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Original Article

Joint geophysical and physicochemical evaluation of the effect of waste from automobiles in mechanic village, Surulere Local Government Area, Lagos State, Southwest, Nigeria

O. J. Airen, V. Emenim

Department of Physics, Faculty of Physical Sciences, University of Benin, Benin City, Nigeria

ABSTRACT

An integrated approach to characterize the effects of used motor oil on soil physical and chemical variables and their particle size distribution was carried out. Resistivity imaging consists of 5 traverses of 2D dipole dipole array data acquisition, four (04) of which were traverse taken in the automated machinery village, and one was in the control traverse. Two (2) soil samples were collected, one from Auto Machinery Village and one as a control; at depths of 0–15 cm and 15–30 cm, respectively. The standard method has been used for field and laboratory analysis. The instruments used include atomic absorption spectrometer (FS 240 Varian type), jewniary, digital pH meter, refractometer (E Line R.ATC type), Lovibond instrument CM 21 type, and mercury machine (thermometer that was used). Two-dimensional resistivity imaging shows two to four resistivity structures, representing clay, sandy clay, clay sand, sand, and hydrocarbon impregnated sand. The specific resistivity value of clay varies from 23.1 to 38.4 Ωm. The resistivity of sand clay is 62.7 Ωm, the resistivity of clay sand is 86.9–103 Ωm, the resistivity range is 170–945 Ωm for sand and hydrocarbon-impregnated sand ranges from 1168 Ωm to 417559 Ωm. The hydrocarbonaceous sand lies in the 1.25–9.6 m depth range relative to the surface. Twenty-three (23) different soil parameters were analyzed, including total organic carbon, heavy metals, soil texture and particle size (clay, sand, and silt), organic Carbon, exchangeable cations (Na, Ca, and Mg), electrical conductivity, salinity, nutrients (N, P, K), bulk density, and organic matter. The results show that the soil has changed in the mechanic village and in the control area. The pH value of automotive machinery floor is acidic, which ranges from 4.6 to 5.2 compared to the control point, with an average of 6.35. The value of heavy metals in the soil of automobile machinery is higher than that of the control. It turns out that disposing of old engine oil on the ground can have a negative impact on soil quality. Therefore, it is recommended that there should be legislation preventing the dumping of waste oil and lubricating oil on the surface of the earth in Surulere Mechanic Village without treatment before disposal.

Keywords: Motor oil, surulere, dipole-dipole, resistivity, soil, disposal, mechanic, samples

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INTRODUCTION

Since engine oil is used in automobiles, it absorbs many additional compounds from the wear and tear of the engine. It contains iron, steel, copper, zinc, lead, barium, cadmium, sulfur, dust, and ash. Disposal of used oils for additives and contaminants may have more adverse environmental impacts than crude oil contamination. These additives and contaminants can cause short-term and long-term effects when allowed to enter waterways and soil environments.[1]

When engine oil is drained from the engine, it is no longer clean because the lubricating oil picks up materials, dust particles, and other chemicals, i.e., the same lubricating oil during engine operation. When the used engine oil or transmission oil overflows onto the ground, the soil becomes rich with heavy metals, which can be drained into surface water and into groundwater. The process of metal corrosion by flushing automobile effluent to the ground is thus destroying the soil. Crude oil comes out environmentally on a regular basis during extraction, transportation, and storage. The ultimate destination for these

Address for correspondence: O. J. Airen, Department of Physics, Faculty of Physical Sciences, University of Benin, Benin City, Nigeria. E-mail: osariere.airen@uniben.edu

pollutants is to penetrate the freshwater aquifer. The characteristic geophysical reactions of hydrocarbon-contaminated media are due to a variety of physical, chemical, and biological mechanisms. Electrical methods are sensitive to a variety of changes in soil properties, including solid composition and void properties, water saturation, electrical resistance of fluids (chemistry of void fluids), and temperature.[2] All previously described variables have been found to be affected by biological activity that increases the complexity of the underground environment.

