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Physicochemical and Geo-electrical Evaluation of Groundwater Quality in Ojo Community, Lagos State, Nigeria

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ABSTRACT

The growth and development of a community are influenced importantly by the quality of water supply aside from the quantity needed for drinking, irrigation, industries, and recreation. Thus, the quality of the main source of water in Ojo community, Lagos State, Nigeria was established through physicochemical assessment, the use of a water quality index, and geoelectrical techniques. Water samples were collected from fifteen (15) different water sample points for chemical analyses and twenty (20) vertical electrical sounding (VES) points using Schlumberger electrode arrangement for possible groundwater potentials. Water quality index (WQI), exceedance, sodium adsorption ratio, and Na/Cl, Ca/Cl ratio were used to further analyze the water data. Only about 93% of the water samples investigated are suitable for irrigation for health reasons. WQI reveals the status of water investigated as excellent (6.7%), and good (20 %), poor (60%) and very poor (13.3 %). The geo-electric results show all 20 VES points to have low resistivity values which is an indication of them being fully, or partially contaminated. In contrast, VES 9 and 10 have high to moderate resistivity values, which diagnoses them as not being contaminated. Continuous monitoring needs to be done to protect the health and sustainability of the environment in line with sustainable development goals (SDG).

1. INTRODUCTION

Water remains the most vital substance that sustains life after air (oxygen). It is important in terms of both quantity and quality for the sustainability of life. Water comes from two main sources namely, surface water and groundwater. Groundwater, otherwise called underground water or subsurface water has a higher preference compared to surface water due to less susceptibility to pollution (Andrade et al., 2018).

Other factors that favor the high preference of groundwater include closeness to where the water is needed, natural existence almost in a pure form that requires no or little treatment, and cheap cost of development (Osibanjo et al., 2017; Ntona et al., 2022). Most public water supplies are produced from groundwater (USGS, 2008). Over 2 billion people depend on subsurface water as their primary water source globally (Famiglietti, 2014).

Only 37% of the population of Lagos State, Nigeria (10.4 million) is covered in the Government municipal water supply scheme (Lagos Organization Review, 2008). Groundwater is prone to various possible threats depending on the area where it is located, consequently affecting the quality of the underground water. These threats or pollution sources can be geogenic (natural) or anthropogenic (man-made) such as infiltrations of leachate from landfills, applications of chemicals and fertilizers during agricultural activities, mining activities, oil leakages and spills, industrial effluents and saltwater intrusion (Nigam and Kumar, 2022). Geological formations of an area and over-abstracting of water can also contaminate of groundwater (Oke and Alowo 2021).

The nature of pollutants varies from physical, chemical, and biological parameters (Adelana, 2014; Costall et al., 2020). Chemical contamination of groundwater has been reported on global scales with serious health consequences. The World Health Organization (WHO) has recognized arsenic and fluoride as the most health-damaging inorganics in many countries including China, India, Bangladesh, and Asia (Abedin et al., 2002; Ravenscroft, 2007). Nitrate is a water quality parameter, but a contaminant with health effects when higher above the WHO permissible limit of 10 ppm (Ward et al., 2005; Palaniappan et al., 2010). Metals particularly potential toxic metals (PTM) such as Cd, Ni, Cr, and Pb have been reported in groundwater (Vaessen and Brentführer, 2014). Some studies have reported pharmaceuticals (antibiotics, tranquilizers, decongestants, antidepressants, and anti-inflammatories) in groundwater through the infiltration of waste wastewater into the aquifer in the United States of America are among emerging grounds (DeSimone, 2009).

Water researchers have extensively reported various methods and techniques employed in carrying out water quality evaluation in the last two decades. Laboratory investigation (chemical, physical and biological) form the crux that generate data which other techniques rest. Most of other techniques simply work further on these laboratory data generated, simplifying and reducing dimension ability of complex data, analyzing and bringing to fore the inherent trends and pattern within the complex data. The techniques include water quality index (Sirajudeen et al., 2013; Ochuko et al., 2014) application of models (Parkhurst and Appelo, 1999; Ejigu, 2021), geophysical and electrical resistivity methods (Adepelumi et al., 2008; Adegbola et al., 2012), mathematical modeling and simulation (Ziemińska-Stolarska, 2012; Kim et al., 2022) and multidimensional data statistical (Reza and Singh, 2010).

