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Application of 2D Geo-Electric Imaging and Geochemical Methods to Investigate Subsurface Contamination in Yenagoa Environs, Niger Delta, Nigeria

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Abstract: **Integrated geophysical and geochemical investigation was helpful in mapping areas of contamination in subsurface formation. Electrical resistivity surveys were carried out at a site of shallow hydrocarbon contamination and were correlated with geochemical analysis in Ikarama, aimed at investigation contamination plume of the subsoil. Thus, three (3) Electrical profiling were carried out using ABEM SAS 1000 terrameter, and six (6) subsoil samples were collected from the study area; which was analyzed using the Atomic Absorption Spectroscope (AAS) and UV Spectrophotometer and the analyzed result was compared with the World Health Organization Standard. The result revealed high contamination content of lead (Pb) at profile 1, 18 mg/l and profile 2, 8.1302 mg/l, while Mn was 6.6611mg/l and 7.7778mg/l at profile 1 and profile 2 respectively. While for the TPH, we have high (404 mg/l) and (124 mg/l) contamination concentration at profile 1 and profile 2 respectively; both at the unsafe zone and low (25.8mg/l) at profile 3, known as the control zone. The very high contamination concentration values for all subsoil samples which exceeded the WHO permissible standard indicates that aquifer may likely be polluted by intrusion. It is advisable to carry out proper water treatment from source and soil degradation, for potable drinking water and cultivation of agricultural product respectively for social economic development.**

Keywords: **Contamination, Concentration, Resistivity, Groundwater.**

1. INTRODUCTION

Water is essential part of human and plant existence on earth. Groundwater resources and soil are increasingly being contaminated due to man's exploitation of energy resources, especially fossil fuels with the consequent slick and spill of oil, in addition to gas flaring which are being released to the environment. Soil and groundwater are susceptible to contamination wherever exploitation of oil/gas is carried out (Bunonyo et al, 2020). A water bearing contaminant is any substance that makes the water unclean or unsafe for use for a particular purpose when it reaches an aquifer. Hydrocarbon contaminants constitute serious problems wherever exploration and exploitation activities are carried out (Ekoriko et al, 1995). Sources of contaminants include field brines and oil spillage, Oil and gas production is usually accompanied by substantial discharge of wastewater in the form of brines; constituents of brines include sodium, calcium, ammonia, boron, trace metals, and high total dissolved solids (TDS). Oil spillage is a result of leakages of hydrocarbon from the pipes, and to an extent, poor maintenance of oil pipelines. Geophysical methods have been shown to be useful to the study of contaminated zones. These methods are based on the contrasts in several physical properties that typically make up the different constituents of the affected zone. In general, hydrocarbons have much lower electrical conductivity than water. This fact makes the resistivity method especially suitable for hydrocarbon contamination delineation (Reynold, J 1998; Fetter, C.W, 1993). Release of hydrocarbons into the environment whether accidentally or due to human activities is a main cause of water and soil pollution (Holliger et al., 1997). These hydrocarbon pollutants usually caused disruptions of natural equilibrium between the living species and their natural environment. The objectives of this study are to: determine the electrical resistivity images of the soil for possible hydrocarbon contaminant and investigate the geochemical parameters concentration present in the water and soil of the study area.

2. MATERIALS AND METHODS

The study area: The study location, Yenagoa is in the Niger Delta. It lies between latitude 4^0 55' 29" N and longitude 6^0 15' 51" E. The community host a manifold and oil pipelines crisscrossing residential areas, owned by one of the oil and gas companies operating in the country. River Niger is the major drainage system from which other discrete river systems originate. The region has a humid equatorial climate; the cloud cover is high, with relative humidity and average rainfall above 80% and 3000 mm (Omo-Irabor and Oduyemi, 2006).

Data Analysis: Sampling procedure involves water samples from the surface water and sub- soil at different depths from the bottom of the spilled and non spilled location. In order to determine the Total Petroleum hydrocarbon (TPH); UV Spectrophotometer was used to analysis it's sample to ascertain it concentration, and for the trace heavy metal in soil; samples were prepared using aqua regia to digest the soil samples, Atomic Absorption Spectrophotometer (AAS) was used to analyse the samples, which in turn ascertain it concentrations. ABEM SAS terrameter was used for the geo-electrical imaging with 5 m minimum electrode spacing, each covered a lateral distance of 120 m. Wenner arrays was chosen for acquiring the field data; because it is relatively sensitive to vertical changes of resistivity below the centre of the array. Res2Dinv software was applied to iterate the acquired data. Analysis measurements were carried out for the surface water and sub-soil samples collected, which was used for the determination of the pollution concentration level.

3. RESULTS AND DISCUSSION

The TPH (Total Petroleum Hydrocarbon) concentration where high in the oil spilled zone at profile 1 and 2, when compared with the unaffected oil spilled zone at profile 3 which serves as control zone as shown in table 1. The heavy metal concentration for profile 1 was very high in Pb and Mn while Cr, Ni and Fe were slightly higher when compared with the WHO permissible limits. At profile 2, the concentration were very high in Pb and Mn but slightly higher for Cr and lastly at profile 3, which is the control zone where spilled did not occur; all metal concentration were very low when compared with the WHO standard limit. The results of the geophysical analysis from the study area infered that, profile 1 is contaminated with anomaly Hydrocarbon Plume (HP), and purple colour with resistivity ranges (411-1365 Ω-m) located between the depths of 2.50 and 7.75m and laterally between 50 and 70m marks as shown in figure 2. From the lithology log, it seems to be located within the silty fine sand and clayey sand layers (up to 7.75m). At figure 3 of profile 2, shows two anomalies (HP1 and HP2) of purple colour (261Ω-m) are displayed. Both are located between the depths 3.88 and 12m and HP1 is laterally located between 50 .0and 62.5 m marks and the HP2 is laterally between 80.0 and 90.0m marks .These anomalies appears to be located within the silty fine sand and clayey sand (up to 10m). While figure 4,where contamination concentration was very low, which serves as the control zone, indicates maximum resistivity, the purple colour shade is 240 Ω-m, less than maximum resistivity (250 Ω-m) likely infer for silty fine sand and maximum resistivity (500 Ω-m) likely infer for clayey sand.

