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2D and 3D Geoelectrical investigation of Hydrocarbon impacted sites in Erhoike Community, Ethiope East local Government Area, Delta State, Nigeria

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ABSTRACT: Hydrocarbon contamination occurs as a result of corrosion of buried pipelines, sabotage of oil and gas facilities and spills during petroleum product transportation. This study was undertaken to characterize hydrocarbon impacted sites in Erhoike community, Ethiope East local government area, Delta State, Nigeria using ten (10) transects were established in grid format to attain geoelectric data that were inverted to yield 2D resistivity structure and 3D depth slices respectively. The 2D results show that the hydrocarbon impacted zones are marked by very high resistivity values ranging from 637 ohm-m to more than 17000 ohm-m from the surface to a depth in excess of 31.9 m in places within the study area. In the same vein, the 3D result indicated that bulk of the contaminant has progressively moved to deeper depth with most of the plume found at between 25.0 – 33.7 m. The data obtained show that the site has been impacted by hydrocarbon contaminant. It also shows that the hydrocarbon moved downwardly at greater depth into the subsurface, through a porous medium - sandy layer. Finally, the study has demonstrated the effectiveness of the adopted geophysical techniques in delineating hydrocarbon contamination.

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For many years, hydrocarbon poisoning of soil has been a severe environmental issue (Manuel and Claudia, 2013). To carry out an adequate remediation, different approaches, mainly direct methods, such as physical analysis (i.e., odor, color, and texture) and chemical analysis (i.e., pollutant concentration), are usually employed to characterize the polluted zone. Geophysical approaches have recently been useful in the characterization of hydrocarbon-contaminated soils. The electrical resistivity of the ground materials is one of the most altered properties in the presence of hydrocarbons. The variation of this characteristic has been mapped by many workers (Atekwana *et al.*, 2000; Slater *et al.*, 2000; Godio and Naldi, 2003; Shevnin *et al*., 2003, 2005, 2006; Sogade *et al*., 2006) in order to establish a link between the variation of the property and the concentration, distribution, and evolution of pollutants. Electrical Resistivity Tomography (ERT) in particular has lately become more widely used in the characterization of hydrocarbons contamination (Godio and Naldi, 2003; Shevnin *et al.*, 2003, 2005; Batayneh, 2005). Therefore, this study was undertaken to characterize hydrocarbon impacted sites in Erhoike community, Ethiope East local governmet area, Delta State, Nigeria.

MATERIALS AND METHODS

The Study Area: Erhoike community is a settlement within Delta State in Southern Nigeria. The area is

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located within longitudes and latitudes E 006 03'32.56 to 006 04'01.62 and N 05 38'38.28 to 05 38' 47.36. Figure 1 is the location map of Delta state showing the study area.

Regional Geological Settings of Niger Delta: Delta State is located in the Niger Delta region of Nigeria, within the geographical coordinates 5˚30'N and 6˚00'E. The climate is typical of the rainforest zone of the tropics and average precipitation is about 200 mm. Mean ambient temperature is 28˚C, with relative humidity of about 88%. Wet season lasts between March-November, with a short dry season covering the rest of the year.