The water quality index (WQI) is an analytical technique that helps in reducing the dimensionalities of complex water quality data sets, describing the suitability of a water source(s) for a particular human need, increasing the understanding and awareness of the general public on water quality issues and improve the handling ability water policymakers (Nasirian, 2007; Ochuko et al., 2014). WQI was developed in 1965 by Horton in USA (Horton, 1965) and has undergone a series of modifications by individual water researchers and agencies (Brown et al., 1970; Dunnette, 1979; Bhargava et al., 1998; Khan et al., 2003; Chauhan and Singh, 2010). Various versions of water quality indices have been developed and modified out of need and improvement, including the National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI), Oregon Water Quality Index (OWQI), and Weighted Arithmetic Water Quality Index Method (WAQI).

The geophysical investigation aims to enable the identification of matter buried by nature or related to human activities and application of the law of physics to study the earth; this helps to differentiate the physical properties of the integrated medium. Geophysical methods include electrical resistivity, seismic reflection or refraction, induced polarization, etc. (Allred et al., 2008). The geophysical method especially electrical method is used to identify physical contrast of substances based on resistivity values, which are indirectly proportional to the conductivity of the groundwater. Most often, groundwater will have high resistivity values, but in a coastal region, low resistivity values are observed, indicating the presence of conductive substantives materials (Vengadesan and Lakshmanan.2019).

The dearth of reports on the use of the water quality index (WQI) technique in analyzing water quality has indeed contributed to low public understanding and awareness of water quality issue. The aim of this study is therefore, to carry out a physicochemical with Water Quality Index and geo electrical assessment of groundwater quality in Ojo community, Lagos State, Nigeria, so as to improve public awareness about of water quality issue and to enhance proper policies by relevant agencies on health and environment.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The study area is Ojo community, in Ojo Local government, Badagry division of Lagos State, Nigeria, between Latitude N6°27'00'' to N6°28'30'' and Longitude E 3°11'30'' to E 3°13'00'' as shown in Figure 1. Ojo community houses some major commercial centers like Alaba International market, the West Africa's largest electronic market.

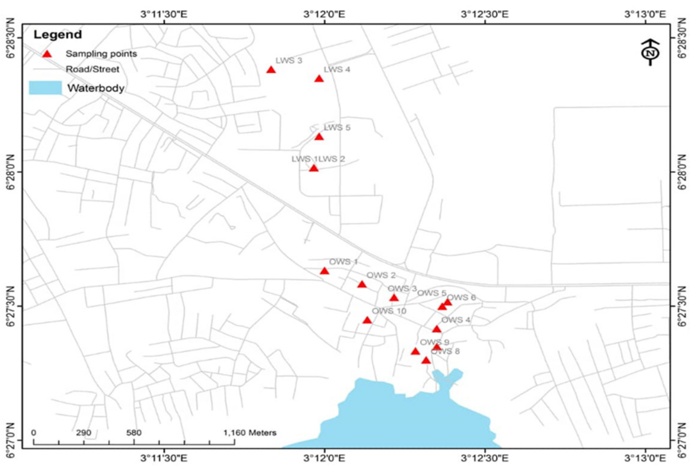

Figure 1: Map of the study area

2.2. Sample Collection and Preservation

Groundwater samples were obtained from fifteen (15) sample points (hand-dug wells), in the Ojo community, sample locations depicted with OWS 1 – OWS 15 as shown in Figure 1. Plastic bottles of sizes 1.5 L and 0.75 L, preserved with 1.5 mL of concentrated HNO_3, were used in collecting water samples for physicochemical parameters and metal analyses respectively. The collected samples were preserved at 4 °C in the lab.

