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Comparative Analysis of Borehole Water Characteristics as a function of Coordinates in Emohua and Ngor Okpala Local Government Areas, Southern Nigeria

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ABSTRACT

Comparative analysis of sixteen (16) borehole water supply sources collected from Emohua and Ngor Okpala Local Government Areas (hereafter referred to as LGAs) were carried out in December 2017 to March 2018. Physicochemical parameters were analyzed using analytical techniques and instruments to study the level of pollutant concentration as index of mine exploitation. Coordinates were used to differentiate the boreholes by way of some physicochemical parameters, while multiplying analyses of variance were applied. The results obtained show the mean values of pH (4.66 ±0.05), conductivity (82.100 ±0.05), alkalinity (0.056 ±0.05), chloride (1.146 ±0.05), total dissolved solids (45.140 ±0.05), total organic matter (0.024 ±0.05), sulfate (0.030 ±0.05), and iron (0.357 ±0.05). The realized pH values indicate that the boreholes are acidic. Moreover, the Fe levels in some boreholes were above the permissible limit of the water standard. From the results of the ANOVA, the null hypothesis (H_0) revealed significant differences in pH, Cl^-, TDS, conductivity, whereas other factors, such as alkalinity, SO_4^{2-}, total organic matter and Fe were not significant in both LGAs. The coordinate results also showed that chloride increases as sulfate decreases in both LGAs. Furthermore, total organic matter increases with increase in alkalinity, and Fe increases with increase in TDS in the two LGAs as well. This concludes that there is pollution in the two study areas.

***Keywords*:** Borehole water, coordinates, Emohua, Ngor Okpala, pollution, variance

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1. INTRODUCTION

Water is one of the "two most essential needs of human beings and is the most abundant natural resources on the surface of the earth" [1] while groundwater is the largest reservoir of drinkable water and due to the natural filtration, it is less contaminated as compared to surface water [2]. Water plays a vital role in the development of communities hence, a reliable source of water is essential for the existence of both humans and animals. Water supply is essentially derived from precipitation and is said to be polluted if it is not suitable for the intended purpose [3]. Water is one of the most abundant and essential resources of man, and occupies about 70% of earth's surface.

About 97% of this volume of earth's surface water is contained in the oceans, 21% in polar ice and glaciers, 0.3-0.8% underground, 0.009% in inland freshwaters such as lakes, while 0.00009% is contained in rivers [4]. According to [5], more than 97% of earth's water is in the oceans and ice caps, and glaciers account for another 2%. Also, the ocean comprises 97%, while 3% of the earth's water is fresh [6].

Water in its pure state is acclaimed key to health and the general contention is that water is more basic than all other essential things to life [7]. Man requires a regular and accessible supply of water which forms a major component of the protoplasm and provides an essential requirement for vital physiological and biochemical processes. Man can go without food for twenty eight days, but only basic household water requirements have been suggested at 50 litres per person per day excluding water to gardens [7].

A borehole is a hydraulic structure which when properly designed and constructed, permits the economic withdrawal of water from an aquifer. It is a narrow well drilled with a machine. Borehole water is the water obtained from borehole drilled into the aquifer or ground water zone, which is usually a fully saturated subterranean zone, some distance below the water table [8]. Ground water is already used extensively in Nigeria through wells and boreholes. Unfortunately, borehole water like water from other sources is never entirely pure. It varies in purity, depending on the geological conditions of the soil through which the ground water flows and some anthropogenic activities.

Until very recently, ground water has been thought of as being a standard of water purity in itself, and to a certain extent, that is indeed true [9]. Apart from the essential role played by water in supporting human life, it also has, if polluted, a great potential for transmitting a wide variety of diseases. According to [10-14], in most developing countries like Nigeria, where dangerous and highly toxic industrial and domestic wastes are disposed of by dumping them on the earth, into rivers and streams with total disregard for aquatic lives and rural dwellers, water becomes an important medium for the transmission of enteric diseases in most communities. Poisonous chemicals are known to percolate the layers of the earth and terminate in ground waters, thereby constituting public health hazards.

In Emohua and Ngor Okpala Local Government Areas (L.G.As), certain anthropogenic activities, like the improper waste disposal, can contribute to ground water pollution and render the water grossly inadequate for consumption. The inhabitants are therefore compelled to depend largely on private borehole water supply whose quality is doubtful. Most of the depths of the boreholes are below the standard depth, consumption of such water therefore can cause water borne diseases, such as typhoid and paratyphoid fevers (*salmonellasis*).