Table.1: showing soil-sample of TPH concentration

SN	SUB-SOIL PROFILES	TOTAL PETROLEUM HYDROCARBON (TPH) (mg/kg)
1	P 1	404
2	P 2	124
5	P3 (safe zone)	25.8
6	DPR	50

Table.2: Showing traces metals concentration

Soil Profile (mg/l)	Pb(mg/l)	Cd(mg/l)	Cr(mg/l)	Mn(mg/l)	Ni(mg/l)	Fe(mg/l)
P 1	18.000	0.1162	0.2849	6.6611	0.6121	0.6121
P 2	8.1302	0.1129	0.2386	7.7778	-0.2918	-0.2918
P 3	- 0.0237	0.1174	-0.1315	0.1697	-0.5255	-.0.3926
WHO	0.01	5.0	0.05	0.1	0.02	0.3

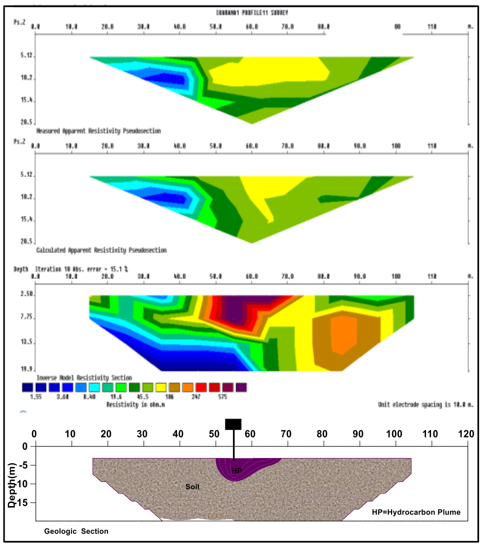

fig.1: Geoelectric model of profile 1

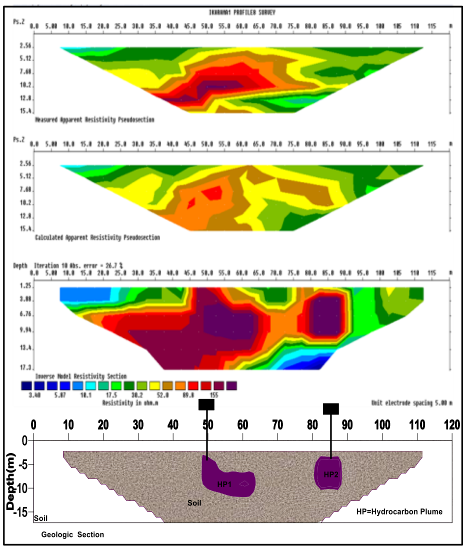

Fig.2: geoelectric model of profile 2

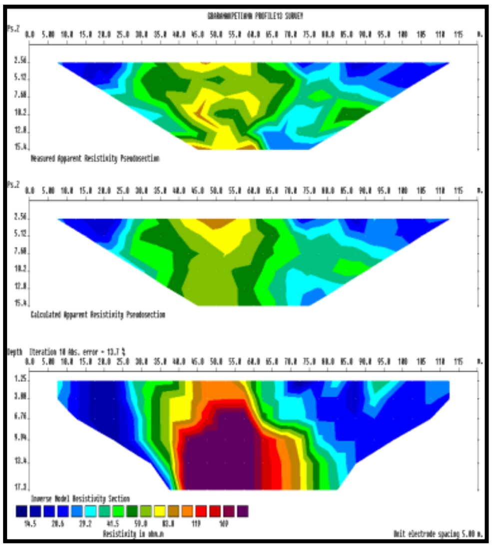

fig.3: Geoelectric model of profile 3

4. CONCLUTION

ERT geophysical method is essentially conveniently helpful in providing high-quality information of subsurface geological framework. From the interpretation of ERT, 3 profile locations were delineated with profile 1 and 2 zone suspected to be polluted zone and profile 3 to be unpolluted zone which serves as control zone. The lithological interpretation by the 2D imaging revealed prominent groundwater pathways and AAS was used to analyse the sample collected to confirm the concentration of heavy mental contamination on the groundwater bearing. Quantitative interpretation of geoelectric profiling at the oil spill site has successfully helped to outline some contaminant plume produced by the oil spillage from faulty oil pipelines. The geophysical methods show promise for application at sites of hydrocarbon contamination to help identify the extent of contamination and was confirmed by carrying out geochemical analysis of the soil samples in the likely contaminated zone which could contaminate the water bearing formation. This calls for an effective mitigation measures on spilled site. Based on the interpretation of the data and field results obtained, the following recommendations should be noted;

I. Drilling of boreholes in the safe zone is advisable.

II. After remediation process, it would also advisable to carry out another geophysical survey and carry out soil and water analysis.

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