2.3. Physicochemical Analyses

Physical parameters determined included temperature, pH, electrical conductivity (EC) and total dissolved solids (TDS) were measured with mercury in bulb thermometer (0–100 °C), pH meter (HANNA HI 98107), conductivity meter (Mettler Toledo) and total dissolved solids meter respectively. Alkalinity and acidity were determined titrimetrically while total hardness was by the complexometric method. Anions including chloride, sulphate, phosphate and nitrate were determined by titrimetry, turbidimetry, colorimetric and Ultraviolet spectrophotometric screening method respectively (Rice et al., 2012). Sodium ion (Na^{+}) and Potassium (K^+) were determined by flame photometry and other trace metals by atomic absorption spectrophotometry (Buck scientific 210VGP model).

2.4. Data Treatment and Statistical Analysis

Descriptive statistics of water quality data generated was carried out using software package SPSS 20. Correlation efficiency was performed employing Pearson correlation procedure. Exceedance, Ca /Cl, and Na/Cl ratio and sodium adsorption ratio (SAR) were also calculated. Water Quality Index was also worked out. The extents by which some of the water quality parameters exceeded WHO acceptable limits was expressed as exceedance level. It is a unitless concept, mathematically expressed as shown in Equation 1:

$$\text{Exceedance} = \frac{\text{Concentration of a quality parameter}}{\text{WHO acceptance limit}} \quad (1)$$

The sodium adsorption ratio (SAR) was expressed in Equation 2 (Subramani, 2005).

$$\text{SAR} = \frac{\text{Na}}{[(\text{Ca+ Mg}) / 2]1/2} \quad (2)$$

2.5. Water Quality Index

Weighted arithmetic water quality index (WQI) method was adopted in this study. It comprises of three mathematical steps:

i. Each of the parameters has been assigned a weight (Wi) according to its relative importance in the overall quality of water for drinking purpose. A maximum weight of 5 has been assigned to nitrate due to its major importance in water quality assessment.

ii. The relative weight (Wi) is calculated from the following equation

$$\text{Wi} = \frac{\text{wi}}{\sum_{i=1}^{n} \text{wi}} \quad (3)$$

where Wi is the relative weight, wi is the weight of each parameter and n is the number of parameters.

iii. A quality rating scale (qi) for each parameter is assigned by dividing its concentration of each water sample by its respective standard according to the guidelines

$$q_i = \frac{\text{Ci}}{\text{Si}} \times 100 \quad (4)$$

where qi, Ci, and Si indicated quality rating scale, concentration of i parameter, and standard value of i parameter, respectively. For calculating the WQI, the sub index (SI) is first calculated for each parameter, which is used to determine the WQI as per the following equations.

$$\text{SIi} = \text{Wi} \times \text{qi} \quad (5)$$

$$\text{WQI} = \sum_{i=1}^{n} \text{SIi} \quad (6)$$

2.6. Geophysical Data Acquisition and Processing

In this work, the field setup for VES, Schlumberger electrode configuration using PASI resistivity meter is shown in Figure 2. The readings were taken with the Schlumberger electrode array, and the current electrode separation (AB) was varied from a minimum of 2 to 240 m. The potential electrode separation (MN) varied from 0.5 to 4 m. Twenty (20) VES stations were acquired at different points, as shown in Figure 1.

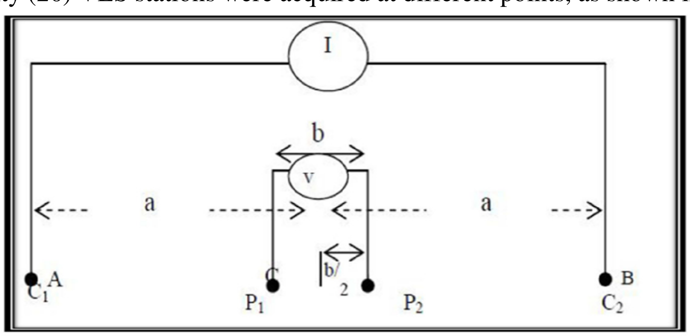

Figure 2: Schlumberger schematic diagram

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The VES curves were interpreted qualitatively and quantitatively using the partial curve matching technique (Mooney et al., 1966) and the interpreted VES data have provided information on geoelectrical parameters in terms of layered formations with their resistivity and thickness.

