other properties of the heavy metals in the study area. This finding corroborates the study of Anornoharan (2014), where he opined that Ozoro has four geoelectric strata, with clay as one of them. This clay layer is reacting with the groundwater in the study area, producing substances suspected to be haematite and limonite, oxides of aluminium and iron. See plates 4.1, 4.2, 4.3 and 4.4 for photos of iron stained sample of soil and water from the study area. The study also identifies the areas in Isoko North LGA, where the suspected heavy metals intrusion is predominant. The work also examined the difference in water quality for both the dry and rainy seasons, as well as established significant relationship between the heavy metals from the host rocks and the groundwater resources of the area. Data from groundwater samples were collected from ten locations within the study area for analyses, using the study and interpretation of the characteristics of natural water as prescribed by Hem (1985). The following are the results of the findings;

Conclusion

It is a known fact that groundwater resources are man's most reliable source of quality water for domestic and industrial use in Nigeria all parts of the world. But a developing nation embellished with numerous dysfunctional actions and activities will continually seek the support of researchers and experts to create awareness and public sensitization. It is evident that the problems of heavy metal intrusion in groundwater is hereby confirmed with the findings of this research.

This study highlights that, the systematic variations in the groundwater resources of the selected zones are explained by the changes in properties of the heavy metal intrusion. Furthermore, there changes in the properties of the heavy metal which affect the quality of ground water resources in Isoko North L.G.A of Delta State. Iron and Calcium Chloride are considered to have stronger and positive effects more on the quality of groundwater resource than the other properties of the heavy metals in the study area. The mean coliform count of the groundwater is 0.8(mpn), this means that is no significant difference in the quality of groundwater resource in both seasons, implying that measuring the biological content of groundwater resource in both season in study area, the quality are the same. On the chemical content of the groundwater which shows the level of heavy metals, there is no significant difference in the quality of groundwater resource between both season in the study area, the quality are the same. The physical content of the groundwater has no significant difference in the quality of groundwater resource seasonally in the study area, Furthermore, the biological, physical and chemical content of groundwater in the study area remains the same through the year's seasons, but the Iron and Calcium Chloride considered to have more stronger and positive effects on the quality of groundwater resource than the other properties of the heavy metals.

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