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Hydrogeochemical Analysis of Water Samples From Nworie River, Owerri Southeastern Nigeria

BY

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ABSTRACT
Nworie river flows through some major parts of Owerri namely, Federal Medical Centre, Alvan Ikoku College of Education etc. It serves as a source of water for many human activities. Since majority of inhabitants sees it as a good substitute for drinking water due to the collapse of the Owerri water scheme, attempts are being made to determine the water quality in order to ascertain its suitability for human consumption and other uses. Water samples were taken from four different locations along the whole length of the river for physiochemical analysis. The results indicated that the mean pH, TDS and electrical conductivity values are;6.125, 51.75mg/l and 103.5 siemens respectively. The concentration of calcium, magnesium, sodium and potassium are 2.05, 0.118, 12.63 and 2.403 respectively while the concentration of zinc, lead, copper, casmium and iron are 0.845, 0.0125, 1.193, 0.056 and 0.575 respectively. The low level of pH implies that the river is acidic. The results of the mean concentration of metals such as lead, iron, copper and cadmium indicate that the river is unhealthy for human consumption without treatment.

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I. INTRODUCTION

The area of study lies between latitudes 5˚25′ – 5˚30′N and longitudes 7˚00′ – 7˚05′E. It covers an area of 1135 square kilometers; Fig. 1.Pysiographically, the terrain is characterized by two types of landforms; high undulating ridges and a nearly flat topography. The ridges trend in the N – S direction and have an average elevation of about 122m above the sea level. Between these ridges is the valley of Nworie river. This river watershed is subjected to intensive human and industrial activities resulting in the discharge of a wide range of pollutions. Whenever the public water supply fails, the river further serves as a sources of direct drinking water. River Nworie flows in the NE – SW direction with average hydraulic gradient between 0.005 and 0.02.Human activities have started to have negative effects on the river. It has been noticed that the quantity of water in the river has diminished. Water weeds have covered many parts of the river. Federal Medical Centre and Alvan Ikoku College of Education are located along the river bank. The waste disposal practiced by inhabitants of these institutions and other members of the public is through open dump for solid wastes, (Ishaku and ezeigbo 2010). This may lead to eutrophication. Also other macroscopic plants have taken over some parts of the river. Because of the increase in organic contents in the river and possible decays thereafter, there is reduction in dissolved oxygen necessary for the survival of the aquatic lives. These plants (both macroscopic and microscopic) cause the slowing down of the speed of the river which invariably leads to the deposition of water load (sediments). As this situation continues, there is occurrence of siltation which may eventually lead to the drying up of the river. Already, fishing activities have stopped along the river by Alvan portion due to the state of the river.Nworie river takes its sources in Ohii and join Otamiri river at Nekede. Its total length is 9.2km. This watershed is covered by depleted rain forest vegetation with an annual rainfall of 2500mm. It flows through the Federal Medical Centre, Owerri (FMC), Alvan Ikoku Federal College of Education (AIFCE) and Holy Ghost College. All these institutions discharge their untreated waste into Nworie River. Alinnor and Obiji (2010) already observed some trace metal elements in fish samples from Nworie River.

1.1.GEOLOGICAL SETTING: The study area is underlain by Benin Formation, Fig.1. The Benin Formation is made up of friable sand with minor intercalation of clay. The sand unit is mostly coarse grain pebble, poorly sorted and contains less of fine grained sands (Onyeagocha 1980). The lithology is made up of sandstone, sand with few shale intercalations. The shale is grayish brown, sandy to silty and contains some fingers of lignites. At many places within the study area, this formation is overlain by a considerable thickness of red earth and subsequences ferrugination of weathered materials. Other structural units such as point bars, chemical fills, black swamp deposits and Ox-bow fills are identified in Benin Formation. Petrographic studies on several thin sections by Onyeagocha (1980) show that quartz makes up about 99% of the grains. Benin Formation conformably overlies the Ogwashi – Asaba Formation.

II. METHODOLOGY

Sample Collection

The samples were collected in small white plastic containers which were rinsed initially with the particular water to be sampled before final collection were established after a reconnaissance visit to the river (Omada et. al 2011).

Station 1 was at Egbeada, upper section of the river, close to the river source.
Station 2 was at Alvan Ikoku Federal College of Education / Federal Medical Centre.
Station 3 was close to Holy Ghost College by Control road.
Station 4 was at Old Nekede road almost at the end of the river before joining Otamiri river, Fig 2.
These water samples were collected with plastic containers at these stations, properly labeled and taken to laboratory for analysis.

Instrumentation

Some of the instruments used for this study included:

i. pH meter
ii. DR 2010 data logging spectrophotometer
iii. Conductivity / TDS meter
iv. ABEM Terrameter SAS 300

III. LABORATORY ANALYSIS

The laboratory tests were carried out to get details about these parameters: pH value, Salinity, Nitrite, Nitrate, dissolved Oxygen etc. A biological parameter known as "total coliform count" was also tested for;
pH value: was determined with the pH meter.

