RESISTIVITY IMAGING OF CRUDE OIL SPILL IN OGULAHA COASTAL COMMUNITY, BURUTU L.G.A, DELTA STATE, NIGERIA

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ABSTRACT

Geophysical investigation has been conducted using resistivity survey along Angalakiri Creek, Okuntu road, Ogulaha area in Burutu Local Government Area (L.G.A) of Delta State, Nigeria with the aim of investigating the lateral and vertical spread of hydrocarbon spilled into the Angalakiri creek along Okuntu road and buried by the banks of the creek during the clean up of the floating hydrocarbon. The 2D resistivity imaging technique using the dipole- dipole array method was adopted for the survey with the aid of the SAS 4000 Terrameter. The inferred lithology from 2D resistivity inversion are topsoil, clayey sand and sand. The study delineated resistivity values ranging from 74 Ωm to 5010 Ωm. The high resistivity values (800 Ωm - 5100 Ωm) are as a result of the buried crude observed in all the profiles except profile 6 which was located outside the polluted area.

This study has revealed that the buried hydrocarbon has not degraded and has spread laterally along the Angalakiri with vertical penetration of penetration over 7m.

This study, has confirmed that the 2D resistivity method is an efficient tool for investigating hydrocarbon pollution in a coastal environment.

Keywords: *Crude oil, contamination, 2D resistivity, Ogulaha, Angalakiri Creek.*

1. INTRODUCTION

The Niger Delta basin is endowed with abundant natural resources which include oil and natural gas, sand, gravel and rich biological diversity. This area which contributes about 90% of the nation's foreign exchange earnings is also the third largest wetland in the world with flat and low lying swamps that are criss-crossed by streams, rivers and creeks. The exploration, production and distribution of crude oil have given rise to environmental degradation the most prevalent of which is crude oil spillage.

The spills may occur as a result of blowouts due to overpressure, equipment failure, operators errors, corrosion, sabotage (vandalisation of pipelines), pigging operations, flow line replacement, flow station upgrades, tank rehabilitation and natural phenomena such as heavy rainfall, flooding, falling of trees and lightening [3]. A World Bank survey [5] estimated that about 2.3million cubic metres of crude oil is spilt into different media in the region each year. It has also been claimed that greater than 70 per cent of this volume went unrecovered [13]. These unrecovered spills and those that are not properly cleaned up constitute a continuous source of contamination to the subsurface water, soils vegetation and biodiversity.

In this study 2D Electrical Resistivity method was utilised to assess the vertical and lateral extent of crude oil that spilled into the Angalakiri creek and the floating crude scooped and buried by the bank during clean up. This method has proven to be useful for the characterization of hydrocarbon contaminated soils [4, 6, 8, 10, 11, 2].

2. LOCATION OF STUDY AREA

The study area, Ogulaha lies within Longitude 5˚ 18.70′ N to 5˚ 21.01′ N and Latitude 5˚ 19.96′ E to 5˚ 21.87′ E, is located in Burutu L.G.A, Delta State, Nigeria, Figures 1 and 2. This area was affected by hydrocarbon pollution from an oil pipeline which spilled into the Angalakiri Creek along Okuntu road. The hydrocarbon was scooped and buried along the bank of the Angalakiri creek as part of the remediation process. The study area is located in a coastal environment where the surface to water level is shallow (less than 3m) and the near surface ground water is brackish to saline with a windy tropical climate. Rain fall is all year round and the annual ten year mean is about 2652mm while the mean daily temperature is 31.2˚C [9].

