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Investigating the near surface leachate movement in an open dumpsite using surficial ERT method

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Abstract. Geoelectrical resistivity imaging technique was conducted at Abule-egba open dumpsite, Lagos with intentions to monitor the movement of the contaminant leachate within the near surface. The two survey traverses (T1 and T2) of 2D electrical resistivity tomography were conducted using Wenner array configuration with minimum electrode spacing of 1 metre and maximum data levels of seven. The inversion models revealed the two delineated geoelectrical layers which are sandy-clay and sand units. The leachate fluids has the resistivity values of 5.75 – 10.4 Ωm at depth range of 2.5 – 4.0 metres along T1 and T2 moving from NW to the SE section. The leachate fluids are capable of polluting shallow groundwater aquifer within the study area and the residents are advised to drill deeper in the subsurface for clean and portable groundwater resources.
Keywords: Environmental Geophysics, Leachates, Near-surface geophysics, Open dumpsite, Electrical resistivity tomography (ERT)

1. Introduction

Leaching of both inorganic and organic contaminants from dumpsites is constituting a serious environmental challenge to both surface water and aquifers. Groundwater pollution from organic and inorganic contaminants is one of the hazards that endangered environments most especially in industrial areas. Contaminations sources are divided into two, which are point source and area contaminations. The point source contaminations include those of accidental spills, landfills, industrial waste disposal sites and gasoline tanks leakage. Whereas, those of area contaminations include fertilizer and pesticides contaminations in agriculture. Landfills and solid waste disposal are the most common point source contaminations and they can produce contamination leachate plumes [1-3]. The migration of the leachate plume can also pollute the aquifers and surface waters for a long period of time thereby causing a long term serious health and environmental risks [4, 5].

In order to properly evaluate these risks, mapping and characterizing the leachate plume is pertinent. There are several techniques for these purposes, however, several of them only provide limited spatial subsurface information which might generate incomplete site investigation thereby resulting into inadequate remedial designs. Geophysical surveys can reduce this gap in provision of spatial information by generating an extensive lateral coverage without jeopardizing the needed high resolution information. Geophysical techniques are non-invasive and have been extensively used for subsurface characterization, in particular electrical resistivity tomography (ERT) has been used for groundwater exploration and pollution studies [6-12]. In this research, we used surficial ERT method to monitor the lateral coverage and migration of leachate plume within the subsurface of an open dumpsite around Abule-Egba, Lagos (Figure 1).

Figure 1: Abule-Egba Dumpsite.

2. Methodology

2.1 Study Area

The area of study is a dumpsite situated between the easting of 3°18'1.31" to 3°18'16.03" and northing 6°38'15.08" to 6°38'15.43" (Figure 2) located along Abule-egba to Iyana-ipaja Road, Lagos state, SW Nigeria. The study area lies geologically within the Eastern Dahomey Basin with east-westward trend sediments deposition and six lithostratigraphic units comprising Benin, Ilaro, Oshosun, Akinbo, Ewekoro and Abeokuta Formations from youngest to the oldest geological formation. Ewekoro Formation is known to be a Paleocene shallow marine deposit of non-crystalline and non-fossiliferous limestone strata. The Ilaro Formation consisting of clays and shales followed by the poorly sorted coastal plain sands of Benin Formation and recent alluvial deposits. Within the Lagos metropolitan area, the coastal plain sand units of Benin Formation are the major aquifers generally exploited by low and medium income earners for water supply.

2.2 ERT Data Acquisition and Processing

The 2D electrical resistivity tomography survey consist of two traverses (T1 and T2) situated within the north-west portion of the dumpsite (Figure 2). Wenner array was used for data acquisition with minimum electrode spacing of 1 m and maximum data levels of seven (7). The electrode positions were clearly pegged prior to the survey in order to avoid electrode positioning error. SAS 1000/4000 series ABEM Terrameter was used for the data measurement. The equipment was set for measurement repetition with minimum and maximum data stacking of 3 and 6 respectively. The minimum and maximum current injected into subsurface for apparent resistivity measurements were 20.0 mA and 100.0 mA. During the survey, we ensured that electrodes were firmly in contact with the ground and effective contact were maintained between the electrodes and the connecting cables. The acquired apparent resistivity datasets for both traverses were processed and inverted with the use of RES2DINV inversion code that employs nonlinear optimization technique to compute the subsurface 2D inverse models.

Figure 2: Google earth map showing the survey area with survey traverses TR1 and TR2.

3. Results and Discussion

The inverse model of the 2D ERT along TR1 (Figure 3) shows two geoelectrical layers of sandy-clay unit with resistivity values range 14.9 – 50.5 Ωm and sand unit with resistivity values range 92.9 – 314 Ωm. A low resistivity layer of sandy-clay unit impregnated with high density leachate fluids with resistivity values less than or equal to 4.40 Ωm that percolate downward to the depth range of 2.5 m to 4.00 m in the subsurface. The inverse resistivity model for TR2 shows two geoelectrical layers of sandy-clay unit with resistivity values range 18.4 – 72.0 Ωm and sand unit with resistivity values range 142 – 558 Ωm. A low resistivity layer of sandy-clay unit impregnated with high density leachate fluids with resistivity values less than or equal to 4.69 Ωm that percolate downward to the depth range of 2.5 m to 4.00 m in the subsurface. Generally, the leachate fluids are observed to flow south-eastward in the study area. The contaminant plume is predominant within the shallow and central portions of the study area. Consequently, any shallow aquifers present in the study area seem to have been polluted by the leachate.