Salinity:A hand held spectrophotometer was used to obtain the salinity value.

Nitrite and Nitrate:DR 2010 data logging Spectrophotometer was used in the chemical analysis of Nitrite and Nitrate. Diazotization method was employed for Nitrite while cadmium reduction process was applied for Nitrate.

Iron, Copper, Manganese, Zinc and Lead: Spectrophotometer instrument was used for the chemical analysis of these elements but the processes were different for each element.

Dissolved Oxygen:_ Winkler tetrimetric method which is the most common method for dissolved Oxygen measurements in waste water, effluent and stream samples was employed.

Total Coliform Count: This parameter was also determined by using the membrane filtration technique.

Conductivity /TDS: These were the last parameters that were determined in the laboratory using the conductivity/TDS probe inserted in a beaker containing the sample. The results of all these laboratory tests are presented using bar charts.

IV. VERTICAL ELECTRICAL SOUNDING (VES)

A geophysical study using the Vertical Electrical Sounding (VES) technique was carried out around Holy Ghost College in order to have a clearer information about the lithologic units within the subsurface at station 3. The data were acquired using the schlumberger electrode arrangement with a maximum spread of AB/2 = 100m. The geophysical equipment used was ABEM Terrameter SAS 1000 with a digital readout. The field data shown in table 2 were analyzed using the Resist computer program. The computer modeled curve is displayed in Fig 4 while the geoelectric section is shown in Fig 5.

V. RESULTS AND DISCUSSION

The results of all the tests are shown in Table 1. Bar charts were used to indicate the level of cations and anions concentration at the different sampling locations. Figures 3a, 3b and 3c display the chart for each parameter.

pH: The range of measured pH is between 5.84 and 6.28. The water is acidic. All the values obtained are below the WHO standard. These low pH value (5.84 – 6.28) got from this study may be attributed to the untreated waste dumped into the river. Akudinobi and Iyiegbu (2008) reported a similar situation in Enugu where untreated waste thrown into Olobo river made the pH value to be as low as 3.7.

Dissolved O_2: Only station 1 (i.e Egbeada) falls below the range of WHO standard. This may be due to the process of eutophication in the area which enhanced the growth of aquatic vegetation or phytoplankton. Algal blooms disrupt normal functioning of ecosystem causing variety of problems which include; lack of oxygen needed for fish and shell fish to survive.

Turbidity: Increase in sediment load adversely affect the biodiversity of most rivers and lakes. This phenomenon reduces the depth of river thus endangering those aquatic species that require specific depth for survival. Sediment loaded rivers are murky or clouded. The FMC axis of Nworie river recorded a high level of turbidity (73 NTU). This could be as a result of the discharge of untreated effluent.

Nitrates and Phosphate: Nitrates normally have four sources namely: natural, waste-materials, crop agriculture and irrigated agricultural practices (Adelana and Olasehinde 2003, Abimbola et. al., 2002, Marias, 1999, and Fan and Steinberg 1996). Nitrate values decrease from 12.4mg/ℓ at Egbeada station to 3.6mg/ℓ around FMC and Alvan. Although the levels are within the acceptable limits. Alkalinity also decreases from 22.5mg/ℓ to 14.9mg/ℓ. Some other heavy metals identified in Nworie River include: lead (Pb), Iron (Fe), Zinc (Zn), Manganese (Mn), Chromium (Cr), Copper (Cu) and Cadmium (Cd). From table 1, the mean value of lead and iron exceeded the WHO limits. These could be due to illegal dumping of wastes. Alinnor and Obiji (2012) identified Iron and Manganese from fish Tilapia got from Nworie River. The cations; Calcium (Ca), Magnesium (Mg) and Aluminum (Al) are all within accepted limits. This indicates that the cationic exchange capability of Nworie river is functional. These physical parameters also determine the suitability of the water for domestic and industrial uses. For example water with low pH (acidic water) may cause severe corrosion of metal casing used for reticulation. In human, it can cause metabolic acidosis.

Geophysical Survey Results: From the computer modeled curve, Fig 4, the geoelectric section was constructed, (Fig 5). Seven geoelectric layers were identified from the geophysical survey.. Other details about the geoelectric layers are shown in table 3. One remarkable observation from the geophysical results is a zone (layers 2, 3 and 4) that has low resistivities. This can be attributed to the presence of mineralized / contaminated groundwater. There are many cases of domestic boreholes within River Nworie basin that produce low quality water. The contamination of this river by indiscriminate disposal of refuse into it may be one of the causes as this river serves as one of the recharge sources to groundwater within this environment.

VI. CONCLUSION

Heavy metals have been identified in the water samples collected from River Nworie. The mean concentration of Lead and Iron is above the safe limits. Other physiochemical assessment of the water samples indicates that some parameters did not exceed the safe limits of WHO standard (WHO 2006). The mean pH is low, this implies that the water is not good for human consumption without treatment. Turbidity increase might enhance the reduction of depth of the river thus endangering those aquatic species requiring specific depth for survival.Based on these findings, it is evident that the causes / sources of contamination / pollution are from agricultural and human activities.