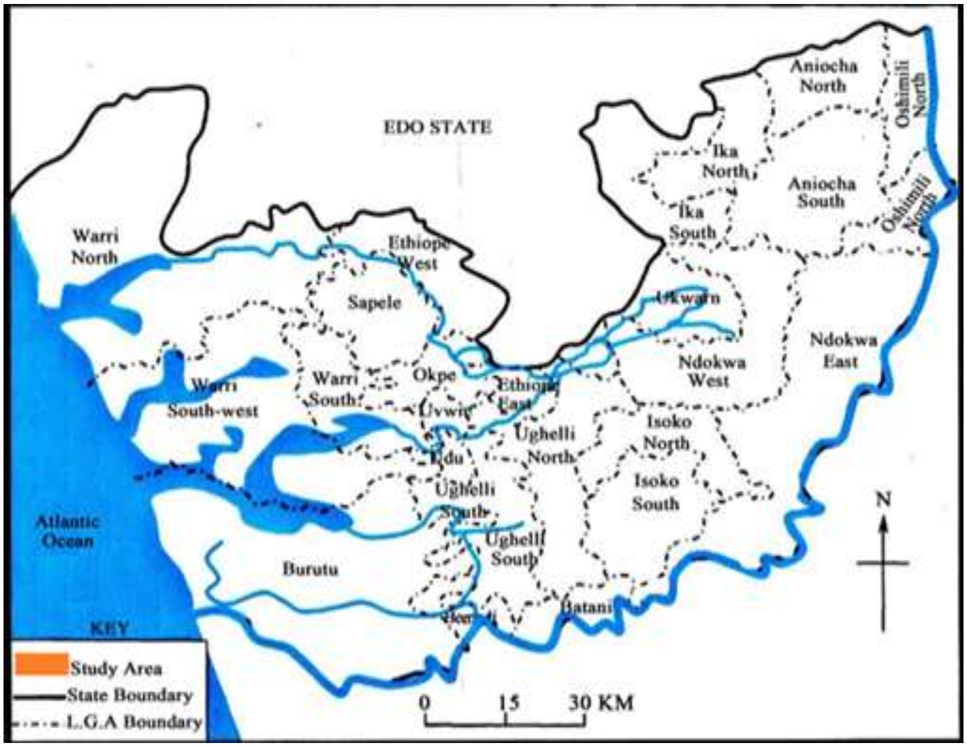

Fig 1: location map of Delta state showing the study area (After Corredor *et al.*, 2005)

The Tertiary Niger Delta covers an area of approximately 75,000 sq. km and consists of a regressive clastic succession, which attains a maximum thickness of 12,000 m (Doust and Omatsola, 1990). The Niger Delta is located in the Gulf of Guinea, Central West Africa, between Latitudes 4^{o} and 7^{o} N and Longitudes 3^{o} and 9^{o} E at the culmination of the Benue Trough (Figure 2) and is considered one of the most prolific hydrocarbon provinces in the world (Corredor *et al.*, 2005). The Anambra basin and Abakaliki high to the north, the Cameroun volcanic line to the east, the Dahomey embayment to the west and the Gulf of Guinea to the south define the boundaries of the Niger Delta. The lithostratigraphy of the Tertiary Niger Delta can be divided into three major units: Akata, Agbada and Benin Formations, with depositionals ranging from marine to transitional and continental settings respectively. The Akata, Agbada and Benin Formations overlie stretched continental and oceanic crusts (Heinio and Davies, 2006). Their ages range from Eocene to Recent, but they transgress time boundaries. These prograding depositional facies can be distinguished mainly by their sand-shale ratios. The Niger Delta is divided into five regional depobelts along the North-South axis of the delta, each with its own sedimentation, deformation and petroleum history. These depobelts include: The Northern Delta, the Greater Ughelli, the Central Swamp I and II, the Coastal Swamp and the Offshore depobelts (Figure 2). Each of these depobelts is bounded by large-scale regional and counter-regional growth faults (Doust and Omatsola, 1990). The activity in each belt has progressed in time and space toward the south-southwest through stepwise alluvial progradation facilitated by large-scale withdrawal and forward movement of the underlying shale. The interplay of subsidence and supply rates resulted in the deposition of discrete depobelts – when further crustal subsidence of the Basin could no longer be accommodated, the focus of sediment deposition shifted seaward, forming a new depobelt (Doust and Omatsola, 1990).