Soil is the most important non-renewable natural resource and is composed of microscopic and macroscopic flora and fauna diversity that plays an important role in maintaining soil quality and is active in performing major environmental functions.[3] A complex mixture of nutrients, organic matter, water, air, and organisms is determined by various environmental factors such as climate, base material, embossing, organisms, and time factors.[4] Disposing of used motor oil on land can minimize microbial abundance and diversity in the soil, leading to loss of soil quality.[5] Such changes affect soil quality on a global scale, and exacerbations impede economic growth and a healthy environment.[6] Soil quality includes soil physical, chemical, and biological properties that depend on soil nutrient pools and reserves, which are regulated by land use and many other management factors.[7] Mechanic workshops accidentally or intentionally release gasoline, diesel, solvents, oils, and lubricants to land and air.

Most of these petroleum products are organic and synthetic chemicals that are highly toxic and have the potential to pose a risk to soil fauna and humans. According to,[8] used oil is less viscous than unused oil. When disposed of in the soil, it reduces the adsorption porosity to soil particles and thus reduces the aeration of the soil[9] and.[10] These have ways of affecting soil quality: physical, chemical, and biological components/parameters associated with heavy metal contamination. In Surulere Mechanic Village, auto mechanic repairs involve the disposal and spillage of oils, greases, gasoline, battery electrolytes, paints, and other materials including heavy metals. This waste oil usually contains additives such as amines, phenols, benzene, petroleum, hydrocarbons, chlorinated phenyl. Pollution from Disposal of used engine petroleum is one of Nigeria's environmental issues and this calls for emergency attention.[11]

In Nigeria, pollution problems associated with incidents of oil spills around automobile-repair workshops, resulting in contamination of soil, have been the subject of many reports.[12] It is, therefore, necessary to assess the extent of contamination resulting from the dumping of lubrication oil using electrical resistivity method and soil samples.

Geology of the Study Area

The study area (mechanic village, Surulere) is located in Surulere Local Government Area of Lagos State, Nigeria. It lies within longitude 3° 15′ 0″ E and 3° 30′ 0″ E and latitude 6° 15′ 0″ N and 6° 30′ 0″ N. The state lies in Southwestern Nigeria and the formations found here occur within the sedimentary series. The state overlies the Dahomey basin which extends almost from Accra in Ghana, through the Republic of Togo and Benin to Nigeria where it is separated from the Niger Delta basin by the Okitipupa rigde at the Benin hinge flank.[13] It is a residential and commercial Local Government Area located on the mainland of Lagos in Lagos State, Nigeria, with an area of 23 km² (9 sq mile). At the last census in the year 2006, there were 503,975 inhabitants, with a population density of 21,864 inhabitants per square kilometer. [Figures 1 and 2] display the geological map of Nigeria and the geological map of Lagos state respectively.[14]

METHODOLOGY AND DATA PROCESSING

The dipole-dipole array method was used for the 2D resistivity imaging data acquisition. These electrode configurations are well suited for data acquisition systems so that many data points can be recorded simultaneously for each current injection. A two-dimensional resistivity survey was carried out using the PASI Terrameter. Measurements were made at sequences of electrodes at 5 m interval using four (4) electrodes for all the five (5) traverses covering a distance of 100 m each within the mechanic workshop. Four traverses on the affected part and one traverse serves as control. The Res2Dinv software was used for the inversion of the 2D resistivity data. The field data pseudo section and the 2D resistivity structure were produced after running the inversion of the raw data to filter out noise. Samples of the soil were collected from the topsoil, 0–15 cm and from the subsoil, 15–30 cm with the aid of soil auger, in one point at the mechanic workshop (mechanic land use) and one serving as the control. The samples were transported to the laboratory, air-dried, ground, and sieved through 2 mm mesh size sieve and subjected to physical, chemical, and biological

