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Integrated Geoelectric and Hydrochemical Methods to Evaluate Groundwater Pollution in Azikoro, Yenagoa, Bayelsa State, Nigeria

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Abstract

This paper presents an investigation on the contamination potential of ground water using integrated geoelectric and hydro chemical methods within Azikoro, Yenagoa, Bayelsa state, Nigeria. The SAS 1000 ABEM Terameter was used to acquire the field data and IPI2win was used to obtain three geoelectric layers result for the 1D VES point; with depth of 0 m, 0.91m and 2.03m and thickness of 0.91m, 0.12m respectively with corresponding resistivity of 0.027 m and 0.00079 m, to show the subsurface lithology and water bearing level. RES2DINV was used to interpret the data for the 2D imaging, with results indicating contamination spread in profile 1 and 2 at depth of 6.94m and 9.94m respectively. Water samples from two boreholes, near and after the vicinity of the cemetery were analyzed for electrical conductivity (EC), pH, total dissolved solids (TDS), phosphorous, nitrates, chemical oxygen demand (COD), potassium, sodium, sulfate and chloride. From the result obtained conductivity is very high due to low resistivity. The water sample results were compared with World Health Organization (W.H.O) permissible limit standard which indicated that the water is safe for consumption within the period of investigation.

Keywords: Geoelectric; Hydrochemical; Resistivity; Groundwater; Contamination; Cemetery.

I. Introduction

Groundwater Pollution also known as groundwater contamination occurs when pollutants are released to the ground and make their way into the groundwater. It can also happen naturally due to minor or unwanted constituents or impurities in the groundwater. Groundwater contamination occurs when products, such as oil, road salts and chemicals get into the groundwater and cause it to become unsafe for human.

In cities, asides domestic uses, groundwater is used to water crops in garden and small farms around the home and a major source of water for fish farmers. The quality of water is described by its physical, chemical and biological contents [1]. The effects of water contamination may be aesthetic (with respect to colour, taste and odour), cosmetic (causing skin or tooth discoloration) or technical (causing damage to water equipment or hampering treatment for other contaminants.

Portable water is usually supplied via bore holes and hand-dug wells, to meet domestic needs. Land-use practices have been found to impact underground water quality [2]. Water contamination is also known to be induced by leakages from septic tanks, Cemeteries and underground storage systems or waste disposal sites [3]. Cemeteries are considered a major threat to groundwater quality because of the perceived microbial activities that occurs with decaying corpses [4].

Reference [5] suggested that wells and springs used for drinking water should be situated at least 30 m from cemetery areas, while [6] proposed that higher burial depth of human corpses can increase the adverse effects of cemeteries on groundwater quality. Therefore, the depth of sampling wells is an important factor in the survey of the effects of cemeteries on groundwater contamination. This research is aimed at investigating the contamination potential of a cemetery to groundwater using geoelectric and hydro-chemical techniques in parts of Azikoro, Yenagoa, Bayelsa state, Nigeria.

A. Study Area

The study area (see Fig. 1) which lies between 4^0 54' 7" N, 6^0 17' 20" E and 4° 45' 29" N, 6° 17' 23" E, is located at Azikoro, Yenagoa, Bayelsa state, Nigeria.