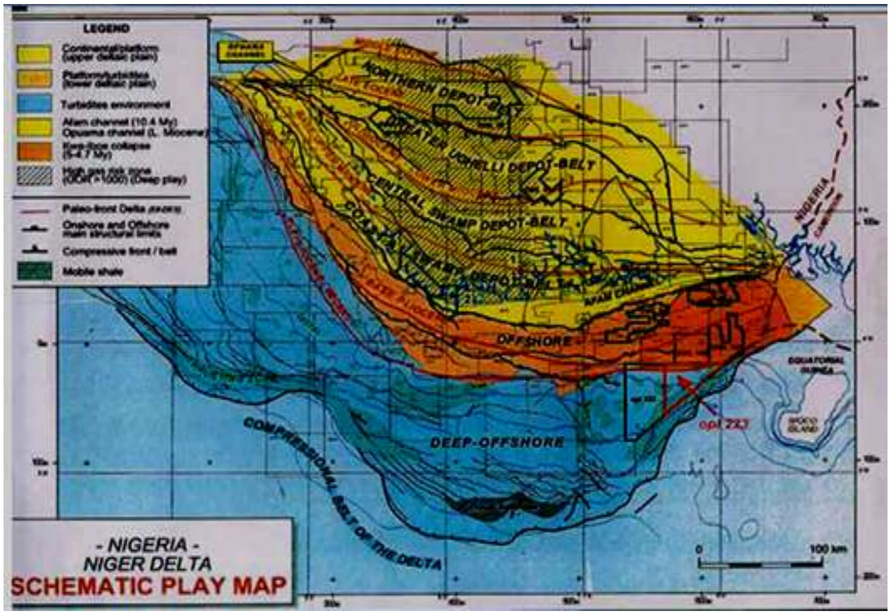

Fig 2: Map of Niger Delta Depobelts **(After Nwozor *et al*., 2013)**

Sampling And Analysis: For this study, ten (10) traverses were established in a grid format as shown in figure 3. The Wenner configuration was adopted and the Res2Dinvx software was used for inversion of the resistivity data to generate the 2D resistivity image of the subsurface. 3D depth slices were also generated to map the continuity of the contaminant in the subsurface. The images were then interpreted qualitatively and semi-quantitatively to map out the possible impacted zones within the area.

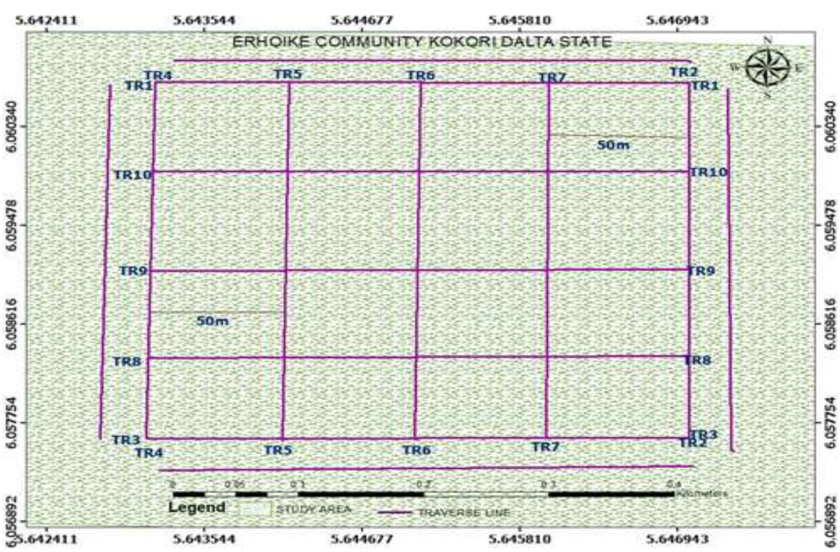

Fig 3: Basemap of the Study Area Showing the Traverse Lines

RESULTS AND DISCUSSION

The 2D Electrical Resistivity (ER) structures generated from the inversion of the acquired resistivity data along traverses 1 – 5 are shown in figure 4. The ER shows resistivity values ranging from less than 10 ohm-m to an excess of 17959 ohm-m. All the traverses covered lateral extent of 200 m and total depth of penetration of 31.9 m.

The ER shows resistivity values ranging from less than 10 ohm-m to an excess of 17959 ohm-m. All the traverses covered lateral extent of 200 m and total depth of penetration of 31.9 m. The resistivity of a soil impacted by hydrocarbon product is expected to be very high most times > 1000ohm-m. Along traverses 1 – 5, the suspected impacted zones are marked with broken lines. The 2D resistivity structures show that the subsurface along traverses 1 – 5 have been impacted from lateral distance of about 40 m to 160 m and depth ranges from 2.5 m to as deep as 31.9 m in places.