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TABLES

FIGURES

TABLE 1: RESULTS OF THE GEOCHEMICAL ANALYSES

Parameters	WHO FMENV STD	Mean	Range	Undredged 1 Egbeada	Partially dredged 2 F.M.C	Dredged 3 Control	Undredged 4 Old Nekede	Standard deviation
pH	6.5-8.5	6.125	5.84-6.28	5.84	6.23	6.28	6.15	0.1974
Conductivity (µs/cm)	100	103.5	84-122	84	112	96	122	16.8424
Total dissolved solids (mg/L)	250	51.75	42-61	42	56	48	61	8.4212
Total suspended solids (mg/L)	50	18	13-26	17	26	16	13	5.5976
Turbidity NTU	50	32.5	3-73	3	73	52	2	35.6885
Nitrate (mg/L)	40	6.975	3.6-12.4	12.4	5.7	3.6	6.2	3.7880
Nitrate (mg/L)	1.0	0.205	0.15-0.26	0.23	0.18	0.15	0.26	0.0493
Phosphate (mg/l)	5	0.758	0.35-1.72	0.40	1.72	0.56	0.35	0.6479
Sulphate (mg/l)	250	8.25	2-13.1	2	13.1	10.1	7.8	4.6979
Alkalinity (mg/l)	200	23.83	14.9-37.4	2.25	37.4	14.9	20.5	9.6046
Chloride (mg/l)	200	11.93	8.5-16.2	8.5	16.2	12.8	10.2	3.3539
Dissolved oxygen (mg/l)	>4	4.48	3.8-5.8	3.8	4.2	5.8	4.1	0.8995
Biological oxygen demand (mg/l)	ND	ND	ND	ND	ND	ND	ND	ND
Calcium (mg/l)	70	2.05	1.95-2.2	1.95	2.0	2.2	2.05	0.1080
Magnesium (mg/l)	0.5	0.118	0.10-0.14	0.10	0.14	0.12	0.11	0.0171
Lead (mg/l)	0.05	0.125	0.08-0.16	0.08	0.13	0.16	0.13	0.0332
Iron (mg/l)	0.3	0.575	0.34-0.72	0.34	0.68	0.56	0.72	0.1708
Zinc (mg/l)	5	0.845	0.78-0.95	0.81	0.78	0.95	0.84	0.0742
Manganese (mg/l)	0.4	0.205	0.12-0.27	0.27	0.18	0.12	0.25	0.0686
Chromium (mg/l)	0.1	ND	ND	ND	ND	ND	ND	ND
Copper (mg/l)	1.0	1.193	0.98-1.54	1.20	1.05	0.98	1.54	0.2492
Aluminum (mg/l)		0.743	0.65-0.91	0.69	0.91	0.72	0.65	0.1153
Cadmium (mg/l)	0.05	0.056	0.046-0.077	0.046	0.053	0.043	0.077	0.0143
Coliform (mg/l)	0-2	-	10>300	10	>300	>300	>300	ND
Sodium (mg/l)		12.63	12.3-13.1	12.6	12.30	12.50	13.1	0.3403
Potassium (mg/l)		2.403	2.3-2.5	2.5	2.3	2.41	2.40	0.0818
HCO_3^-		18.19	16.9-20.54	20.54	17.20	16.90	18.10	1.6507
NO_3^-				0.10	0.12	0.18	0.15	
SO_4^{2-}				1.69	1.60	1.49	1.50	

TABLE 2: FIELD DATA OF THE GEOPHYSICAL SURVEY

AB/2 (m)	Apparent Resistivity (Ωm)
1	1345
2	1484
2	1460
4	1747
6	1591
6	1677
8	1489
10	1107
10	1190
15	896
20	765
20	814
30	533
40	462
40	482
50	499
60	791
60	576
80	745
100	990
100	1000

TABLE 3: THE GEOELECTRIC LAYERS

Layer	Resistivity (Ωm)	Depth (m)	Probable Lithology
1	1250	1.1	Top Soil
2	2860	2.6	Silty Sand
3	940	11.4	Sand with Fe^{+} H_2O
4	415	15.6	Sand with Fe^{+} H_2O
5	146	26.7	Sand with Fe^{+} H_2O
6	1570	37.8	Sand with Fe^{+} H_2O
7	8000	α	Sand with Fresh H_2O