3. RESULTS AND DISCUSSION

3.1. Physicochemical Analysis

The results of laboratory analyses of physicochemical parameters and trace metals in groundwater from Ojo community is presented in Table 1 and correlation confidence is shown in Table 2. The pH values in the water analyzed ranged from 5.3 to 7.5 with an average value of 6.3. Over sixty percent (60%) of the water investigated were observed to be below the WHO allowable range of 6.5 - 8.5 for drinking purpose. The acidic level of the water probably indicates high CO_2 content reflecting high population in the study area (Edet, 1993; Wali et al., 2020). The water needs further treatment to be potable. High acidic pH in water has been linked to intestinal proliferation and acidosis (USGS 2008). The electrical conductivity (EC) is a quality parameter that indicates capacity of the medium (water being investigated) to allow passage of electrons through it, a reflection of presence dissolved minerals. The EC level observed has minimum of 212 µS/cm and maximum of 2940 µS/cm with mean of 1310 µS/cm. Thirty percent (30%) of the water samples investigated were above the WHO limit of 1400 µS/cm. EC is closely related to total dissolved solids (TDS), with moderate chemical interrelation as EC/TDS (r = 0.632) as well as in EC/TH (r = 0.591). EC also maintains a positive strong correlation with K^+ (r =0.727) and anions; Cl, NO_3 and SO_4 (r = 0.836, 0.610 and 791 respectively) as shown in Table 2. The TDS concentration observed in this study ranges from 117 to 1786 mg/L with the average value of 809 mg/L. TDS also maintains strong correlation withal the anions investigated. The mean value of total hardness in this study was 83.1 mg/ L while the minimum and maximum were 22 and 133 mg/L respectively. Water is classified into very soft, moderately soft, moderately hard and very hard (Aghazadeh and Mogaddam 2010). The entire water samples investigated in this study is made up of very soft (13 %), soft (27%), moderately hard (60 %), hard (0 %) based on the values of total hardness. The seemly hard nature of the water in the study requires some level of treatment to be potable.

Chloride, nitrate, phosphate and sulphate levels in the water analyzed ranged from 1.00 to 181.20, 6.68 to 40.00, 0.02 to 0.11, 25.00 to 251.00 mg/L respectively while the average values of Cl, NO_3, PO_4^{3-} and SO_4^{2-} are 62.00, 29.20, 0.04 and 120.00 mg/L respectively. The concentration of all anions investigated wert lower than the WHO allowable limits except that of nitrate and over 70% of the water analyzed are above the WHO maximum limit of 10 mg/L nitrate in potable water. This portends health risk. A number of health conditions have been linked to elevated levels above the permissible limits, including baby syndrome and even death. However, some studies have evolved, disputing the possible linkage between elevated level of nitrate and baby syndrome, methemoglobinemia (Fewtrell, 2004; van Grinsven et al., 2006). Some factors have been implicated in the emergence of baby syndrome (Ward et al., 2005).

The possible sources of nitrate include leachates from dumpsite, agricultural activities and urban runoff which characterize the communities in Lagos due to unplanned drain systems. Over 53% of the water sampled in this have chloride concentration pointing at possible salt water intrusion. This is according to Bimal and Harun, (2017) 40 mg/L of chloride could indicate movement of salt water from large water body underground. Correlation coefficient (Table 2) show correlation among the anions in this study reflecting possible sources of the pollution in the study area. Strong inter chemical association observed include SO_4^{2-}/ Cl (0.924) and SO_4^{2-}/ NO_3 (0.764).