There is a global concern on water pollution as it affects human health and one of the major causes of groundwater pollution is disposal of waste materials directly into the land surface [15-16]. The concentration of the contaminants in groundwater also depends on the level and type of elements naturally or by human activities distributed through the geological stratification of the area. The presence of such contaminants, in groundwater, above the recommended standard set by water quality regulatory bodies like Environmental Protection Agency (EPA), World Health Organisation (WHO), and FEPA may result in serious health hazards [17]. This perceived consequence of consumption of unregulated waters (used as portable water) has triggered various studies on water aquifer and aquatic ecosystem [18, 19].

To the best of our knowledge, no work has been reported earlier on the pollution index of these two Local government areas. We report here the extent of pollution of oil wells' effluent on borehole water in Emohua and Ngor Okpala L.G.As, determining the level of heavy metals in the samples and contaminants occurring between water in one borehole location and another, using information in the coordinates.

2. MATERIALS AND METHODS

2. 1. Description of the Study Area

Emohua is one of the L.G.As in Rivers State of Nigeria; its capital is Port Harcourt and its geographical coordinates are latitude 4º50' N and 6º10' N and Longtitude 6º40' E and 6º54' E giving an area 1012 m^2. Ngor-Okpala is one of the L.G.As in Imo State of Nigeria, its capital is Owerri. It lies within the latitude 5º7' N and 5º17' N longitude 7º00' E and 7º17' E giving an area of 99 m^2 (**Figs. 1-3**).

2. 2. Collection of Water Samples

Eight (8) borehole water samples were collected in Emohua L.G.A and another eight (8) were collected in Ngor Okpala L.G.A; stored in captured unused plastic bottles. These were taken in cooler packed with ice blocks and transferred to refrigerators in the laboratory prior to analysis. Each of the sixteen (16) borehole water was sampled using the standard sampling method.

Table 1. Identification of sampling locations of Emohua L.G.A

SAMPLE LOCATIONS	COORDINATES	ELEVATION	DEPT
EGBEADA	006º51'33.1''E, 04º53'13.9"N	52 feet	90 feet = 27.432m
RUMUYI	006º46'48.7''E, 04º56'37.9"N	40 feet	90 feet = 27.432m
ELELE ALUMINI	006º43'35.8''E, 05º03'19.3"N	96 feet	100 feet = 30.48m
EMOHUA	006º51'33.1''E, 04º53'09.6"N	65 feet	100 feet = 30.48m
RUMUEKPE	006º46'51.8''E, 04º56'37.9"N	53 feet	100 feet = 30.48m

NDELE	006º43'45.6''E, 05º03'15.4"N	70 feet	110 feet = 33.528m
ODUOHA	006º43'41.0''E, 05º03'16.6"N	66 feet	110 feet = 33.528m
OBELLE	006º51'34.2''E, 04º53'08.4"N	50 feet	110 feet = 33.528m

Table 2. Identification of sampling locations of Ngor Okpala L.G.A

SAMPLE LOCATIONS	COORDINATES	ELEVATION	DEPT
UMUEKWUNE	007º04'58.8''E, 05º20'11.6"N	197 feet	120 feet = 36.576m
IMERIENWE	007º04'60.8''E, 05º21'01.4"N	204 feet	120 feet = 36.576m
NGURU	007º07'13.4''E, 05º19'10.3"N	158 feet	130 feet = 39.624m
EZIAMA	007º07'22.4''E, 06º24'45.7"N	192 feet	130 feet = 39.624m
UMUNEKE	007º06'10.2''E, 05º18'03.5"N	170 feet	130 feet = 39.624m
ORISHIEZE	007º05'11.0"E, 05º17'30.4"N	149 feet	140 feet = 42.672m
OBIANGWU	007º05'03.0''E, 05º17'39.3"N	181 feet	140 feet = 42.672m
OBIKE	007º06'08.9''E, 05º17'50.2:N	138 feet	150 feet = 45.72m

2. 3. Statistical Analysis

Standard analytical techniques and instrumentation were used for data generation as the data were presented as arithmetic mean and standard deviation. Analysis of variance (ANOVA) was used to calculate the test statistics (the F-ratio) to obtain the probability (the p-value).

3. RESULTS AND DISCUSSION

Tables 3 and **4** show the values and mean values of physicochemical parameters of the borehole samples under investigation. Alkalinity, conductivity, Total dissolved solids (TDS), chloride, sulphate and total organic matter all recorded values within the drinking water standard. However, the borehole water samples of the two L.G.As were acidic and this could be as a result of sewage waste through leaching into the soil which ultimately increased the soil acidity and consequently lowered the pH [20] and anthropogenic activities from septic systems and animal sources [21].

Table 3. Data analysis of physicochemical parameters showing the cordinates in Ngor Okpala borehole water samples.

