Geophysical Characterisation of Crude Oil Spill Contamination on Subsurface Formation in Egbebiri, Biseni Environ, Nigeria

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Abstract

Geophysical method was used to study the subsurface properties formation of hydrocarbon contamination on a recent spilled and clean-up site. Electric technique was adopted, using Schlumberger with maximum current electrode spread of 200 m and Wenner array spread of 120 m laterally to determine the resistivity of the subsurface. A total of four data was collected; one Schlumberger to infer the lithology, while three Wenner to obtain the profile lateral changes. The IPI2WIN and RES2DINV software were used to interpret the field data. The result obtained showed that, the 1D data have resistivity values of 0.00045Ωm, 0.0032 Ωm and 0.829 Ωm at thicknesses 0.5m, 0.5m and 15.1m respectively, which implies that all three layers are top soil. For the 2D case, profile1 indicate that plume is spread downward from about 75m mark and laterally between 65 m and 85 m mark, while profile 2 serves as control, indicate absent of plume due to the direction of flow because of the elevation point. Geochemical analysis result was carried out in the laboratory, using the UV spectrometer, indicates high Total Hydrocarbon Content (THC) concentration of soil at 87.5 for mg/kg for S1, 205mg/kg for S2 and 85mg/kg for S3 when compared with the WHO permissible standard of 30mg/kg for soil, which confirm the hydrocarbon plume from the geophysical model. The result obtained will help to give a guide line direction, the best remediation technique to carry out clean-up on the surface/subsurface soil contamination with crude oil spill.

Keywords : Subsurface, Hydrocarbon, Contamination, Plume

INTRODUCTION

In order to properly characterize and give an effective delineation of a given subsurface location affected by crude oil spill, certain geophysical methods could be applied; one of such is the geoelectric method. Subsurface formation is the materials that are beneath the land surface. Examples are ground water, rock structures, soil etc. Contamination by petroleum hydrocarbon occurs through leaks and spills due to corrosion and sabotage of oil and gas facilities. These have remained the dominant point sources of oil and ground water contaminations in the area. When oil spill occurs, the ecosystem, plant, soil, and ground water systems are contaminated and options available for their use becomes limited. The major impact of hydrocarbon plume on the subsurface formation includes environmental degradation, Human health hazards, economic hardship, and social dislocation. The problem of oil spillage (plume) is as long as the discovery of oil; it is a universal problem that affects the economy, health, and the environment at large. The department of Petroleum Resources estimated 1.89 Million barrels of Petroleum spillage in the Southern part of

Nigeria, the Niger Delta Region from, 1976 -1996 out of a total of 2.4 million barrels that were spilled in 4535 incidents. The number of oil spillage has continued to increase all over the world although awareness, curbing and cleanup methods have also been made (Amnesty 2018). Investigation using geoelectrical method have demonstrated the efficiency in the assessment of oil contamination both in the sub-soil and the ground water by oil spill in Niger Delta region, Bunonyo (2020). This study is necessary at the time considering the increasing environmental deterioration in the Niger delta region and presently the increase of migration of people from the rural areas to urban areas, aimed at delineating contamination plume in the subsurface formation in order to proffer guidelines for environmental resource in the study location.

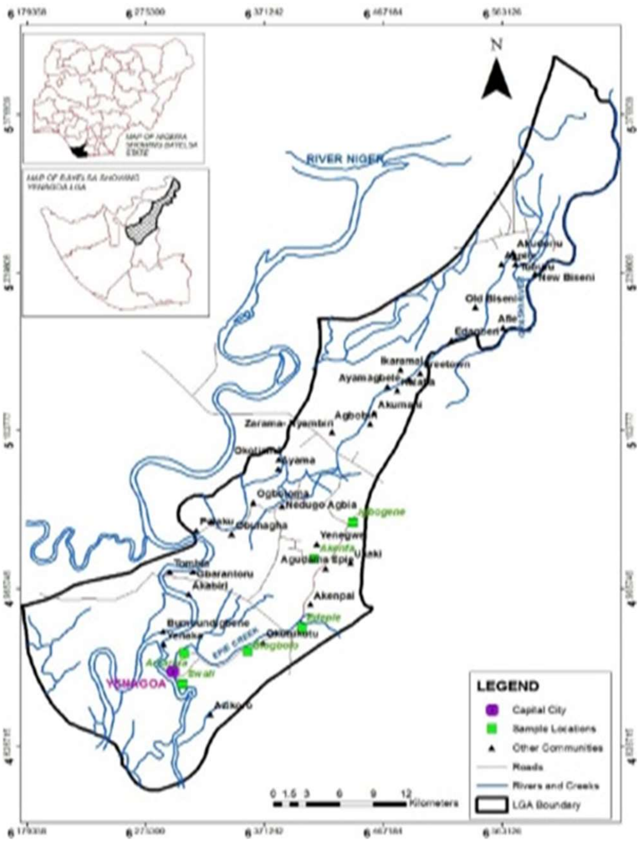

Figure1: Study location (Nigerian Geology Survey, 2004)