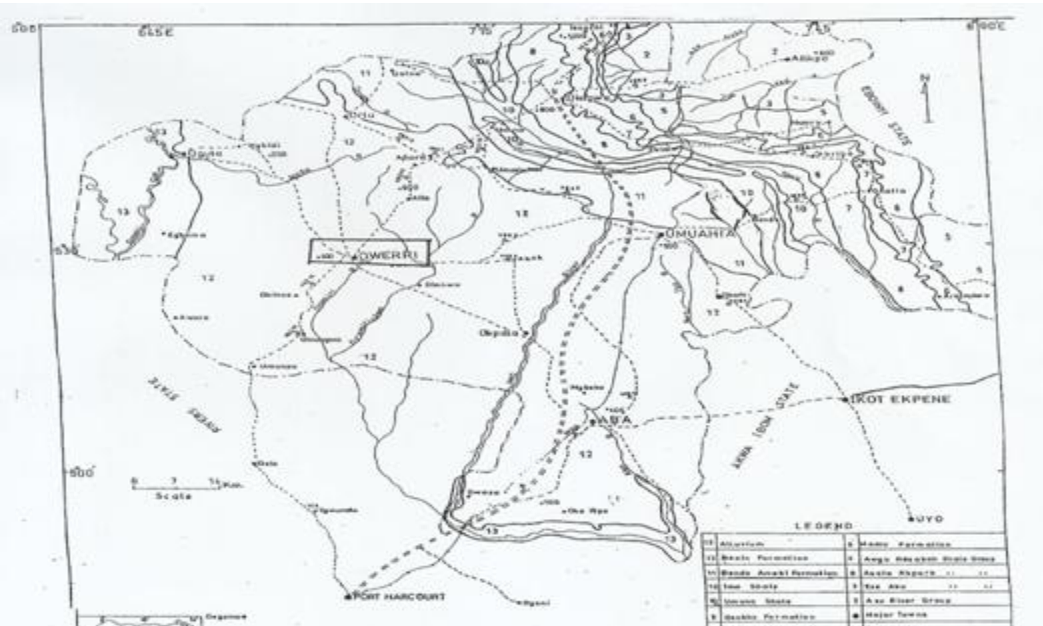
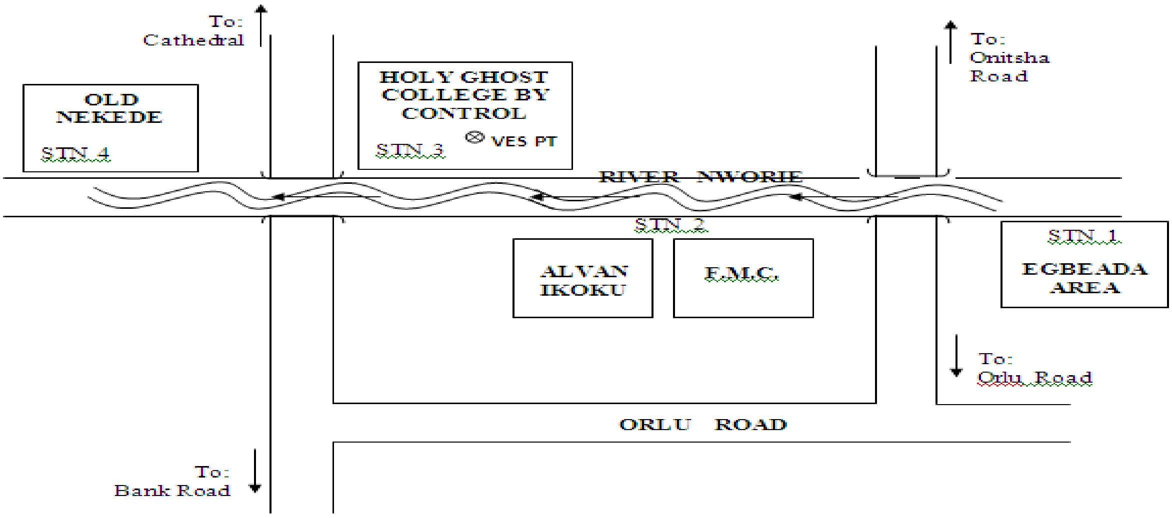