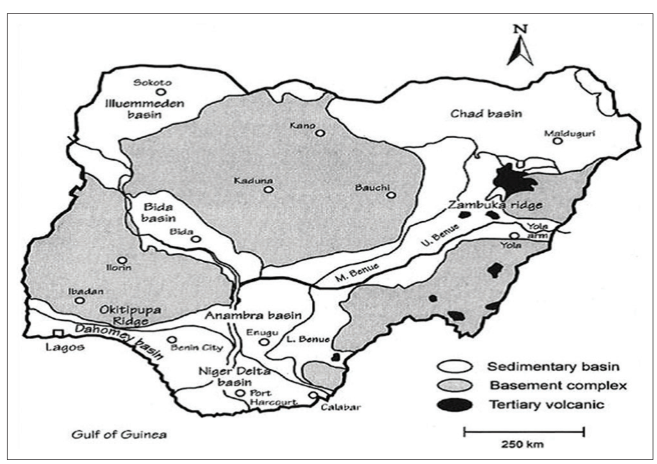

Figure 1: Geological Map of Nigeria[13]

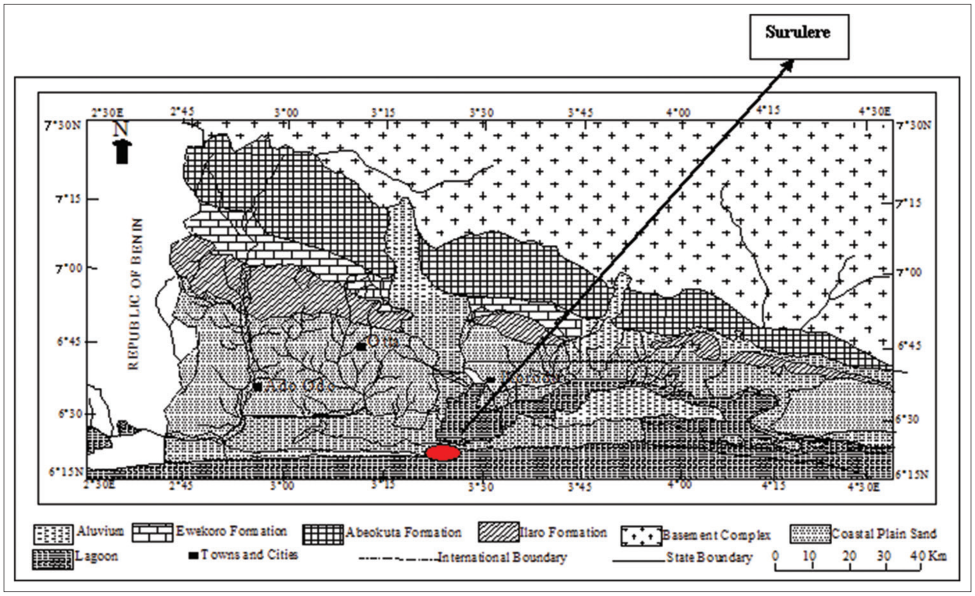

Figure 2: Geological Map of Lagos State showing the location area[14]

analysis. Soil Particle Size Distribution was analyzed using the Bouyoucos hydrometer method. The dried soil sample was dispersed with a solution of sodium hexametaphosphate and sodium carbonate (8 g/l) in a <2 mm mesh size. 5 ml of distilled water was added to enhance the texture and stirred while the content of the container was transferred quantitatively into a liter measuring cylinder and first reading was taken 40 s.