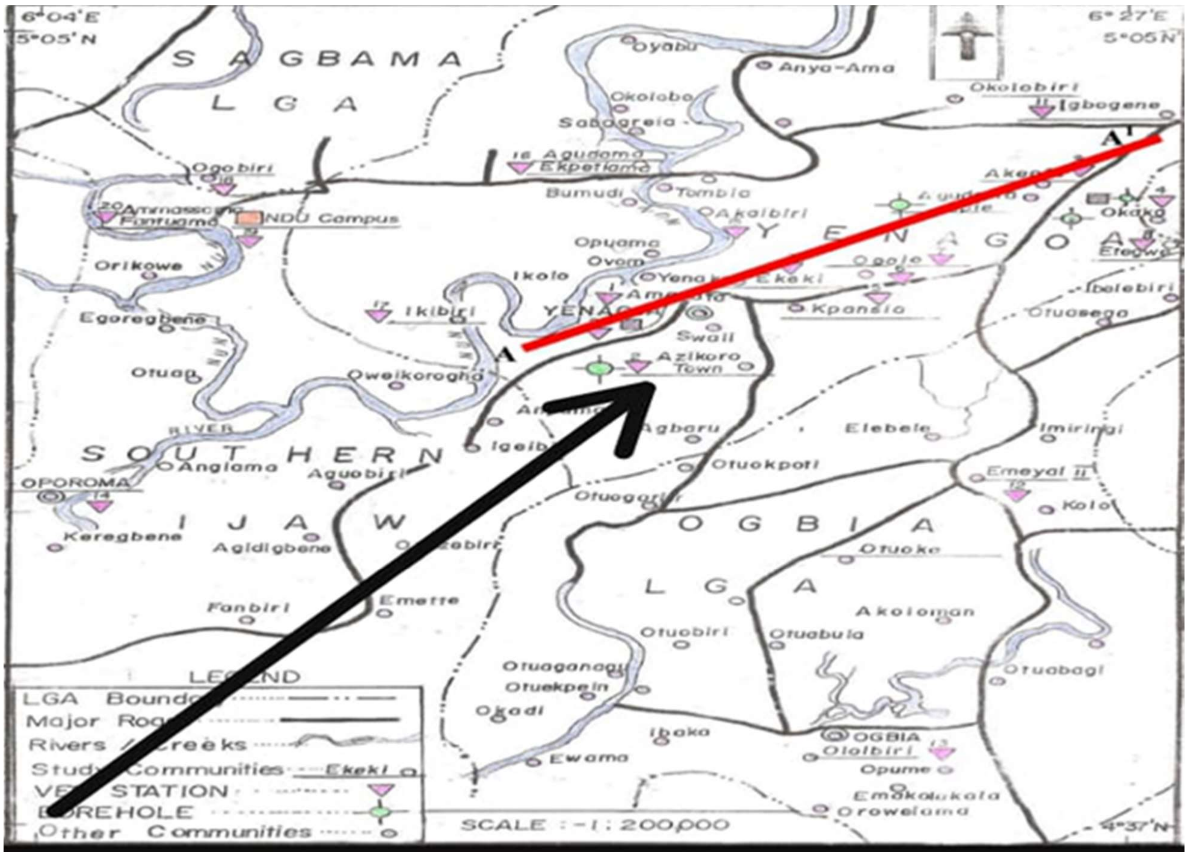

Fig. 1 Map of the Study area [7]

II. MATERIALS AND METHODS

A. Materials

Materials used in this research include the ABEM SAS 1000 Terrameter, five steel electrodes (current and potentials); rechargeable (DC) battery source, measuring tapes, cables, Hammer, Global Positioning System (GPS), and Recording sheets.

B. Methods

1) Geo-electrical resistivity survey

The geoelectric survey was obtained by employing the Schlumberger and Wenner electrode configuration using the materials stated in A. At each location, the respective coordinates and elevations were measured using the hand-held GPS.

As the current electrodes are expanded, it penetrates deeper and at a stage the signals on the Terrameter becomes weak. The current electrode spread ranged from the minimum spacing of 200 to 400 m maximum spacing. The result from the VES soundings obtained was used to compute the apparent resistivity. The apparent resistivity values were arranged in an excel spreadsheet environment and later loaded into IP12WIN® resistivity analysis software to generate the desired results of number of layers, depth and layer thickness at each sounding location.

2) 2-D resistivity method

Wenner array was used to determine the distribution of apparent resistivity horizontally and vertically. The resistivity meter used in this survey, typically has four electrodes connected via four separate cables, a multi-electrode system that has 25 or more electrodes connected to the resistivity meter via a multi-core cable. According to [8] the 2-dimensional measurement data provides a subsurface view into several squares that have resistivity value according to the measurement results. The model used for inversion consists of cell unit which size depends on the distance of the installed electrode that is set manually.