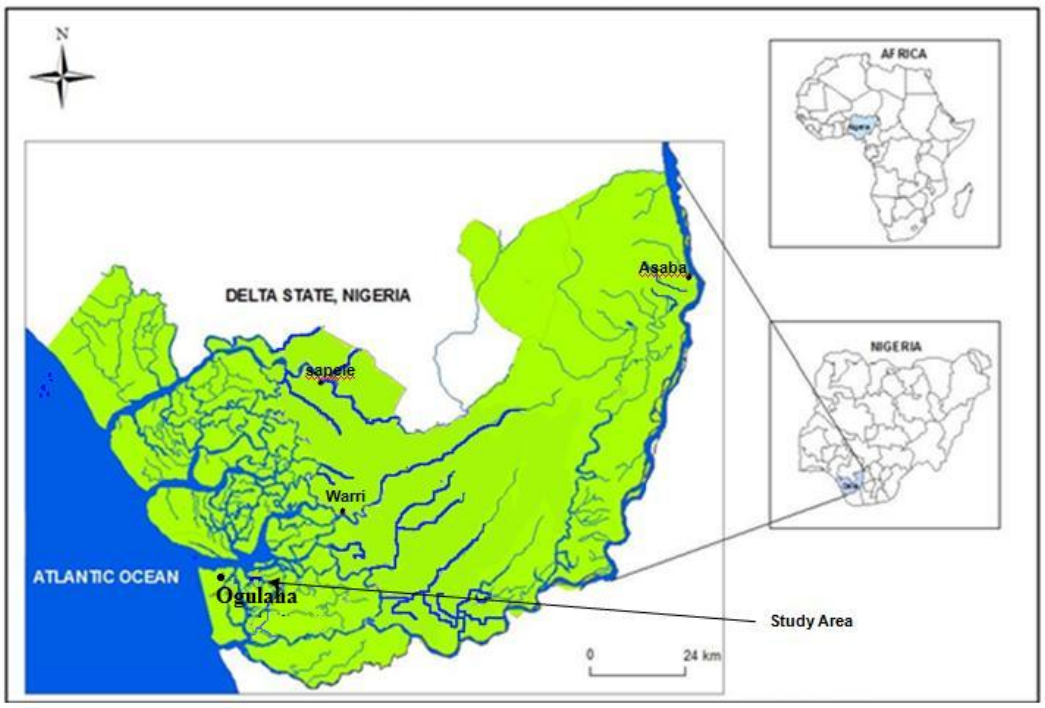

Fig. 1. Map of Delta State, Nigeria showing study area.

3. GEOLOGY

The morphological features of the Niger Delta and its sedimentary environments are much studied and summary descriptions may be found in Short and Stauble [12] and Asseez [1]

The geologic sequence of the Niger Delta consists of three main tertiary subsurface

lithostratigraphic units which are overlain by various types of quaternary deposits. The base of the unit is the Akata Formation and it comprises mainly of marine of holomarine shales, silts and clays with some sand beds. The formation ranges in thickness from about 550 to over 6000

meters. Very little hydrocarbon has been associated with the formation. The Agbada Formation is the overlying paralic and stratigraphic components which consist of interbedded sands and shale with a thickness of 300 up to about 4500m, thinning both seawards and towards the Delta margin. The top most unit is the youngest Benin Formation which is over 90% sandstone with shale intercalations. It is coarse grained, gravely, locally fine grained, poorly sorted, sub angular to well rounded and bears lignite streaks and wood fragments [1]. The Quaternary-Recent sediments that overlie the Benin Formation consist of grey coloured fine-medium grained sands that dominate the beaches which flank the Atlantic Ocean and the Forcados estuary. These sediments are the recent and modern expression of the Benin Formation.

4. METHODOLOGY

The crude, spilled into the Angalakiri creek was buried by the bank of the creek during the clean up the hydrocarbon along Okuntu road in Ogulaha (Figure 2). The 2D resistivity imaging technique using the dipole-dipole array method was adopted for the survey with the aid of the SAS 4000 Terrameter. In order to map the vertical and lateral extent of the hydrocarbon pollution, six 2D dipole-dipole profiles, were occupied with electrode spacing of 5 m along the bank of the creek where the spilled crude was scooped and buried. Due to the topography of the area the profiles were occupied at elevations between one to three meters from the water level along the creek. The stored data in the Terrameter was transferred to a computer for processing and inversion using the DIPPRO inversion software.