Table 1: Concentration of physicochemical parameters and trace metals in the groundwater in Ojo community

Code	pH	Temp. (ºC)	EC (µS/cm)	Acid (mg/L)	Alkalinity (mg/L)	TH (mg/L)	TDS (mg/L)	Cl (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)	SO_4^{2} (mg/L)	Zn (mg/L)	Fe (mg/L)	Cu (mg/L)	Pb (mg/L)	Mg (mg/L)	Ca (mg/L)	Na (mg/L)	K (mg/L)
OWS 1	6.3	27.2	1037	52.6	43.4	60.6	615.0	43.6	43.2	0.04	168.0	0.16	0.00	0.02	0.00	1.14	9.95	43.40	19.20
OWS 2	6.5	27.1	1954	69.4	69.2	111.0	117.0	120.9	41.8	0.03	251.0	0.13	0.41	0.01	0.02	9.64	86.29	64.99	35.94
OWS 3	6.4	27.7	2460	60.6	56.0	133.0	1465.0	141.6	42.1	0.03	199.1	0.19	0.45	0.01	0.00	1.72	61.10	3.16	27.84
OWS 4	5.3	28.9	1324	66.0	12.6	82.6	799.0	58.9	43.8	0.04	116.0	0.27	4.01	0.01	0.175	13.02	180.3	32.89	21.00
OWS 5	6.9	29.0	503	60.6	50.6	48.0	300.0	12.0	10.4	0.03	31.4	0.20	4.34	0.03	0.11	9.31	130.8	7.83	5.760
OWS 6	6.6	30.1	909	72.0	74.0	81.4	551.0	33.6	9.32	0.04	92.9	0.17	0.00	0.06	0.00	1.11	11.67	19.75	12.96
OWS 7	5.9	29.8	212	96.6	32.0	118.6	1272	103.3	43.9	0.04	167.0	0.00	0.00	0.02	0.00	2.24	12.01	69.53	34.56
OWS 8	6.4	30.3	2940	81.4	59.4	125.4	1786	181.2	43.4	0.07	275.0	0.01	0.00	0.03	0.00	2.15	12.15	50.56	48.48
OWS 9	5.9	30.5	1453	46.0	24.0	70.0	868	70.3	44.0	0.04	101.0	0.16	0.00	0.01	0.00	1.56	11.32	53.72	22.56
OWS 10	6.3	31.5	1768	48.6	42.0	87.4	1605	102.3	43.6	0.11	146.0	0.08	0.00	0.00	0.00	1.31	12.29	55.30	20.16
OWS 11	7.5	32.6	850	55.4	98.0	109.4	511.0	8.6	26.3	0.03	44.9	0.22	0.11	0.00	0.03	5.35	40.01	12.31	9.18
OWS 12	6.7	31.6	554	42.6	59.4	70.6	327.0	9.60	8.43	0.04	25.0	0.23	0.52	0.01	0.09	5.07	45.29	9.795	4.56
OWS 13	6.6	30.0	791	60.6	67.4	95.4	481.0	33.3	9.85	0.05	82.9	0.05	0.81	0.00	0.00	0.82	4.68	11.06	3.84
OWS 14	6.5	31.5	691	24.6	20.0	22.0	173.9	1.0	21.2	0.05	63.5	0.03	0.52	0.00	0.00	0.28	12.14	6.32	1.44
OWS 15	5.9	31.8	323	62.0	21.4	30.0	201.0	12.6	6.68	0.05	27.8	0.10	0.00	0.00	0.00	0.43	8.46	7.11	1.92
Mean	6.3	30.0	1310	60.0	48.7	83.1	809	62.0	29.2	0.04	120	0.13	0.74	0.01	0.03	3.68	43.60	29.9	18.01
SD	0.7	1.7	0.8	17.0	24.0	34.0	53.0	56.0	16.0	0.02	80.0	0.09	1.72	0.02	0.05	3.97	52.30	24.10	14.17
CV%	11	5.7	61.1	26.5	49.2	40.5	85.5	90.0	54.8	50.00	66.7	70.00	190.20	125.00	191.00	107.00	122.00	80.50	78.70
Excedance	0.8		0.94			0.17	0.81	0.25	2.92	0.01	0.48	0.04	2.48		27.70	7.36		0.15	
WHO	6.5 – 8.5		1400			500	1000	250.00	10.00	5.00	400.00	3.00	0.30	1.50	0.01	0.50		200.00	