3) Hydro chemical analysis

Sample tubes (100 ml sterilized polyethylene bottles) were used to collect water samples from two boreholes, located at After Cemetery (AC) and Near Cemetery (NC). Physical parameters such as temperature, pH, color, electrical conductivities were tested. The Hydro chemical parameters analyzed are pH, Color, Conductivity, Dissolved Oxygen (DO), Total Dissolved Solids (TDS) Alkalinity, Hardness, Chloride, Ammonium-N, Phosphate, Sulphate, Turbidity, Nitrites and Nitrates (see Table I). The pH was determined using a Mettler Toledo (GmbH 8603 Schwerzenbach) pH meter by direct measurement, an analogue mercury thermometer was used in taking temperature measurements, a Hach 2100A turbid meter was used to determine the turbidity of the samples, while chemical method was used to analysis the hydrochemical elements.

III. RESULTS AND DISCUSSION

Table I presents the results of the physical parameters (temperature, pH, color, electrical conductivities) that were tested and the hydro chemical parameters (pH, Color, Conductivity, Dissolved Oxygen (DO), Total Dissolved Solids (TDS) Alkalinity, Hardness, Chloride, Ammonium-N, Phosphate, Sulphate, Turbidity, Nitrites and Nitrates) that were analyzed.

Table I. Water Sample Analysis Result.

Parameters	Units	After Cemetery	Near Cemetery	WHO Limits
pH	-	6.1	6.3	6.5 -9.5
Colour	Pt.Co	1	3	10
Conductivity	μS/cm	57	83	2.1
T.D.S	mg/l	30.21	43.99	300-900
Suspended Solid	mg/l	1	0	1000
Turbidity	NTU	1	2	5
Hardness	mg/l	28	36	270
Chloride	mg/l	21.18	21.18	250
Dissolved Oxygen	mg/l	4.1	4.8	250
Sulphate	mg/l	6	19	250-500
Nitrite	mg/l	0.013	0.016	3
Nitrate	mg/l	2.11	1.5	50
Ammonium-N	mg/l	0.236	0.317	1.5
Phosphate	mg/l	0.078	0.064	5.0

A. Geoelectric Survey

The VES data was processed with IP2WIN and interpretation shows a three-layer K-type model ($p1 < p2 > p3$) with resistivity of $0.0275\ \Omega m$ as the first layer and thickness of $0.9\ m$, to be likely Sulfide present (see Fig. 2). The second layer has a resistivity of $0.00079\ \Omega m$ with a depth of $0.91\ m$ and thickness of $0.12\ m$ with subsurface to be likely Sulfide present too. The third layer has a resistivity of $0.0896\ \Omega m$ with a depth of $2.03\ m$, at an infinite thickness of the study location. For the 2D imaging survey, Sulfides contaminant was likely suspected at profile 1 from the low resistivity value of $0.173\ \Omega m$, lateral intrusion of different leachating points at depth of $6.94\ m$ as shown in Fig.3. While profile 2 has resistivity value of $0.173\ \Omega m$ with likely different sulfides intrusion points at depth of $9.94\ m$ as shown in Fig. 4.