SAMPLING LOCATIONS	pH	CONDUCTIVITY (µS/cm)	TDS (mg/L)	ALKALINITY (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	TOM (mg/L)	Fe (mg/L)	CORDINATES
WB1	5.96	10.60	5.83	0.06	0.81	0.01	0.01	0.42	0.21
WB2	5.54	11.20	6.16	0.06	0.71	0.01	0.01	0.00	0.51
WB3	5.57	12.10	6.65	0.05	0.78	0.03	0.00	0.15	0.22
WB4	5.64	13.80	7.59	0.05	0.67	0.09	0.04	0.44	0.28
WB5	5.56	12.30	6.77	0.06	0.78	0.11	0.03	0.80	0.65
WB6	5.59	13.30	7.26	0.06	0.79	0.05	0.06	0.20	0.18
WB7	5.57	12.70	6.99	0.06	0.69	0.07	0.06	0.42	0.17
WB8	5.72	63.20	34.76	0.05	0.88	0.11	0.04	0.00	0.28
MEAN	5.67	18.56	10.17	0.06	0.76	0.06	0.03	0.40	
SD	0.13	17.04	9.39	0.01	0.07	0.04	0.02	0.21	
WHO	6.5-8.5	1400	1500	100	200	200	0.2-0.5	0.3	

WB - Water Borehole, **SD -** Standard Deviation, **WHO -** World Health Organization

Table 4. Data analysis of physicochemical parameters showing the cordinates in Emohua borehole water samples

SAMPLING LOCATIONS	pH	CONDUCTIVITY (µS/cm)	TDS (mg/L)	ALKALINITY (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	TOM (mg/L)	Fe (mg/L)	CORDINATES
WB1	4.41	24.40	13.42	0.060	0.92	0.00	0.05	0.00	0.21
WB2	4.27	58.80	32.34	0.060	1.09	0.00	0.00	0.00	0.51

WB3	4.80	253.50	39.42	0.050	2.32	0.04	0.03	0.66	0.20
WB4	4.89	19.70	10.83	0.050	0.89	0.03	0.02	0.70	0.28
WB5	4.44	87.70	48.23	0.050	0.97	0.15	0.01	0.14	0.65
WB6	4.49	39.60	21.78	0.060	0.76	0.05	0.01	0.13	0.18
WB7	4.66	165.00	90.75	0.040	1.43	0.06	0.02	0.21	0.17
WB8	4.85	1010	5.55	0.050	0.80	0.02	0.01	0.03	0.28
MEAN	4.66	82.10	45.14	0.050	1.44	0.03	0.02	0.35	
SD	4.20	81.00	44.54	0.00	0.49	0.02	0.01	0.24	
WHO	6.5-8.5	1400	1500	100	200	200	0.2-0.5	0.3	

WB - Water Borehole, **SD -** Standard Deviation, **WHO -** World Health Organization

In Table 3, the pH values for Ngor Okpala ranged from 5-540-5.960 with a mean value of 5.660, whereas pH values in Table 4 pH for Emohua ranged from 4.270-4.890 with a mean value of 4.660. Again, the cation (Fe) tested in most of the locations: WB3 and WB4 in Emohua and locations WB1, WB4, WB5 and WB7 in Ngor Okpala were above the permissible limits for drinking water standard, which constitutes pollution in those locations.

The research findings in **Figures 4-9** shows the coordinates (which were used to differentiate two borehole locations) on the x-axis and concentrations in mg/L on the y-axis: in Figures 4 and 5, the chloride concentration increases as the sulfate concentration decreases in Emohua L.G.A likewise in Ngor-Okpala. The higher concentrations of chloride (1.43 mg/L) in Emohua and (0.88 mg/L) in Ngor Okpala against 0.06 mg/L and 0.11 mg/L in Emohua and Ngor Okpala, respectively, indicates salt water intrusion, sewage and other pollution sources which introduce chloride to ground water are higher in those locations [22-25].

In Figures 6 and 7, TOM increases with increase in alkalinity in the two L.G.As. The mean values of alkalinity 0.06 mg/L and 0.05 mg/L for Ngor Okpala and Emohua respectively were lower than the mean value of alkalinity (8.00 mg/L) for a borehole water studied in Wukari town, Taraba state of Nigeria [26-29]. Even though both studies when compared recorded alkalinity within the WHO standard, the lower values in the studied borehole locations in this work suggest lower pollutions.

In Figures 8 and 9, Fe increases with increase in TDS in the two L.G.As as well. High iron (Fe) concentrations in mg/L of 0.42, 0.44, 0.88 and 0.42 at four different locations in Ngor Okpala LGA and concentrations in mg/L of 0.66 and 0.77 in Emohua LGA are indicative of pollution [30-39].