Table 2: Correlation coefficient of quality parameters in groundwater in Ojo community, Lagos

	pH	Temp	EC	Acid	Alkal	TH	TDS	Cl	NO_3^-	PO_4^{3-}	SO_4^{2-}	Zn	Fe	Cu	Pb	Mg	Ca	Na	K
pH	1																		
Temp	.246	1																	
EC	-.074	-.350	1																
Acid	-.224	-.315	.136	1															
Alkal	.834**	.028	.166	.163	1														
TH	.101	-.286	.591*	.616*	.510	1													
TDS	-.257	-.050	.632*	.389	-.059	.627*	1												
Cl	-.276	-.420	.836**	.531*	.036	.748**	.783**	1											
NO_3^-	-.419	-.429	.619*	.243	-.224	.522*	.646**	.737**	1										
PO_4^{3-}	-.165	.374	.286	-.110	-.189	-.014	.531*	.288	.191	1									
SO_4^{2-}	-.232	-.593*	.791**	.491	.082	.675**	.601*	.924**	.764**	.182	1								
Zn	.099	-.158	-.062	-.234	.161	-.069	-.296	-.339	-.106	-.478	-.349	1							
Fe	-.147	-.258	-.155	.012	-.238	-.217	-.214	-.234	-.133	-.261	-.266	.475	1						
Cu	.062	-.283	.063	.469	.228	.118	.112	.133	-.110	-.182	.180	.077	.085	1					
Pb	-.176	-.099	-.171	-.029	-.181	-.147	-.228	-.269	-.099	-.268	-.307	.669**	.867**	.016	1				
Mg	-.076	-.325	.035	.163	.027	.108	-.246	-.020	.122	-.366	.012	.591*	.764**	.018	.857**	1			
Ca	-.181	-.393	.066	.091	-.127	.032	-.169	-.026	.102	-.366	-.035	.640**	.882**	.028	.889**	.935**	1		
Na	-.401	-.288	.318	.451	-.161	.391	.431	.612*	.745**	.297	.669**	-.349	-.253	.104	-.195	.081	-.101	1	
K	-.294	-.459	.727**	.624*	.035	.727**	.686**	.936**	.801**	.130	.929**	-.276	-.202	.254	-.180	.110	.034	.756**	1

It’s worth noting that only K and Na among trace metals investigated maintained correlations with chloride, nitrate, and sulfate pointing at possible common source (s) of these possible salts (KNO_3, KCl, $NaNO_3$, and NaCl). Of the eight trace metals investigated (Zn, Ca Na, K, Mg, Cu, Fe, and Pb), only Fe, Mg and Pb show concentrations above the WHO allowable limits in potable water. High levels of iron and lead can initiate several health conditions including death (Lieu et al., 2001). Most of these metals are observed to interrelate as shown in Table 2; Zn/Pb (0.669), Zn/Ca (0.640), Fe/Pb (0.867), Fe/Ca (0.882)), Fe/Mg (0.764)), Ca/Mg (0.937) and Na/K(0.756). This trend shows ecological importance. The Na/Cl and Ca/Cl ratio concepts calculated are shown in Table 3. The ratio concepts have a long history, indicating levels of salt water intrusion in coastal area.