Location and Geology of the Study Area

Biseni kingdom, which is the study location (figure1.1) lies between latitude (5^0 16' 23" – 5^0 16' 22") N and longitude (6^0 32' 59" – 6^0 33' 3") E in Yenagoa local government area of Bayelsa State, Nigeria consist of about eight (8) communities. The study is a coastal Niger Delta sedimentary basin that is within the deltaic environment of sensitive wet land, water ways and estuaries of the southern Nigeria. Geologically, the area falls within the Niger Delta region of Nigeria which is underlain by three stratigraphic units: Akata, Agbada and Benin Formations (Short and Stauble, 1967). The marine Akata Formation, Paleocene to Holocene in age, is composed of shales and occurs at the base of the delta sequence. It is overlain by the Agbada Formation which forms the hydrocarbon prospective unit in the Niger Delta and consists of an alternation of sands, silts and clay in various proportions and thicknesses. It ranges from Eocene to Recent in age and has a thickness of more than 3000m (Doust and Omatsola, 1990).

MATERIALS AND METHODS

The field data were acquired with an ABEM SAS 1000 model Terrameter by sending current into the ground and recording the potential with some conducting electrodes consists of 25 electrodes, used for the acquisition of Electrical Resistivity Tomography (ERT) data. The electrodes were driven into the ground surface at a spacing of 5m interval and spread length 120 m, to obtain the resistivity section; acquired data were processed by exporting them into the inversion algorithm (RES2DINV) software proposed by (Loke and Barker, 1996). Two Wenner array to view lateral changes and three (3) soil samples from the geophysical survey interpreted result area were collected. One Vertical Electrical Sounding (VES), Schlumberger array was used to characterize subsurface lithology and depth. Soil sample was taken to the laboratory for geochemical analysis, using the UV-Spectrophotometer to test for Total Hydrocarbon Content (THC) concentration, to confirm the presence of contamination in the study location. The Department of Petroleum Resources (DPR), standard of 30mg/kg for THC of soil, was used to compare the analysed result.

RESULT AND DISCUSSION

1D resistivity data (VES) was inverted using IPI2Win software running on personal computer. The raw apparent resistivity data were input into the software window to obtain true resistivity of the geoelectric layer which may be differ from the geologic layers depending on the geological make up. The model parameters, depth, layers, resistivity, and thickness were displayed.