From the results of the analysis of variance (ANOVA), the p-values of the parameters in the two LGAs described their null hypothesis (H_0). In Emohua and Ngor Okpala L.G.As, (H_0) of the following parameters were rejected because their p-values were less than 5% (0.05): pH, conductivity, TDS Chloride and Sulphate which concludes that there was significant difference in those locations which suggests impurities.

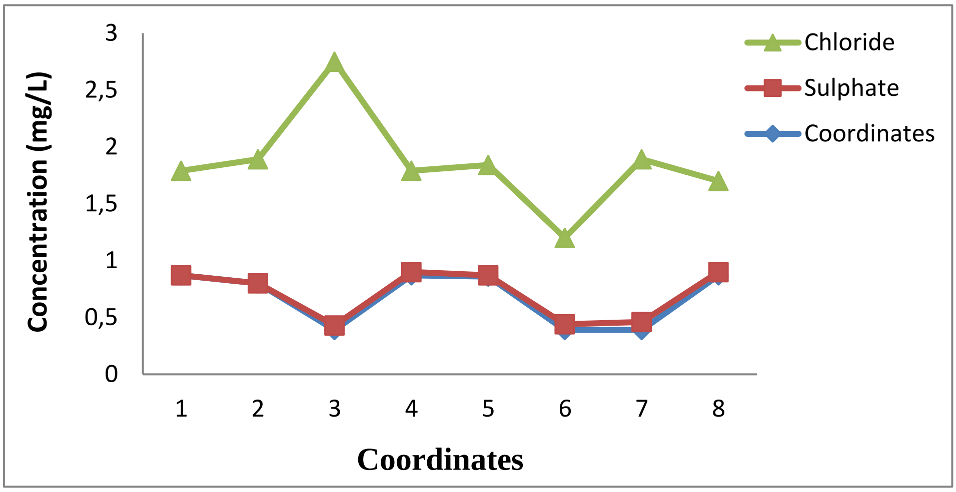

Fig. 4. Chloride and Sulfate of Water Samples in Emohua L.G.A

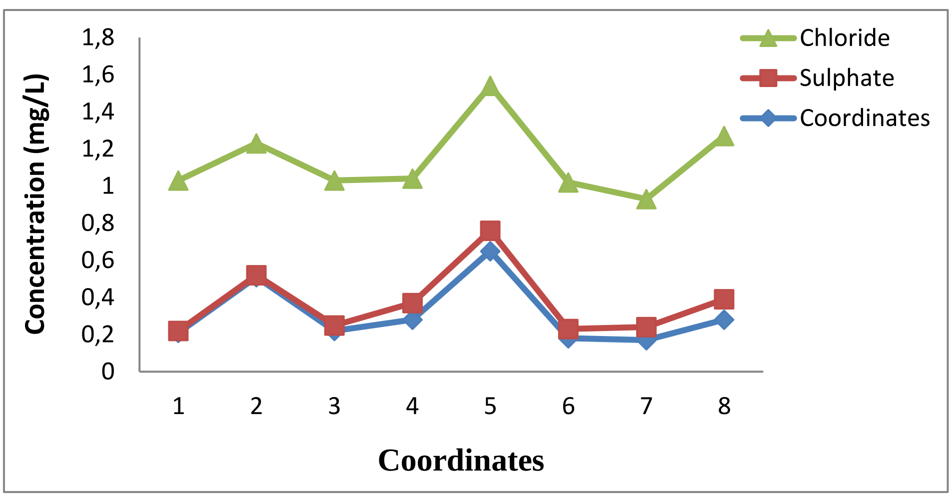

Fig. 5. Chloride and Sulfate of Water Samples in Ngor Okpala L.G.A

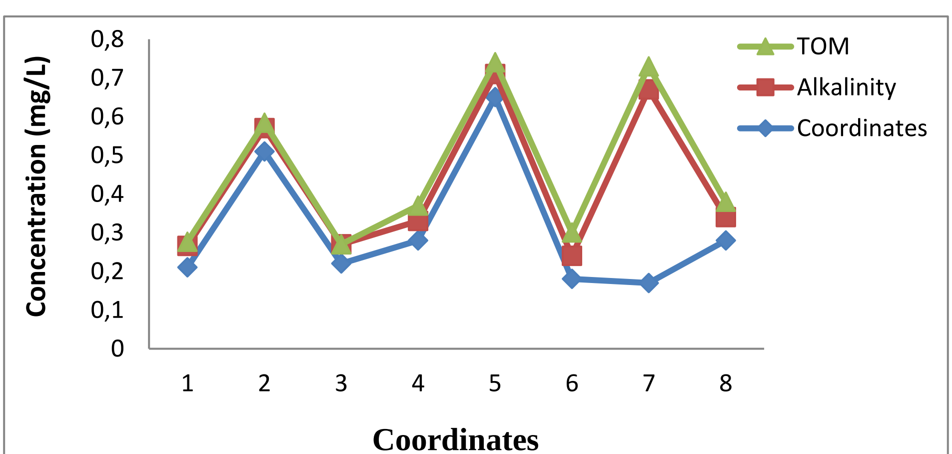

Fig. 6. TOM and Alkalinity of Water Samples in Emohua L.G.A

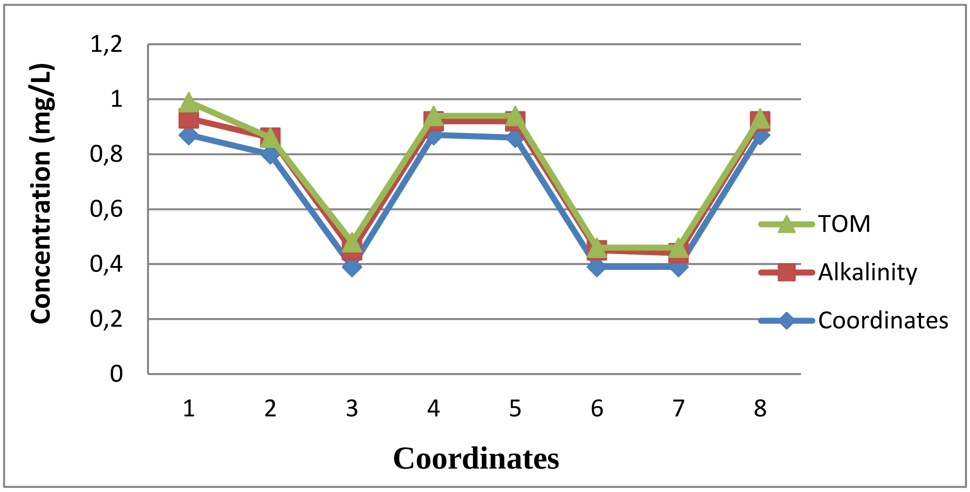

Fig. 7. TOM and Alkalinity of Water Samples in Ngor-Okpala L.G.A

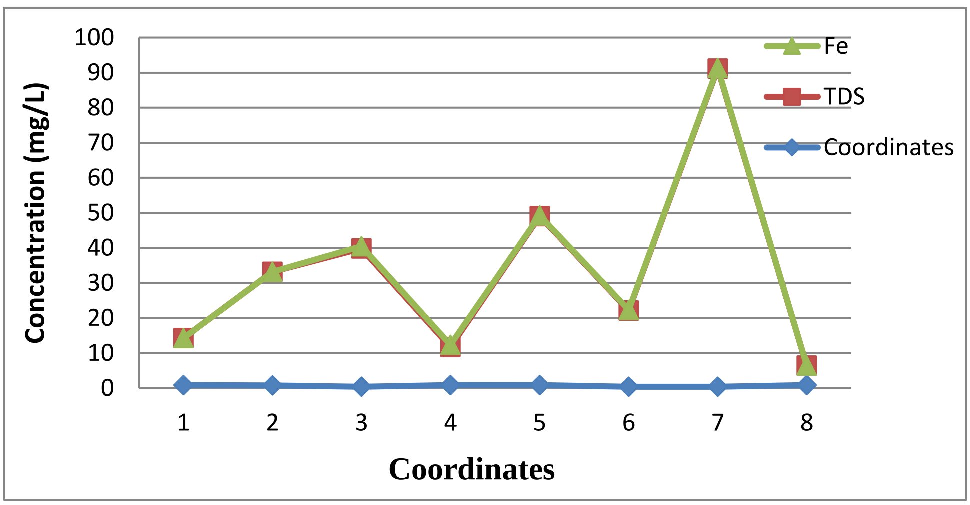

Fig. 8. Fe and TDS of Water Samples in Emohua L.G.A