Table 3: The Na/Cl, Ca/Cl and SAR ratio of groundwater in Ojo community, Lagos

Code	Na/Cl	Ca/Cl	SAR
OWS1	1.01	0.23	17.2
OWS2	0.54	0.72	9.37
OWS3	0.02	0.43	0.56
OWS4	0.56	3.06	3.35
OWS5	0.65	11.57	0.94
OWS6	0.586	0.002	7.82
OWS7	6.75	0.0002	26.1
OWS8	0.279	0.0002	18.66
OWS9	0.76	0.0001	21.32
OWS10	0.542	0	21.27
OWS11	1.43	0	2.59
OWS12	1.02	0.001	1.95
OWS13	0.33	0	6.70
OWS14	6.32	0	2.54
OWS15	0.56	0	3.39

Table 4: Classification of groundwater for irrigation based on SAR

Classification	Range
Excellent	< 10
Good	10 – 18
Doubtful	18 – 26
Unsuitable	>26

Table 5: Water quality index of groundwater in Ojo community, Lagos

Code	pH	EC	TH	TDS	Cl	NO_3^-	Ca	Mg	Na	K	WQI
OWS 1	6.3	1037	60.6	615.	43.59	43.2	9.95	1.14	43.4	19.20	121.7
OWS 2	6.5	1954	111	117	120.9	41.8	86.29	9.64	64.9	35.94	247.6
OWS 3	6.4	2460	133	1465	141.6	42.1	61.10	1.72	3.16	27.84	161.1
OWS 4	5.3	1324	82.6	799.	58.9	43.8	180.3	13.02	32.89	21.00	301.2
OWS 5	6.9	503	48.0	300.	12.0	10.4	130.8	9.31	7.83	5.760	176.3
OWS 6	6.6	909	81.4	551	33.6	9.32	11.67	1.11	19.75	12.96	62.6
OWS 7	5.9	212.	118.6	1272	103.3	43.9	12.01	2.24	69.53	34.56	142.6
OWS 8	6.4	2940	125.4	1786	181.2	43.4	12.15	2.15	50.56	48.48	177.2
OWS 9	5.9	1453	70.0	868.	70.3	44.0	11.32	1.56	53.72	22.56	137.1
OWS 10	6.3	1768	87.4	1605	102.3	43.6	12.29	1.31	55.30	20.16	148.1
OWS 11	7.5	850	109.4	511.0	8.60	26.3	40.01	5.35	12.31	9.18	149.6
OWS 12	6.7	554	70.60	327.0	9.60	8.43	45.29	5.07	9.795	4.56	109.2
OWS 13	6.6	791	95.40	481.0	33.29	9.85	4.68	0.82	11.06	3.84	56.5
OWS 14	6.5	691	22.00	173.9	1.00	21.2	12.14	0.28	6.32	1.44	61.0
OWS 15	5.9	323	30.00	201.0	12.60	6.68	8.46	0.43	7.110	1.92	34.8
w_i	4	4	2	4	3	5	2	2	2	2	
W_i	0.133	0.133	0.067	0.133	0.10	0.166	0.067	0.067	0.067	0.067	
WHO	7.5	1400	500	1000	250	10	75	0.5	200	200	

Table 6: Water quality classification based on WQI value

WQI	Classification
1< 50	Excellent
50 - 100	Good
100- 200	Poor
200 - 300	Very poor

Over 66.7% and 86.7% of water samples investigated showed Na/Cl and Ca/Cl ratios respectively that are below sea water (0.86) indicative of salt- water intrusion (Singh, 2014). The SAR calculated from the

groundwater data is shown in Table 3 and grading of water based on SAR is shown in Table 4. The SAR helps in establishing the grades of water for irrigation purpose. About 67% of the water samples investigated are in excellent condition for irrigation purpose, 6.7% are in good conditions and 20% in doubtful and 6.7% of the water samples analyzed are not suitable for irrigation for health reason. The Water quality index (WQI) of groundwater in Ojo community investigated is shown on Table 5 and classified based on Water Quality Classification or WQI grading system shown on Table 6 (Nazir et al., 2016). A 6.6% of the water samples analyzed had an excellent WQI values, 20 % with good WQI and 73.3% with poor grade.