FIG. 1 GEOLOGIC MAP OF THE STUDY AREA

FIG. 2 LOCATION OF SAMPLE COLLECTION AND VES SPOTS



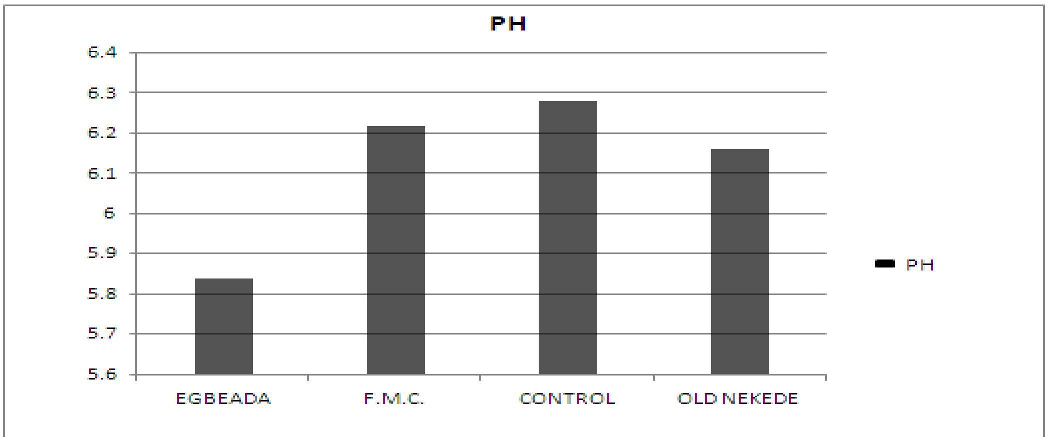


FIG. 3a
BAR CHART FOR PH

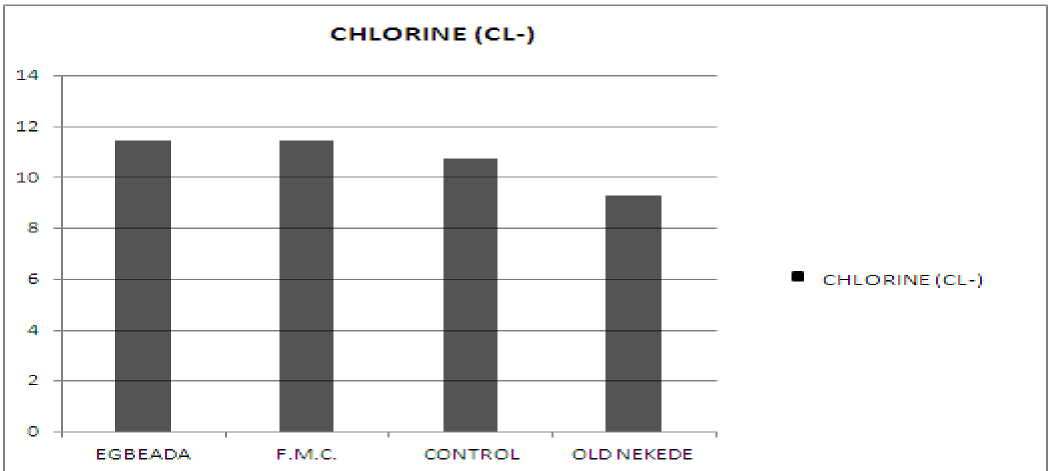


FIG. 3b
BAR CHART FOR CHLORINE (CL-)

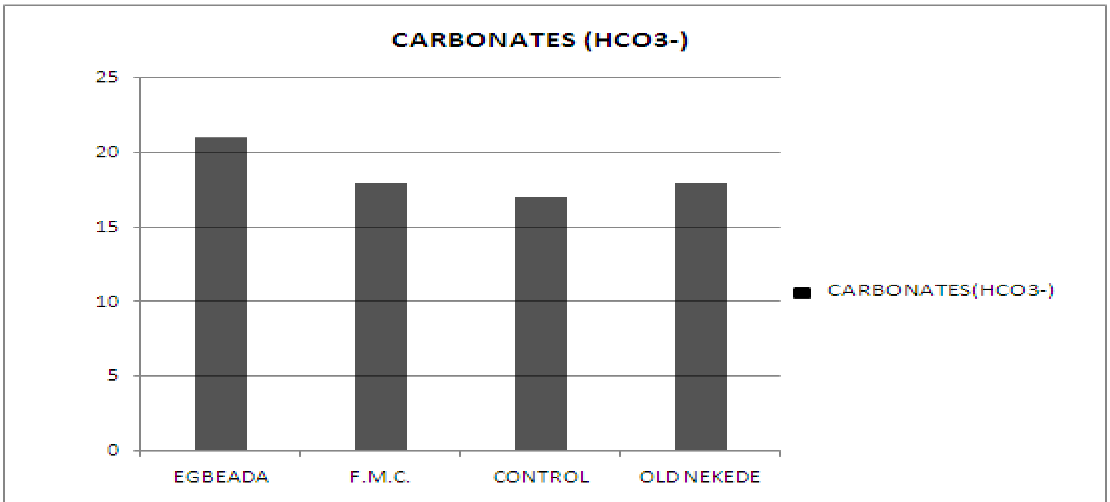


FIG. 3c
BAR CHART FOR CARBONATES (HCO3-)

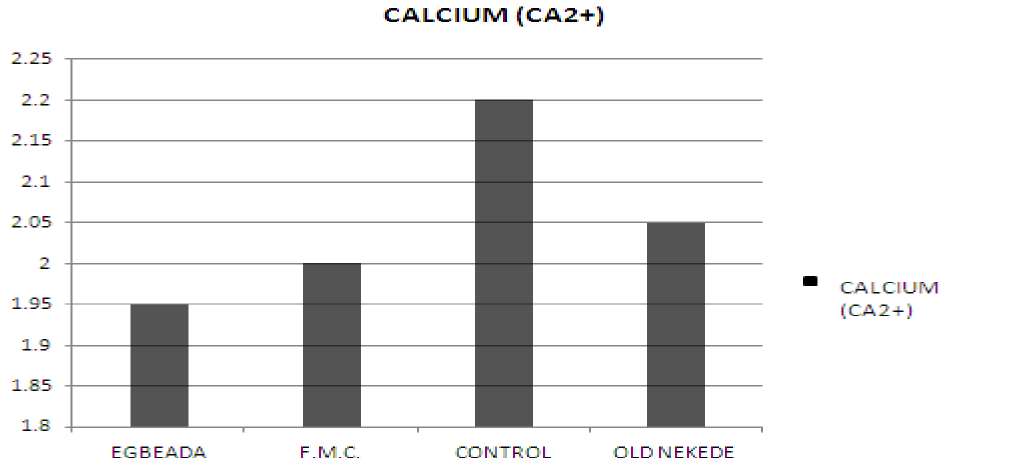


FIG. 3d
BAR CHART FOR CALCIUM (CA^{2+})