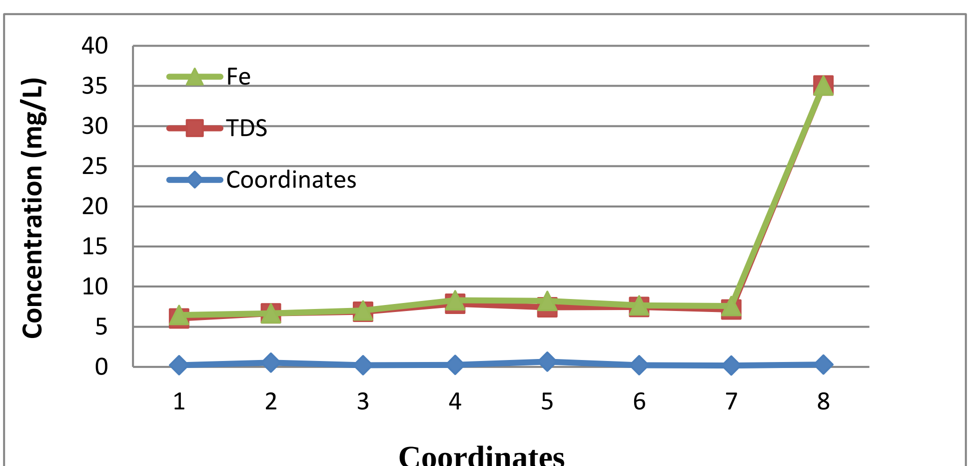

Fig. 9. Fe and TDS of Water Samples in Ngor-Okpala L.G.A

4. CONCLUSIONS

In conclusion, the comparative analysis of sixteen (16) borehole water supplies was carried out from Emohua and Ngor Okpala LGAs. Physicochemical characteristics were determined using the level of pollutant concentration as an index mining exploitation. The use of coordinates to differentiate the boreholes using some physicochemical parameters and multiply analysis of variance was carried out. The result obtained showed that pH (4.66 ±0.05), Conductivity (82.100 ±0.05), Alkalinity (0.056 ±0.05), Chloride (1.1460.05), Total dissolved solids (45.140 ±0.05), Total organic matter (0.024 ±0.05), Sulfate (0.030±0.05), and Iron (0.357 ±0.05). Emohua and Ngor-Okpala locations had impacts on all borehole water parameters determined. Except WB3 and WB4 in Emohua, and some locations