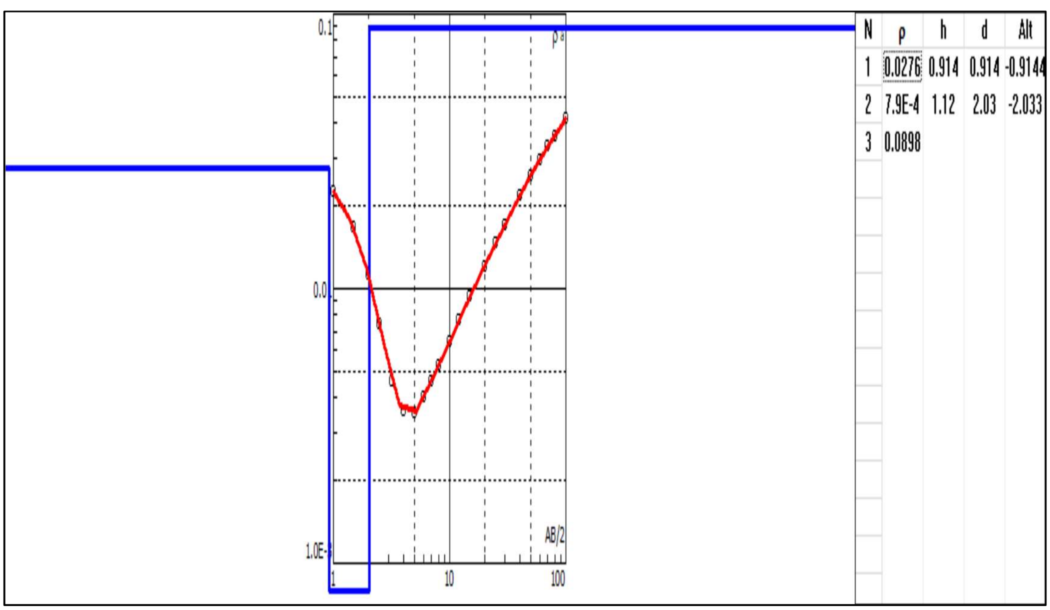

Fig. 2 VES point

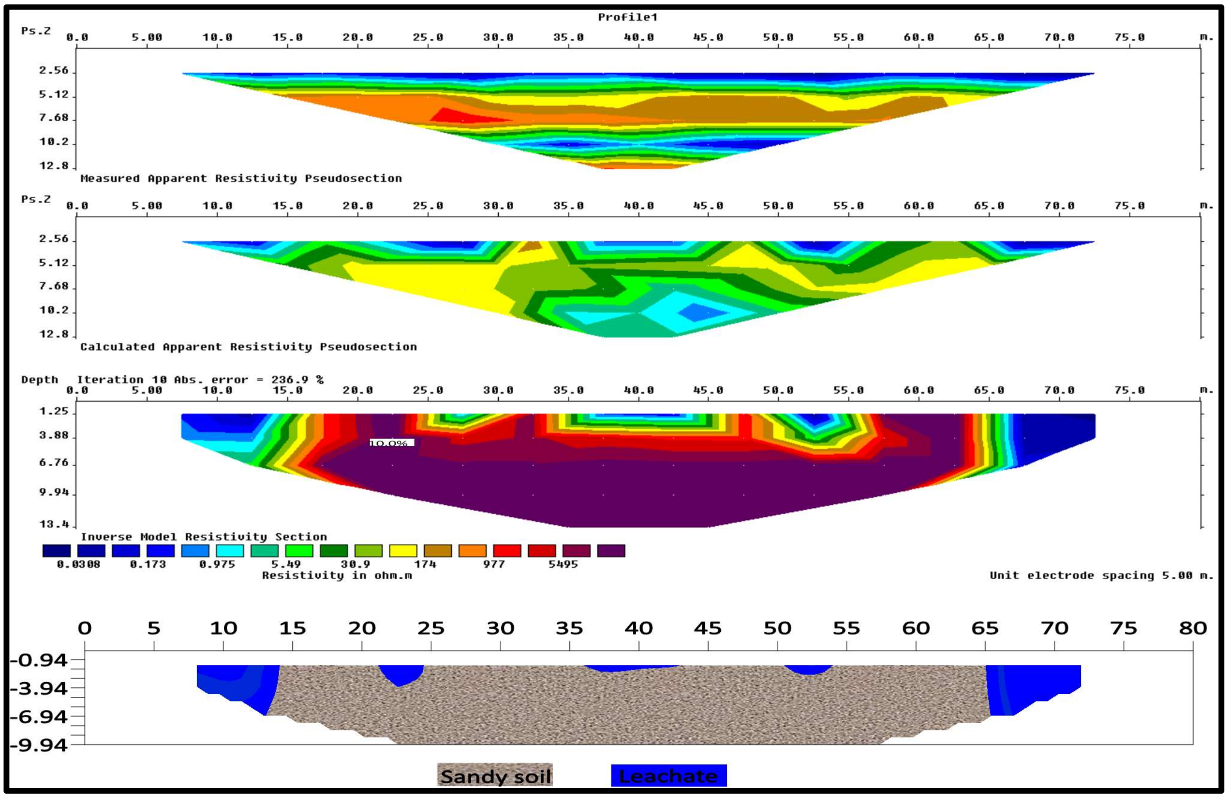

Fig. 3 Geoelectric model of profile 1

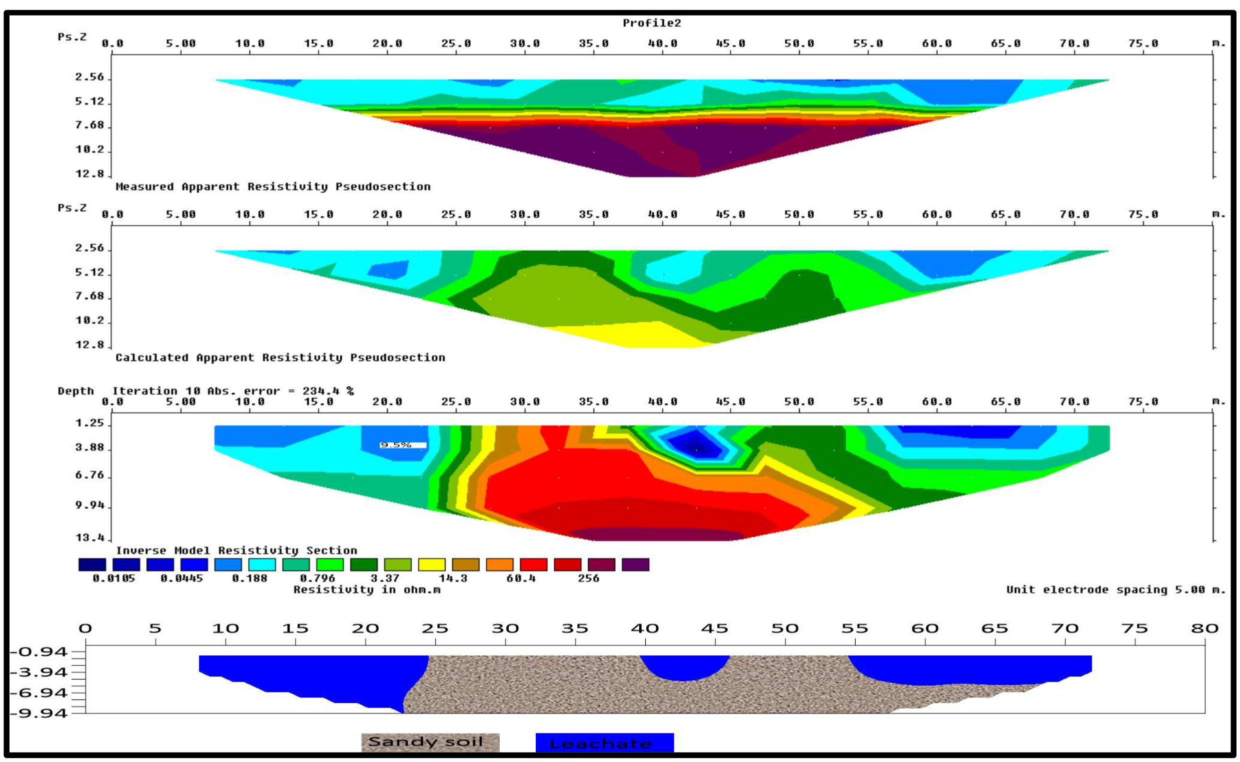

Fig. 4. Geoelectric model of profile 2

IV. CONCLUSION

An integrated geoelectric and hydrochemical method was used to evaluate groundwater pollution in Azikoro, Yenagoa, Bayelsa state, Nigeria, using 1 D vertical electrical sounding (VES) method. The results obtained shows groundwater at shallow depth of 2 m down the subsurface will be affected by the likely inferred sulfide present from the resistivity. The 2D imaging survey indicates lateral changes along profile lines from the resistivity values and inhomogeneity of the study area, which indicates likely contamination spread at maximum depth of 6.94 m and 9.94 m as indicated in Fig. 3 and 4 respectively. Furthermore, water samples were analyzed to ascertain the concentration level of some organic and inorganic materials, so as to establish its level of harmfulness to persons and animals living within the vicinity of the study area. The results obtained indicates that the water samples collected were safe for consumption during the period of this study when compared with W.H.O permissible standard limit. However, it is recommended that a geophysical time lapse migration of the study area be carry out, to assess the level of contamination intrusion of the sub-soil formation for futuristic precaution.

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