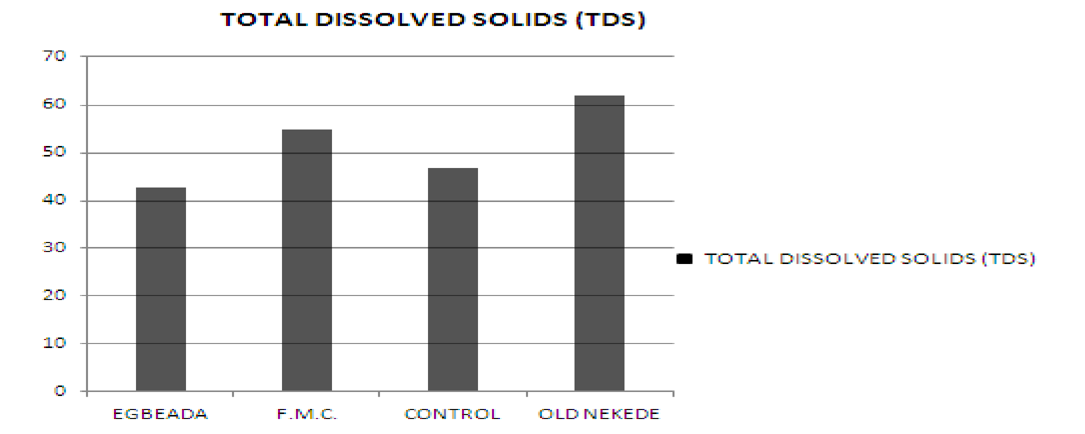


FIG. 3e
BAR CHART FOR TOTAL DISSOLVED SOLIDS (TDS)

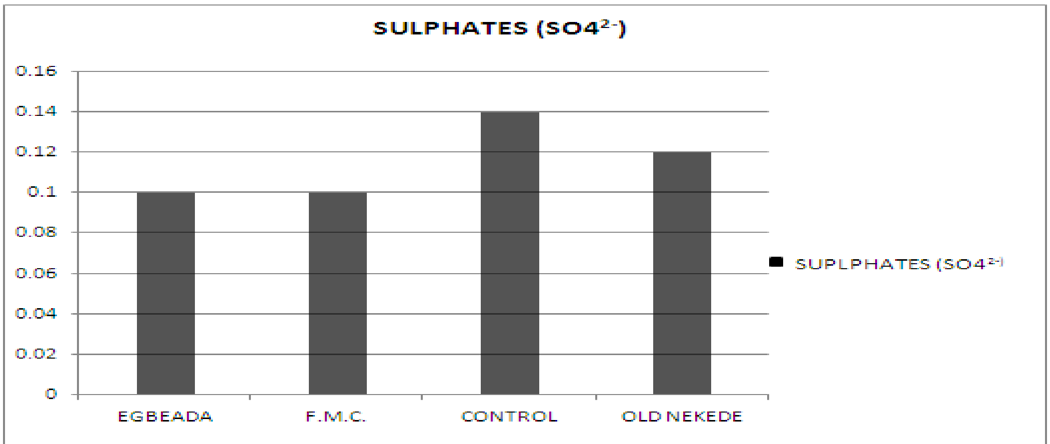


FIG. 3f

BAR CHART FOR SULPHATES (SO_4^{2-})

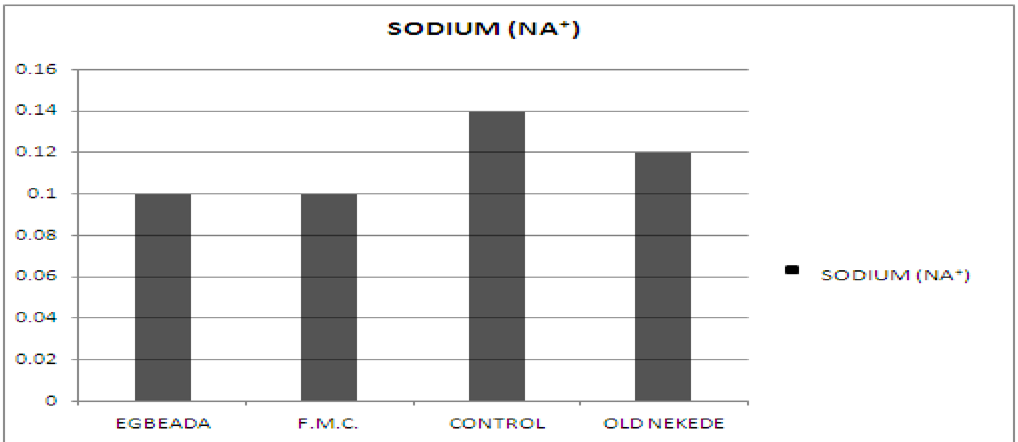


FIG. 3g

BAR CHART FOR SODIUM (NA^+)