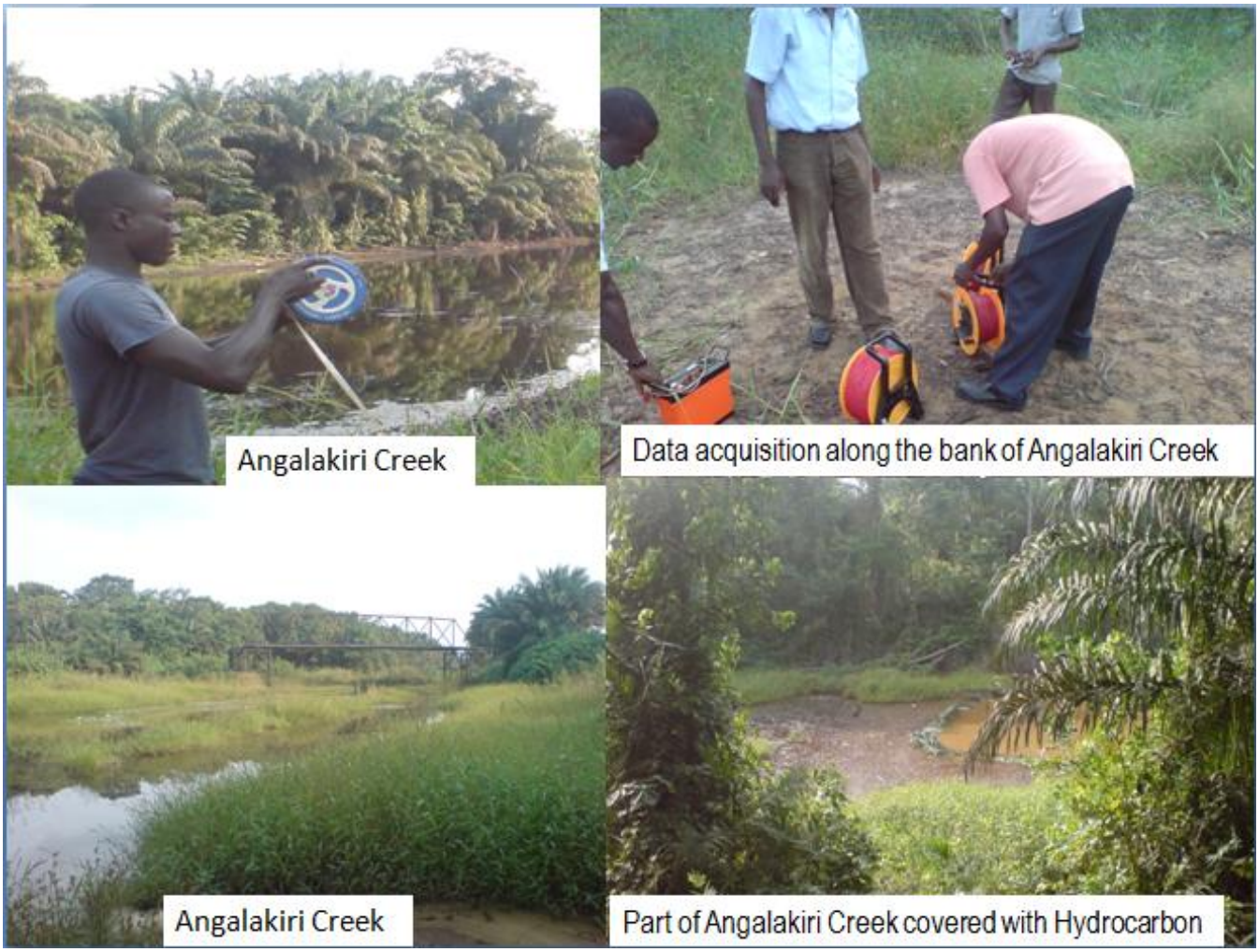

Figure 2: Data acquisition at buried Hydrocarbon spill in Okuntu Road Ogulaha

5. RESULTS

The results of the 2D resistivity inversion in Okuntu road Ogulaha along the banks of the Angalakiri creek are shown in Figures 3 (a-f) as 2D inverted resistivity structures.

The inverse model 2D resistivity structure of profile 1 (Figure 3a) shows resistivity values between 96-495 Ωm from the surface to the depth of about 5m suggestive of clayey sand/ sand lithology. There is increase in resistivity 762 to 4742 Ωm (red colour) between electrode positions 9 and 14 below 5m depth, suggestive of soil material that is affected by pollution.

Profile 2 is located 20m south of profile 1 along the Angalakiri creek (Figure 3b). The inverse resistivity model shows lateral changes in resistivity values between 74 – 370 Ωm from the top to a maximum depth of about 5m suggestive of clay/clayey sand/sand. Below this depth is a high resistivity zone with resistivity values ranging from 1000 to 3000 Ωm (red colour) along the entire profile length of 60m. This zone is suggestive of crude oil contaminant plume.

The inverted resistivity model along profile 3 (Figure 3c) is located 50m south of profile 2 along the Angalakiri creek. The inverse resistivity model shows lateral changes in resistivity values between 157 – 485 Ωm from the top to a maximum depth of about 5m suggestive of clayey sand/sand. Below this depth are lenses of high resistivity zone with resistivity values ranging from 1000 to 3600 Ωm (red colour) between electrode positions 4 and 6, 8 and 10 & 11 and 14, suggestive of crude oil contaminant plume.

Profile 4 is located 20m south of profile 3 along the Angalakiri creek (Figure 3d). The inverse resistivity model shows lateral changes in resistivity values ranging from 143 – 407 Ωm from the top to a maximum depth of about 8m. However high resistivity values (836 to 3003 Ωm) are delineated between electrode positions 9 and 12 suggestive of crude oil contaminant plume.