Textural triangle was used to obtain the sand, silt, and clay fractions. Soil moisture content was determined by using an oven drying method (because of the reliability) in which samples were dried to constant weight at 105°C[15] and the differences in mass of wet and dry samples recorded and expressed in percentage. Soil bulk density was determined using the core method of Grossman.[16]

Exchangeable cations of Sodium, Potassium, Magnesium, and Calcium ions were extracted according to the ammonium acetate extraction method[17] as modified.[18] Wet digestion method was used for determination of Organic Carbon and Organic Matter. Nitrogen was determined using Macro Kjeldahl method of (Bremner and Mulvaney, 1982). Soil pH, temperature, conductivity was determined using multi-probe meter. For heavy metal analysis, 1gram of sample was digested in 250 ml conical flask by adding 30 ml of aqua regia and heated on a hot plate until volume remains about 7–12 ml. This is to enable the sample to be efficient for further processes. The digest was filtered using what-man filter paper and the volume made up to the mark in a 50 ml volumetric flask and was then stored in a plastic container for Atomic Absorption Spectrophotometer analysis by thoroughly mixing the sample through shaking and 100 ml of it transferred into a glass beaker of 250 ml volume. The sample was aspirated into the oxidizing air-acetylene flame or nitrous oxide acetylene flame to facilitate absorption of radiation by atomic species during flame reactions. When the aqueous sample was aspirated, the sensitivity for 1% absorption was observed. Other parameters were determined using standard methods

RESULTS AND DISCUSSION

Figures 3-5 present the 2D electrical resistivity images across the mechanic village. Figures 6 and 7 is the control traverse. Lateral distance of 100 m was covered and a maximum depth of 9.26 m was imaged across all the traverses. Resistivity values generally vary from 86.9 to 417559 Ωm across the traverses but on the control traverse, the resistivity values vary from 23.1 to 760 Ωm. Two to four resistivity structures are delineated which are indications of clay, sandy clay, clayey sand, sand, and sand impregnated with hydrocarbon. The clay has resistivity values varying from 23.1 to 38.4 Ωm and occurs at a depth range of 6.38–9.26 m. The sandy clay has resistivity value of 62.7 Ωm, clayey sand with resistivity values ranging from 86.9 to 103 Ωm, sand having resistivity values ranging from 170 to 945 Ωm and sand impregnated with hydrocarbon has resistivity values varying from 1168 to 417559 Ωm across the location. Sand impregnated with hydrocarbon is relatively surficial at depth range of 1.25–9.6 m. The clay/sandy clay/clayey sand/sand is widely distributed across the study area. It is important to note that the sand impregnated with hydrocarbon is evident and mapped across traverses 1, 2, 3, and 4 only in this location [Figures 3-6]. Conductive zones at the same horizontal interval on the 2D resistivity section. The control traverse [Figure 7] shows no evidence of the presence of sand impregnated with hydrocarbon whatsoever. This clearly agrees with the elevated values of earth resistivity of the subsurface resistivity structures