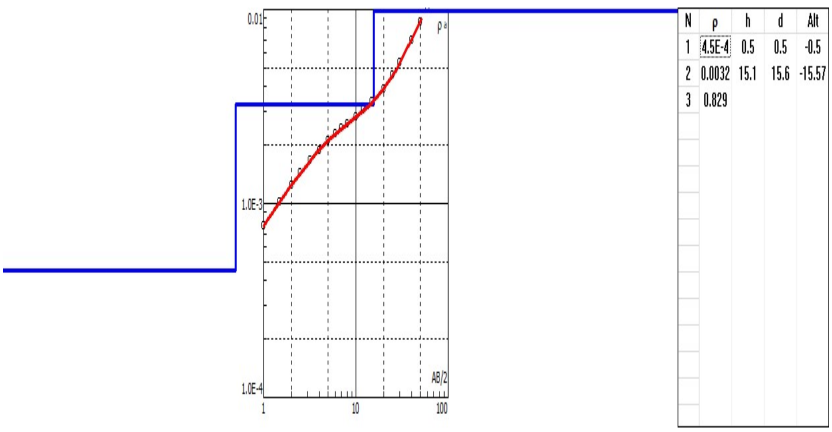

Figure 2: VES location

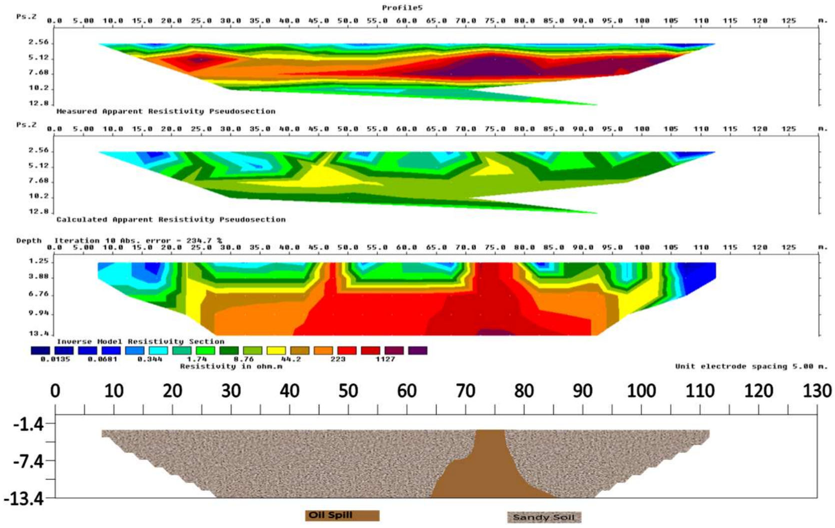

Figure 3: Geoelectric model of Profile 1

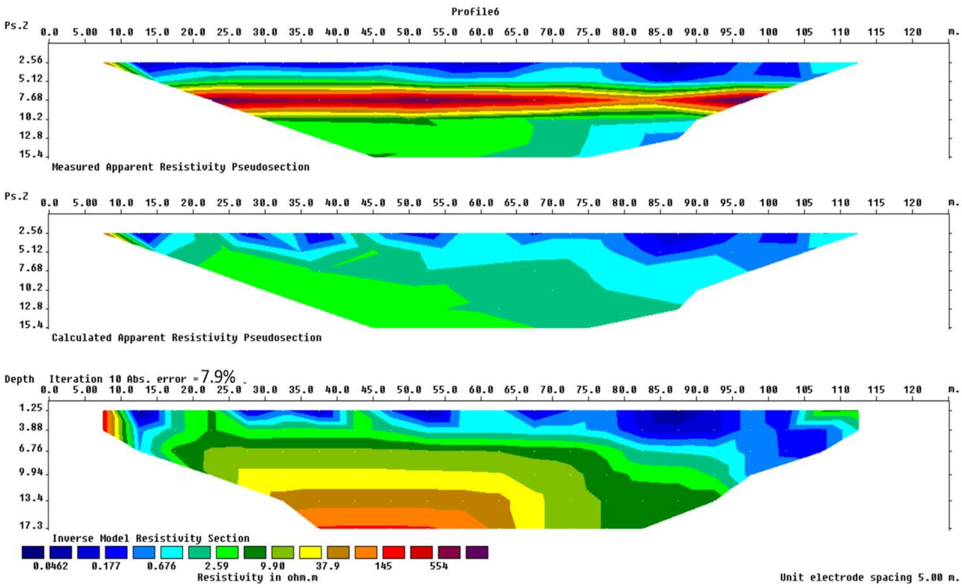

Figure 4: Geoelectric model of profile 2 (Control Zone)

Table 1: THC concentration of soil

PARAMETERS	**UNITS**	**S1**	**S2**	**S3**	WHO
THC (soil)	*mg/kg*	87.5	205	85	30

The 2 D resistivity acquired by applying Wenner configuration was inverted using res2dinv software to model. The apparent resistivity data were input into the software, to invert the raw apparent resistivity data. The inverted resistivity indicates the true resistivity distribution in the subsurface. Thus, three sections were displayed: the first and second show the pseudosections of the field and computer-generated apparent resistivity data respectively. The third section indicates the true or model resistivity section for the case of figure1.3 while a fourth section which show the

geologic section as shown in figure 1.4, the geological environment deduced from the true resistivity picture. The spill oil was likely indicated laterally between 65 and 85m marks, it spreads downward from about 75m marks, with the invaded area widen downward up to the maximum section depth for profile 1 as shown in figure 1.3, while Profile 2 likely shows that there's no hydrocarbon plume which serves as the control. Soil samples were collected in area affected by oil spill and area unaffected by oil spill; to confirm the present of pollutant in the study area, a UV Spectrophotometer was used to test for Total Hydrocarbon content (THC) concentration in the Soil. The soil samples collected were strategically located to assess the contamination levels at the spill site and the unaffected surrounding, which indicate high concentration at S1 as 87.5mg/kg, S2 as 205mg/kg and S3 as85mg/kg. The vertical sounding was used for the description of the subsurface soils. It was analysed in preference to total hydrocarbon content (THC), this was used to correlate the electrical resistivity results.

CONCLUTION

The study has revealed that the study area has been considerably contaminated due to migration of plume which could pose some health risks to the residents and the plants. This is evident from the high value of concentration obtain from the analysed result as regards to the resistivity value. It could be concluded from this study that contaminant is present in the area. In addition, based on the result of geochemical analysis of the soil, it could be concluded that the groundwater is mostly unsuitable for human consumption which could also affect plant growth and cause damage to the ecosystem due to the high-level concentration of the soil samples for geochemical analysis when compared to the WHO permissible limit of THC for soil. However, it is recommended that effective and frequently monitoring of ground water quality will safeguard the health of the public residing in the surroundings of the polluted site and improved the environment management system by carrying out a proper and standard remediation process to clean up the affected environment.

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