in Ngor Okpala which recorded high iron values and the acidity of the samples, the other parameters investigated recorded values within the permissible limit for drinking water. High iron (Fe) contents and the acidity of the samples suggest a pollution of the locations which could be as a result of Sewage Waste [34-36]. Also Iron concentrations were higher in some locations in both LGAs which could be attributed to the impact of high anthropogenic activities. The null hypothesis (H_0) varied significantly in both LGAs. Polyvinylchloride and other non-corrosive materials are therefore recommended for use in borehole water construction to avoid rusting of pipes and possible introduction of impurities. Finally, there was a higher degree of water pollution in Emohua L.G.A compared to that in Ngor Okpala L.G.A.

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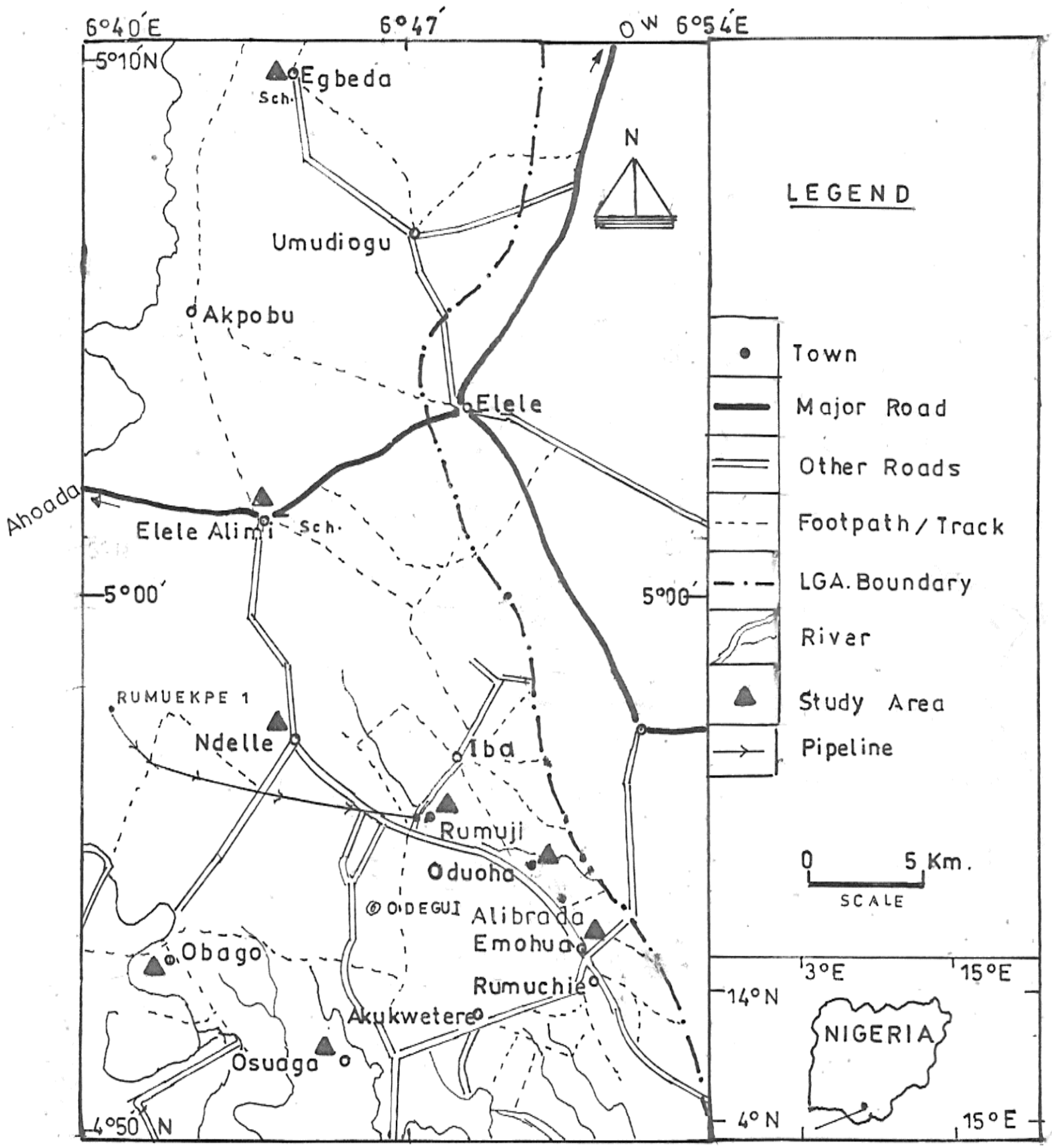