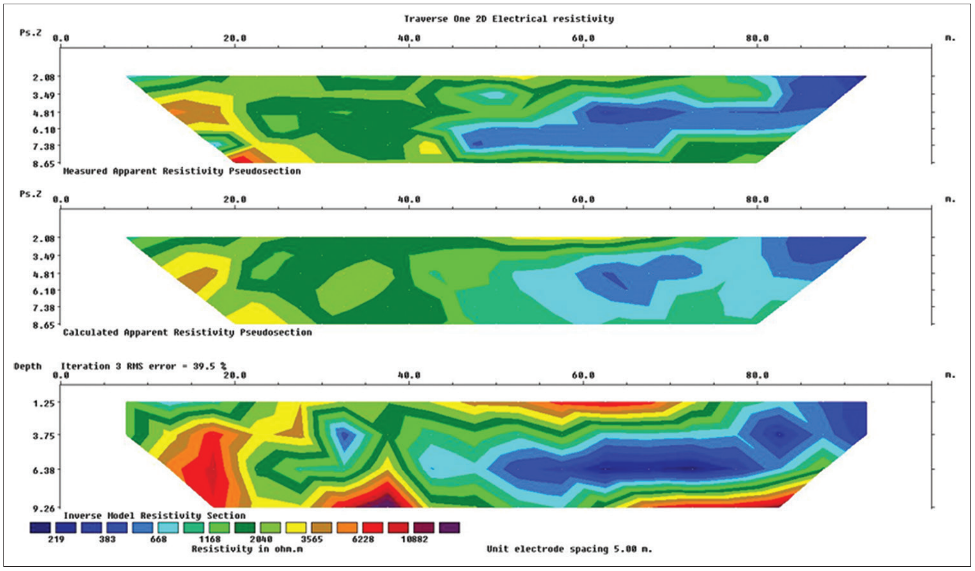

Figure 3: 2D resistivity sections along traverse 1

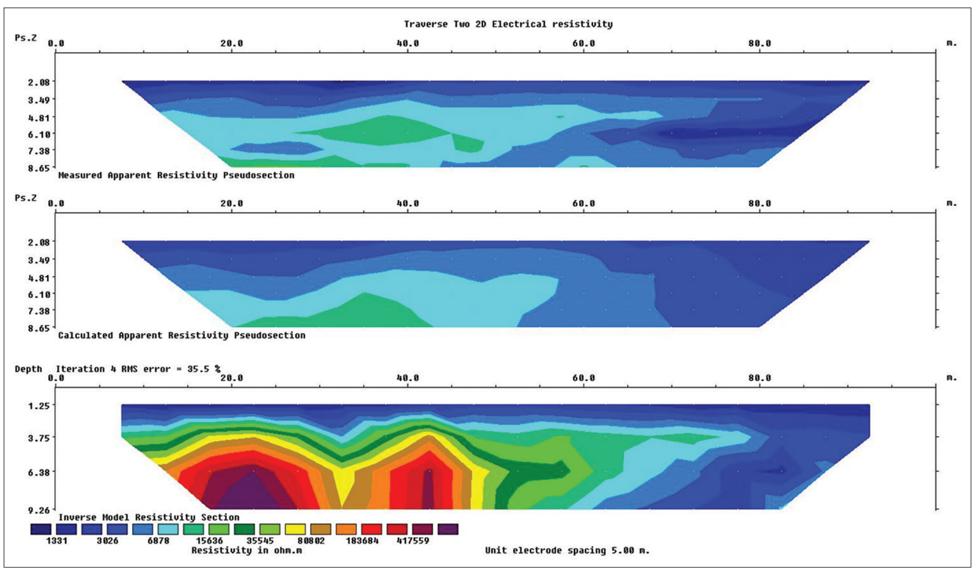

Figure 4: 2D resistivity sections along traverse 2

across the traverse when compared to other traverses in this location.

Table 1 shows the distribution of soil particle size. In the table, using Wentworth size classes with the diameter of the mesh size (mm) in the textures of the ground, the average sand values were high in all stations and more control. The distribution of the size of the soil particles has determined the texture of the soil which, in turn, affected the ease or difficulty in which the soil particles have been highlighted and transported in the process of soil erosion (erodibility) Thus, the particle size distribution has been used to explain erodability, as different soils have different trends in their erodability, as shown in the K value [Table 2]. Soils with the highest percentage of sand were fragile in the structure, well drained, well ventilated, and very erodable. The erodibility of the soil is derived from the properties of the soil, including the texture, structure, permeability, and organic matter and quantifies the consistent nature of a type of soil and their resistance to displacements and transport due to the ‘impact of raindrops and horrible flow shear forces.