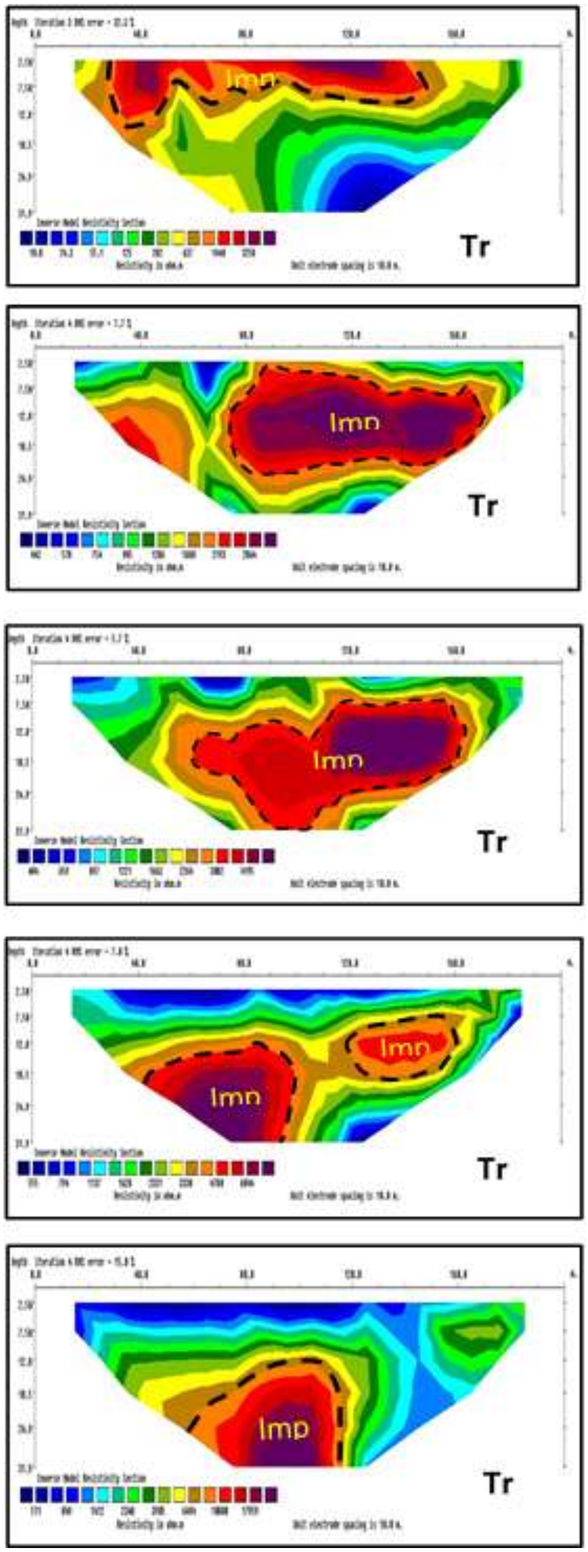

Fig 4: 2D Structures along Traverses 1 - 5

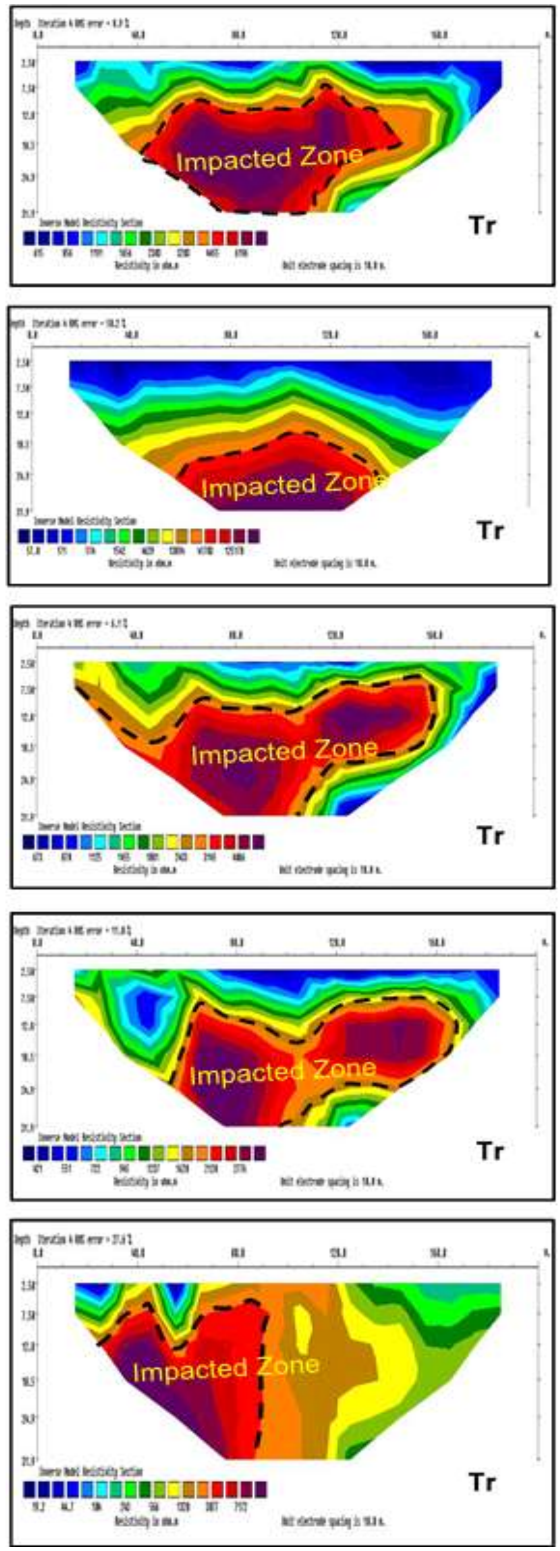

Fig 5: 2D Structures along Traverses 6 – 10

The 2D Electrical Resistivity (ER) structures generated from the inversion of the acquired resistivity data along traverses 6 – 10 are shown in figure 5 below. The ER shows resistivity values ranging from less than 19.2 ohm-m to an excess of 125170 ohm-m. All the traverses covered lateral extent of 200 m and total depth of penetration of 31.9 m. The resistivity of a soil impacted by hydrocarbon product is expected to be very high most times > 1000ohm-m. The pattern of the pollution plume along these traverses (6 – 10) are similar to what was observed along traverses 1 – 5. The suspected impacted zones are marked with broken lines. The 2D resistivity structures show that the subsurface along traverses 6 – 10 have also been impacted from lateral distance of about < 40 m to about 160 m and depth ranges from 2.5 m to as deep as 31.9 m in places.

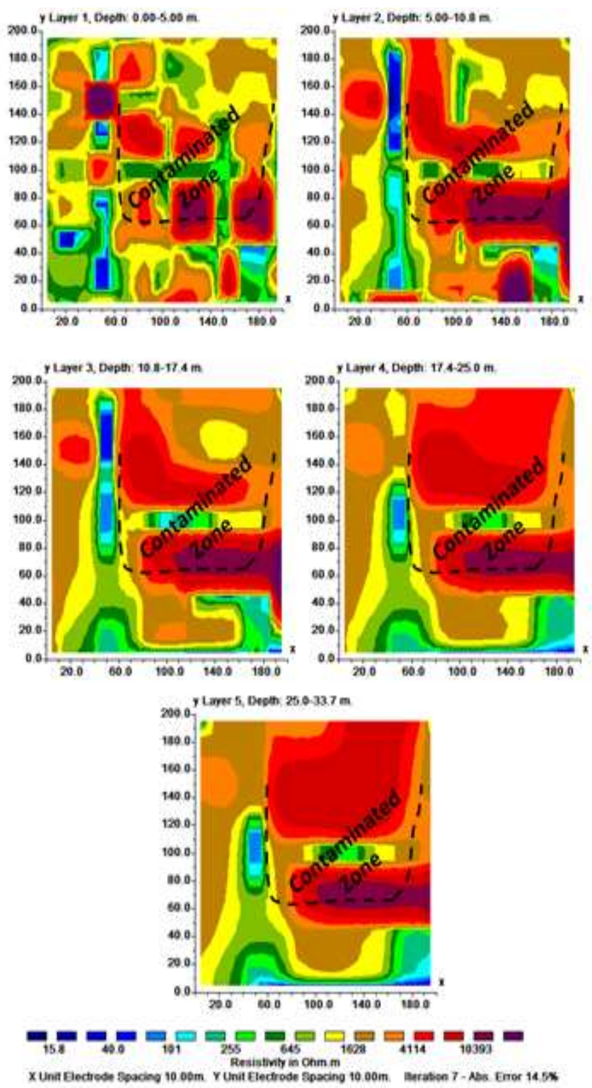

Fig 6: 3D Structures

3D Depth Slices: The 3D Electrical Resistivity (ER) depth slices generated are shown in figure 6 below. The suspected impacted zones are indicated with broken black lines. The discussion in this section is therefore centered on this zone. At depth range of between 0 – 5 m, the resistivity values range from about 255 ohm-m to more than 4114 ohm-m. At depth range of between 5 – 10 m, the resistivity becomes progressively higher with high resistivity becoming more pronounced. The value ranges from about 255 ohm-m to as high as 10000 ohm-m. Generally, the 3D depth slices shows that the resistivity values progressively increased downward with the highest resistivity values occurring at depth of 25 – 33.7 m. This indicates that the hydrocarbon pollutant has moved downward to a depth in excess of 33.7 m.

Conclusion: The area under study has been shown to be polluted by hydrocarbon products. The 2D results show that the hydrocarbon impacted zones are marked by very high resistivity values. Likewise, the 3D result indicated that bulk of the contaminant has progressively moved to deeper depth. It also shows that the hydrocarbon moved downwardly at greater depth into the subsurface. Finally, the study was able to demonstrate the effectiveness of the adopted geophysical techniques in delineating hydrocarbon contamination.

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