Fig. 1. Location Map of the study Area (EMOHUA L.G.A) adopted from [15]

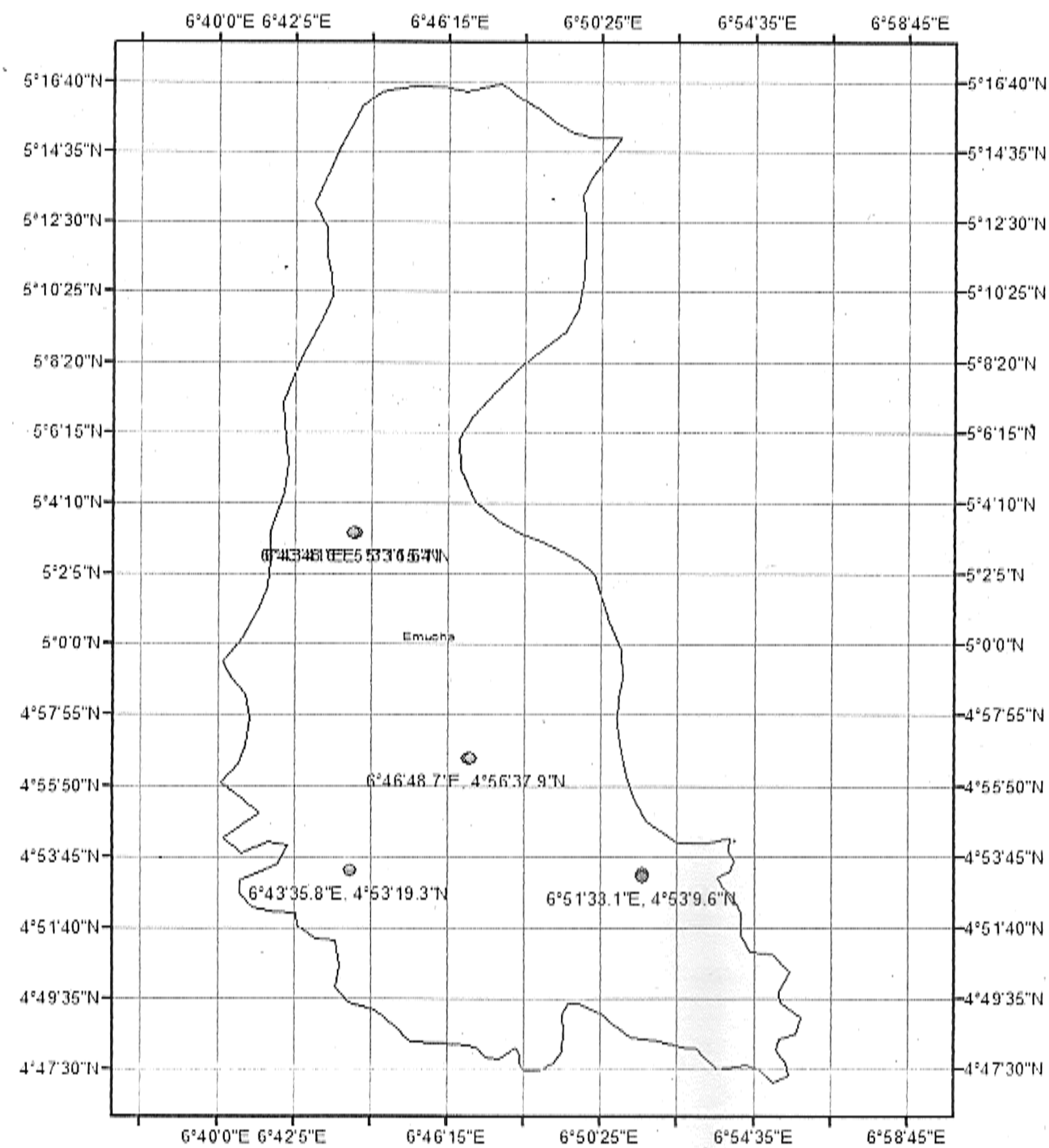

Fig. 2. A grid map of Emohua L.G.A showing the boreholes adopted from [15]