From Table 3, the value of the pH was more acidic in the Mechanic village than in the control village, then fell with a depth range of 15–30 cm. The electrical conductivity was higher in the mechanical floor and had significantly higher conductivity values than in the control medium. The high conductivity can be explained by the presence of a certain amount of metal substances in the waste of the Mechanic village, whose contents were finally washed in the soil below

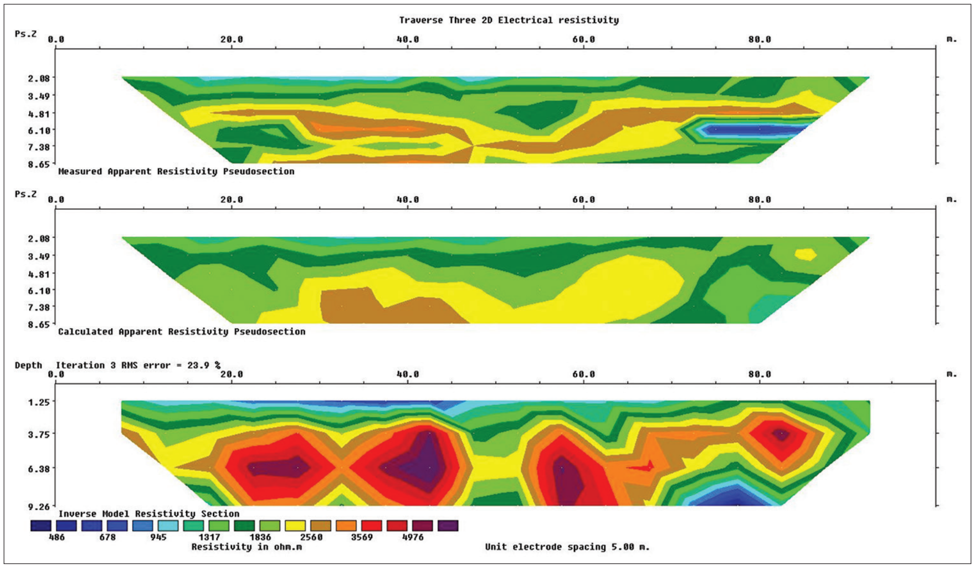

Figure 5: 2D resistivity sections along traverse 3

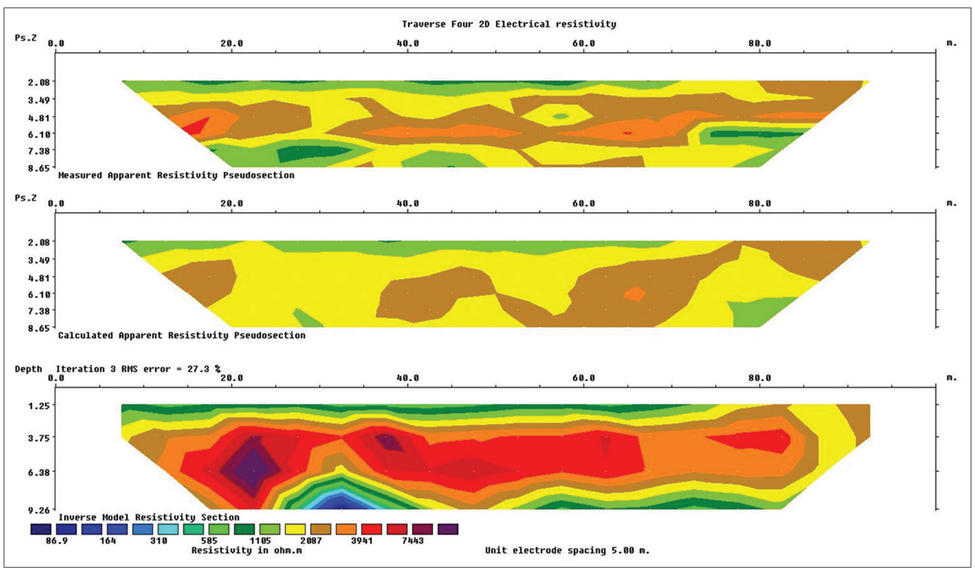

Figure 6: 2D resistivity sections along traverse 4

and therefore resulted in an increase in the concentration of certain ions such as sodium, calcium and other. The level of knock on the soil of the Mechanic village was higher than that of the control soil. This indicates the possible presence of organic matter, which tends to increase with the addition of carbon substances, as was the case in this study due to the presence of oil residues and other carbonated fluids from cars. This can increase the presence of soil microorganisms that destroy organic compounds in soils. The value of the soil texture increased from 0–15 cm to 15–30 cm. The result showed that heavy metal concentrations in soil