3.3. Generation of Geoelectric Sections

The study has shown the depth and directional behavior of resistivity variations of the subsurface vertically and laterally, pseudo sections were generated by combining multiple VES. From the pseudo section, low resistivity and high resistivity zones were interpreted. A total of four geoelectric sections were obtained (Figure 3), which are a combination of 20 VES obtained which revealed different layers with maximum depth at 80 m. Based on the geoelectric data obtained using VES, the subsurface layers are indicative of topsoil, saturated clay, clay, sand, clayey sand, and sandy clay with resistivity and thickness as shown in Table 7. Aquifer units are present in VES 3,9,16 and 20 and the depth to aquifer from the VES results in VES 3,9,16, and 20 are 49.1 m, 48.5 m, 28.1 m, and 22 m.

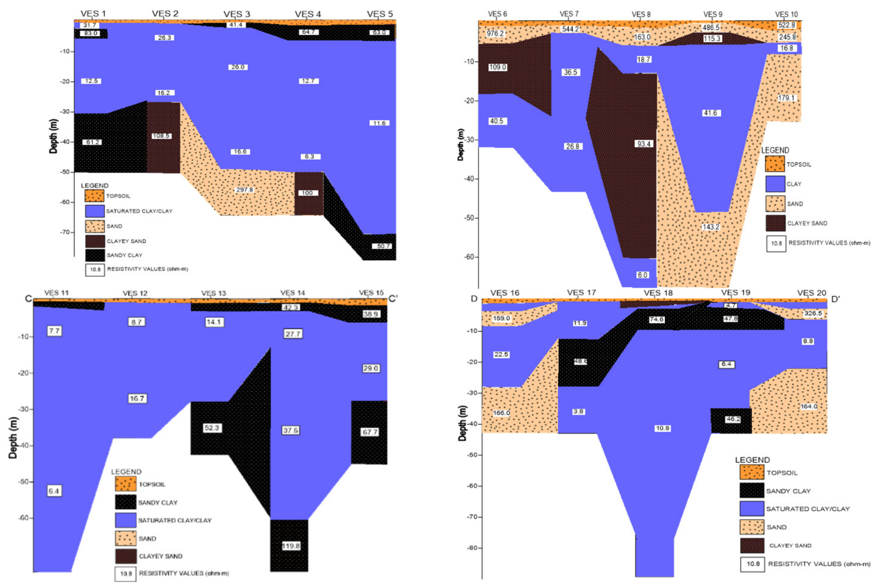

Figure 3: Typical geoelectric sections

Table 7: Summary of geoelectric results

Lithologic unit	Resistivity range (Ωm)	Thickness range (m)
Topsoil	30.9-784.8	0.2-1.8
Sandy Clay	41.4-108.5	1.8-83.2
Saturated Clay	1.5-11.9	1.3-77.1
Clayey sand	83.0-119.8	1.5-60.2
Sand	143.2-976.2	2.5-8.4

4. CONCLUSION

The quality status of groundwater, the main source of water supply in Ojo community in Ojo, Badagry division of Lagos State was investigated through physicochemical and geoelectrical methods. Water quality index was employed to further analyze the laboratory data generated. Acidic and moderately hard water was revealed, which portend a level of health risk, thereby requiring some treatment to make the water potable. The concentration of nitrate and lead was observed higher than the WHO permissible limits, thus raising questions about health safety in the water under investigation. The exceedance results show Pb > Mg > NO3- > Fe, while the 66.7% and 86.7% of water samples investigated showed Na/Cl and Ca/Cl ratios respectively indicating possible salt intrusion. About 93 % of the water samples investigated are suitable for irrigation purposes while only 6.7 % of the water samples analyzed are not suitable for irrigation for health reasons. Water quality index was calculated to show the suitability of water under investigation for drinking purposes. WQI shows grades of excellent (6.7%), Good (20 %). Poor (60%) and very poor (13.7 %). This indicates strongly the water samples need some form of treatment before it is considered safe to drink. The geoelectrical method reveals the potential aquifer zones and the probable depth to aquifer has been observed from the VES results in VES 3,9,16, and 20 to be averagely 36.9 m.

5. ACKNOWLEDGMENT

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6. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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