The inverted resistivity model along profile 5 (Figure 3e) is located 30m south of profile 4 along the Angalakiri creek. The inverse resistivity model shows lateral changes in resistivity values between 116 - 793Ωm from the surface to the depth of about 5m suggestive of clayey sand/sand. The elevation of this profile is 1m above the water level along the bank. Between electrode position 4 and 8 is a lenses of high resistivity zone with resistivity values ranging from 1000 to 5000 Ωm (red colour) suggestive of crude oil contaminant plume.

Profile 6 is located 20m south of profile 5 and 10m away from the Angalakiri creek where no crude oil was buried (Figure 3f). The inverse resistivity model shows lateral changes in resistivity values ranging from 55-280 Ωm from the top to a depth of about 8m suggestive of clay/clayey sand/sand.

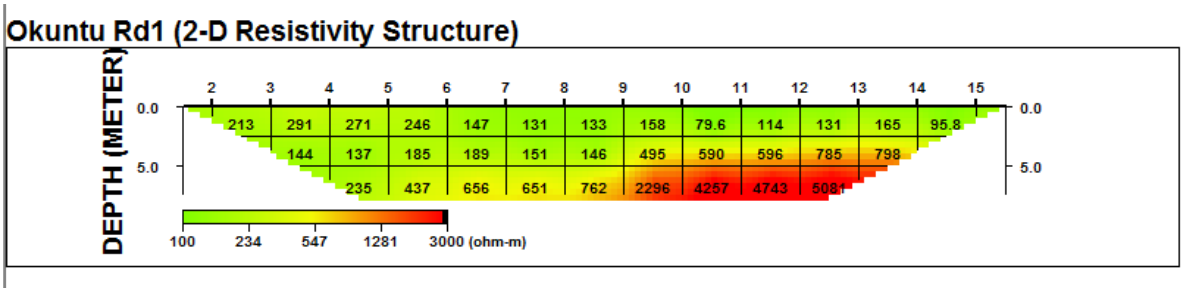

Figure 3a: Inverted 2D Resistivity structure along Dipole-Dipole profile (DP1) in Okuntu Road

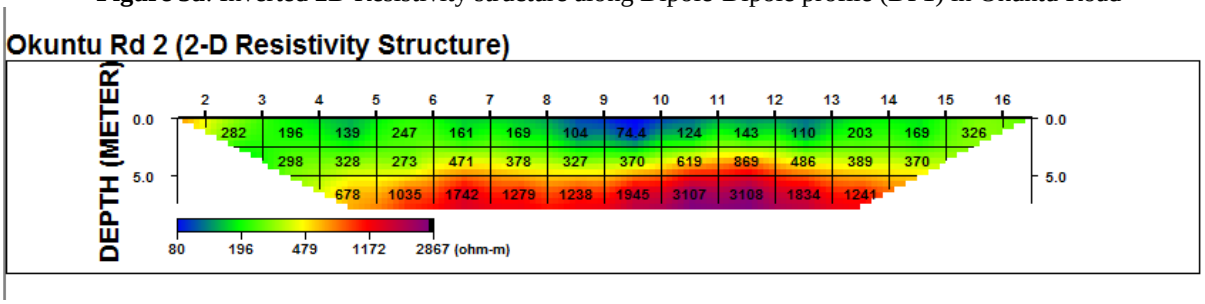

Figure 3b: Inverted 2D Resistivity structure along Dipole-Dipole profile (DP2) in Okuntu Road

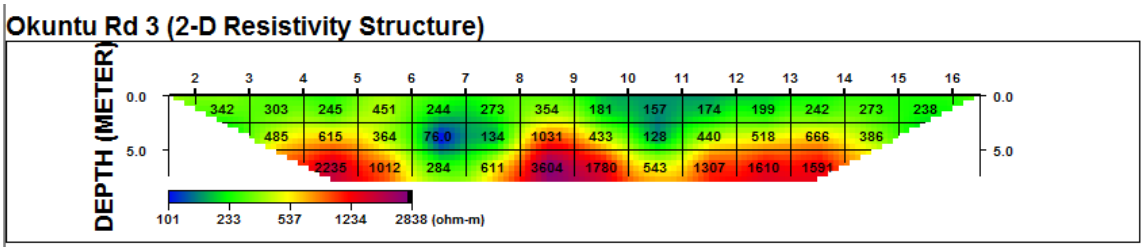

Figure 3c: Inverted 2D Resistivity structure along Dipole-Dipole profile (DP3) in Okuntu Road