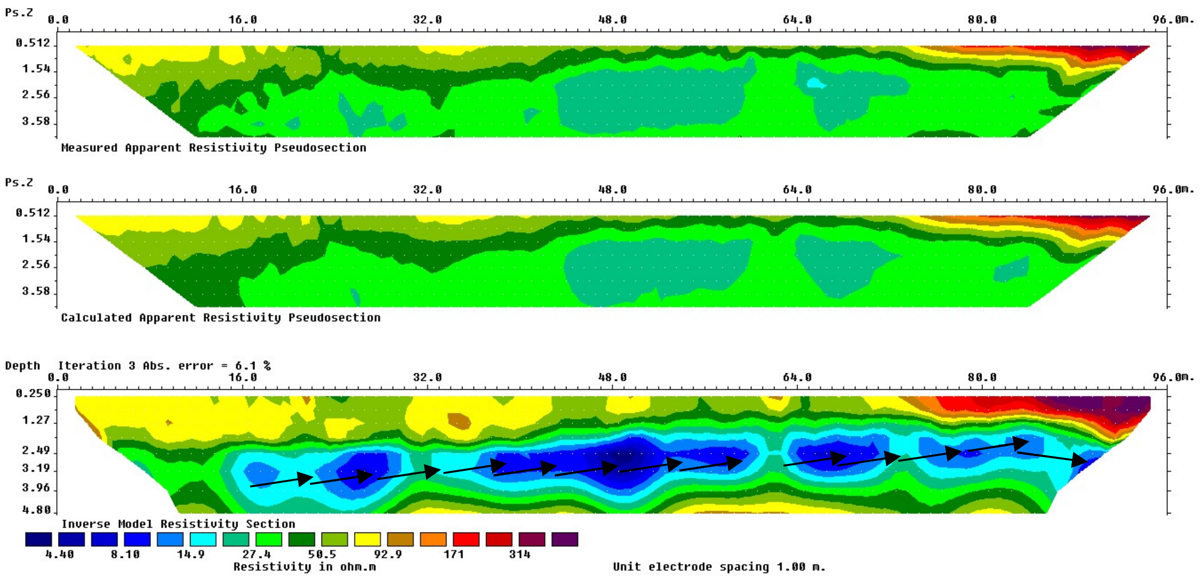

Figure 3: 2D ERT Inverse resistivity model for traverse TR 1

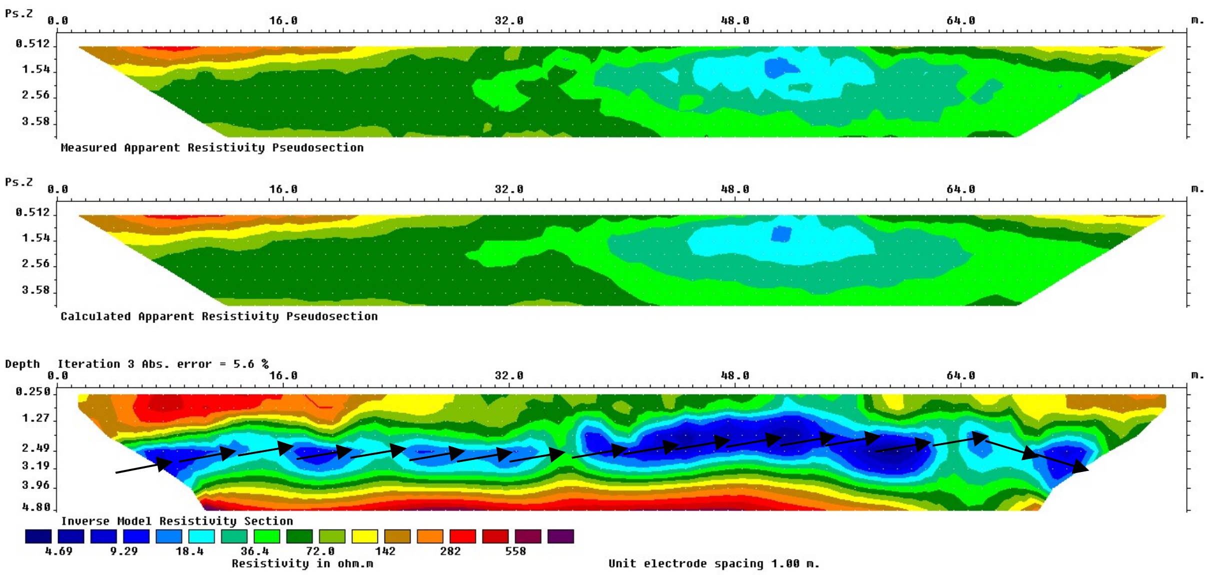

Figure 4: 2D ERT Inverse resistivity model for traverse TR 2.

4. Conclusions

2D electrical resistivity tomography has been used to determine the near surface occurrence of leachate plume within a dumpsite around Abule-Egba, Lagos Nigeria. The preferential flow movement of the leachate fluid is investigated. The geoelectrical imaging results show that the contaminant leachates occur in the near surface depths at about 2.5 m to 4 m and flow south-eastwards. The residents are admonished to drill deeper for clean groundwater source as any shallow aquifers would have been contaminated by the leachate plume. Hydrogeochemical analysis of the groundwater in the area is recommended so as to ascertain the extent of groundwater pollution in the area.

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