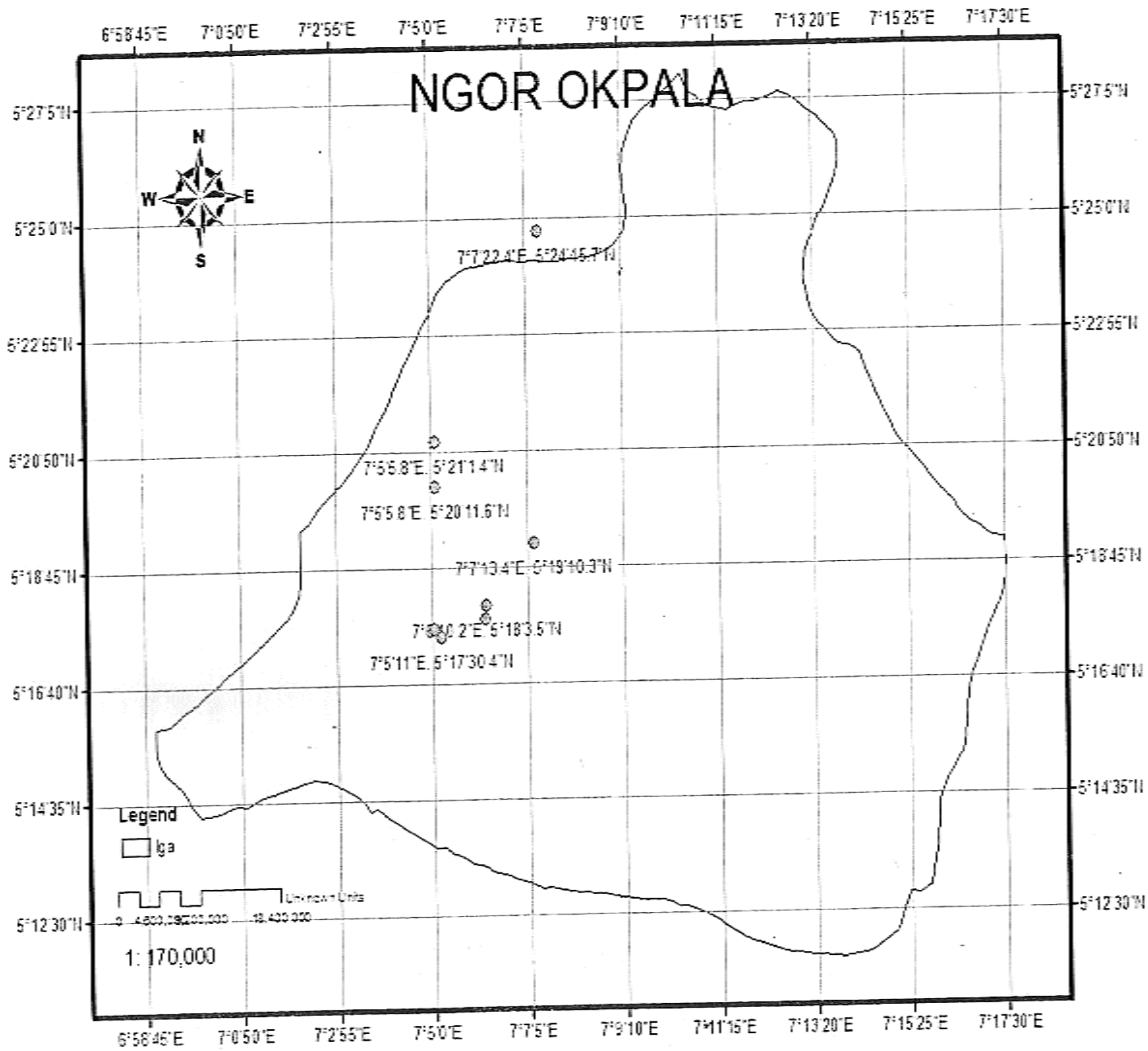

Fig. 3. A grid map of Ngor-Okpala L.G.A showing the boreholes adopted from [15]