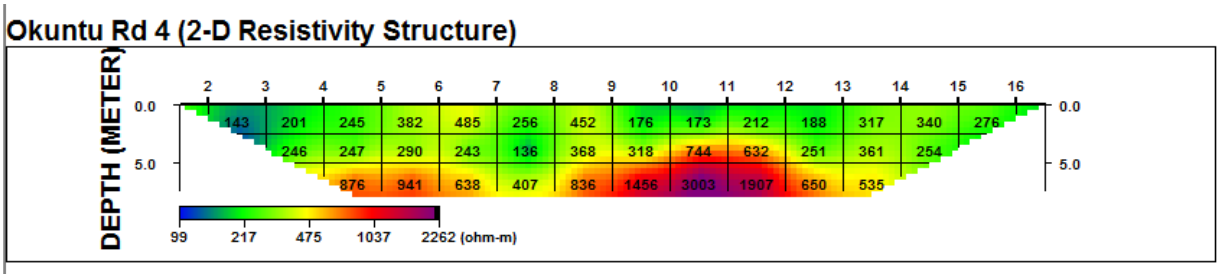

Figure 3d: Inverted 2D Resistivity structure along Dipole-Dipole profile (DP4) in Okuntu Road

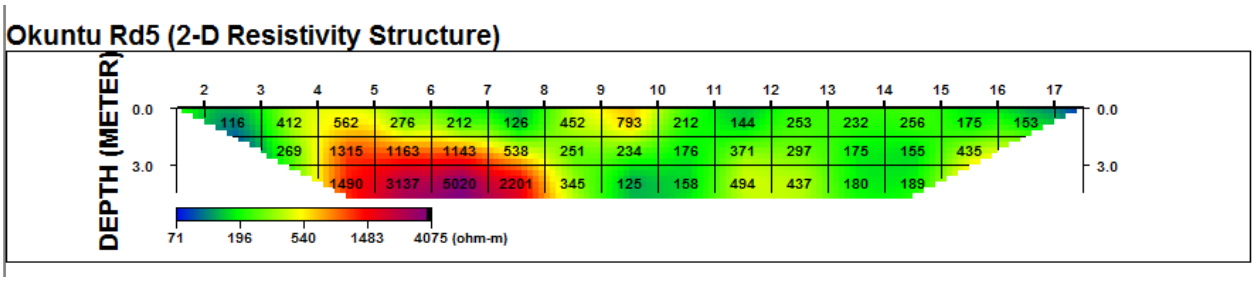

Figure 3e: Inverted 2D Resistivity structure along Dipole-Dipole profile (DP4) in Okuntu Road

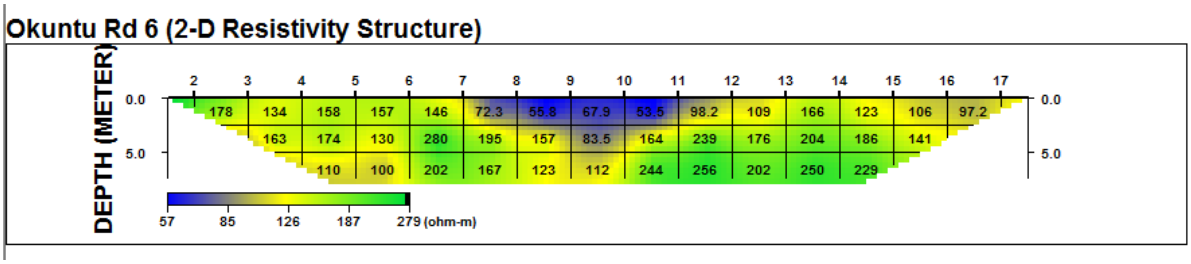

Figure 3f: Inverted 2D Resistivity structure along Dipole-Dipole profile (DP5) in Okuntu Road

6. CONCLUSION

In this study, 2D surface resistivity survey was undertaken in Ogulaha to investigate the lateral and vertical spread of hydrocarbon spilled into the Angalakiri creek along Okuntu road and buried by the banks of the creek during the cleanup of the floating hydrocarbon. The 2D resistivity imaging technique using the dipole- dipole array method was adopted for the survey with the aid of the SAS 4000 Terrameter. The study has delineated resistivity values ranging from 74 Ωm to 5010 Ωm. The high resistivity values (800 Ωm - 5100 Ωm) may be as a result of the buried crude. This study has revealed that the buried hydrocarbon has not degraded and has spread laterally along the Angalakiri with vertical penetration of penetration over 7m.

This study, has confirmed that the 2D resistivity method is an efficient tool for investigating hydrocarbon pollution in a coastal environment.

7. REFERENCES

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