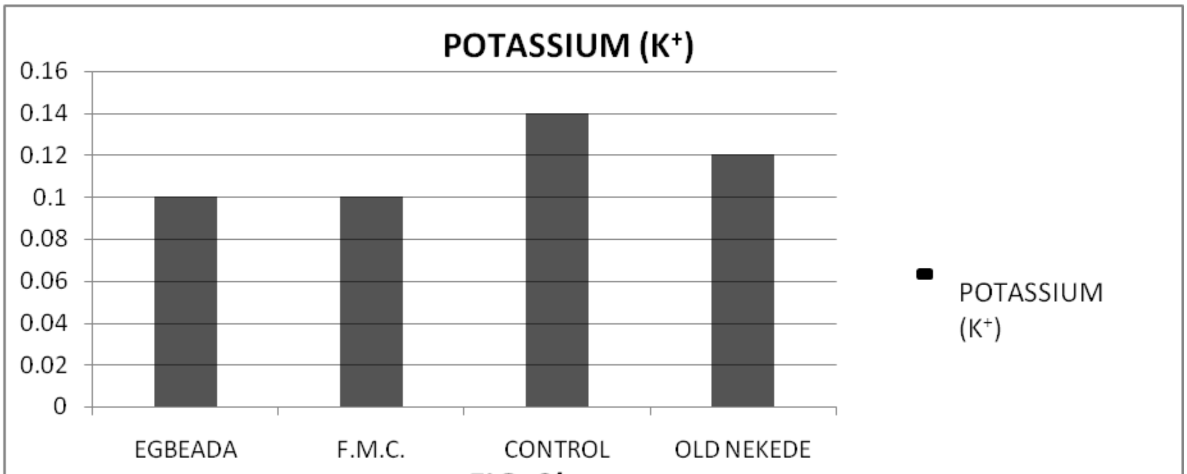


FIG. 3h

BAR CHART FOR POTASSIUM (K^+)

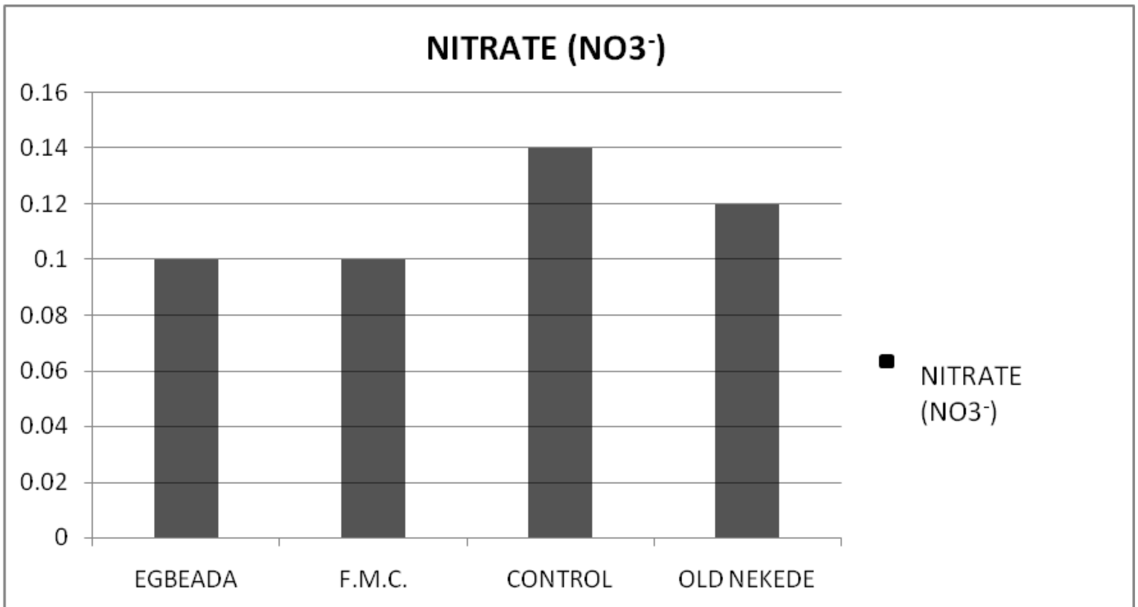


FIG. 3i

BAR CHART FOR NITRATE (NO_3^-)

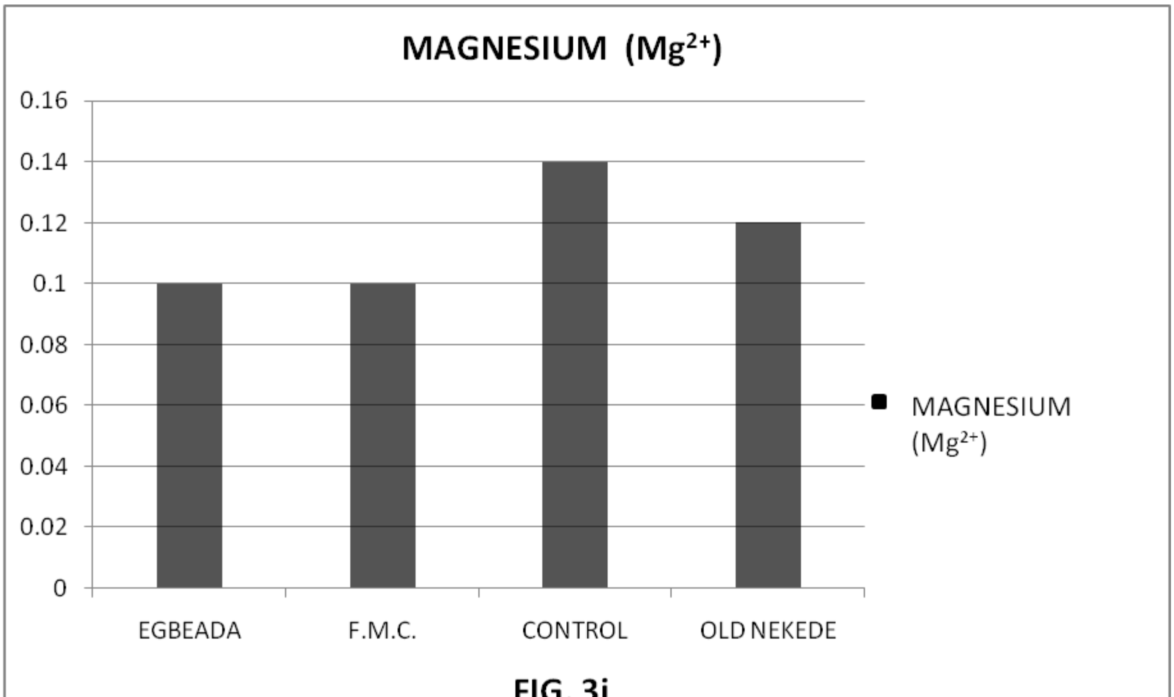
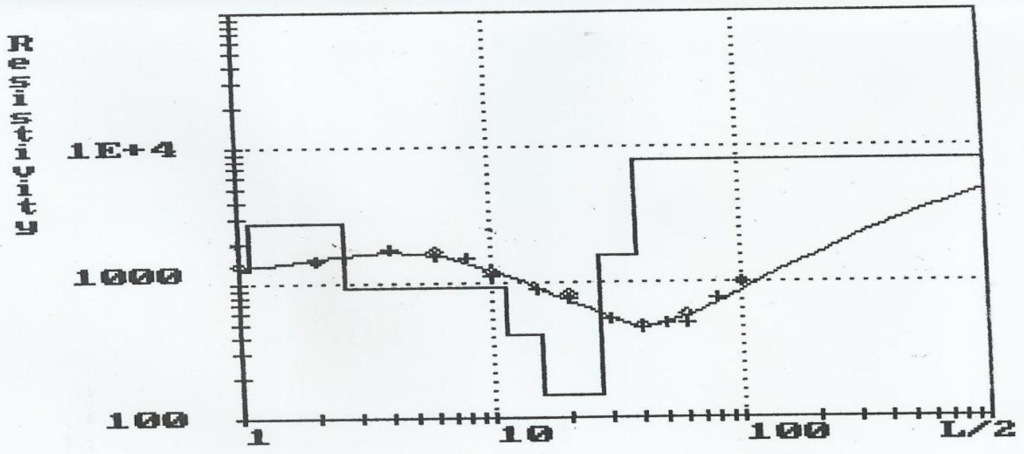


FIG. 3j

BAR CHART FOR MAGNESIUM (Mg^{2+})



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Code name	VES 1	Remarks	IMO STATE
Coordinates	OWERRI (behind Holy Ghost College)	Schlumberger	O'Neill

L/2 (m)	Rho (Ohm.m)	L/2 (m)	Rho (Ohm.m)	L/2 (m)	Rho (Ohm.m)
1.0	1345.0	10.0	1107.0	40.0	482.0
2.0	1484.0	10.0	1190.0	50.0	499.0
2.0	1460.0	15.0	896.0	60.0	491.0
4.0	1747.0	20.0	765.0	60.0	576.0
6.0	1591.0	20.0	814.0	80.0	745.0
6.0	1677.0	30.0	533.0	100.0	990.0
8.0	1489.0	40.0	462.0	100.0	1000.0

Resistivity (Ohm.m)	Depth (m)
1250.0	1.1
2860.0	2.6
940.0	11.4
415.0	15.6
146.0	26.7
1570.0	37.8
8000	

FIG. 4

COMPUTER MODELED CURVE