samples in the Mechanic village were higher than control as shown in Table 4. The high levels observed can be due to a large amount of used engine oil and other chemical fluids near-automatic repair villages. Copper, mercury, and nickel have had the highest concentrations of heavy metals analyzed in collected soil samples. The copper values recorded for the mechanical village were greater than the control station due to the electrical wiring, in addition to the oil used, and only a limited number of plants has probably survived the Coppertel floors, according to.[19] Cadmium was found in both soils, but the concentration on the control soil was much smaller than in the village. The presence of cadmium can be attributed to the storage of PVC plastics, nickel batteries, engine oil, and sewage sludge from cars. When mixing with the ground, they turn into different moving forms before entering the drainage of the environment. The accumulation of cadmium in the environment is a certain threat to human health because it can accumulate in the

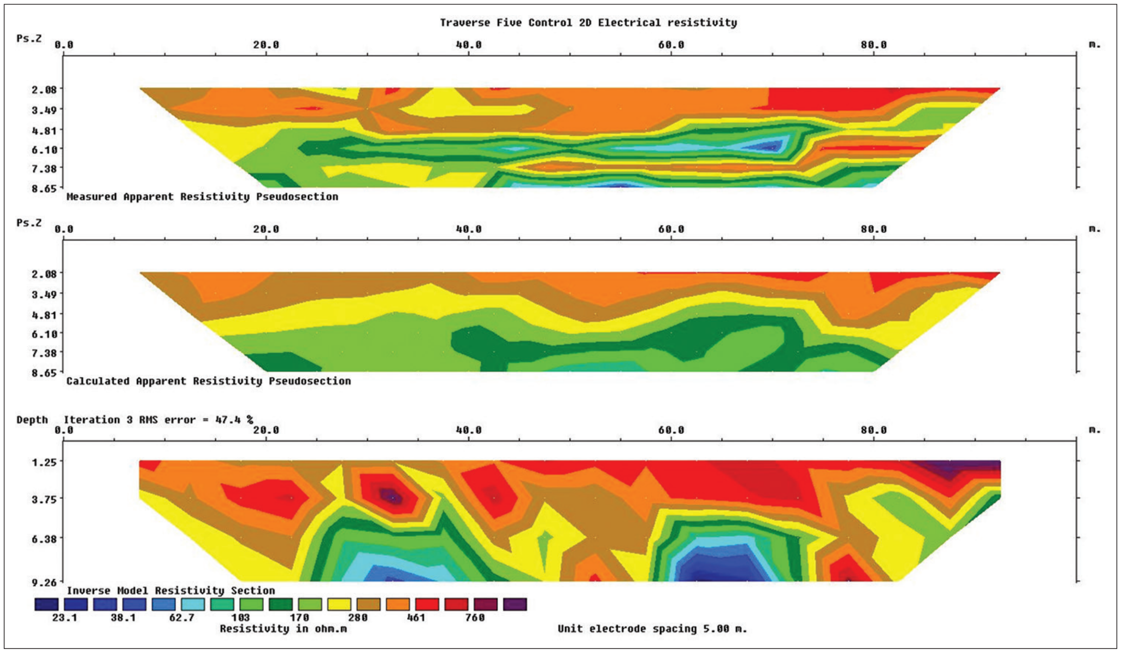

Figure 7: 2D resistivity sections along traverse 5 (Control)

Table 1: Particle size distribution for the soil samples

Mesh Size (mm)	Soil Sample 0–15 cm	Soil Sample 15–30 cm	Soil Sample Mean	Control 0–15cm	Control 15–30 cm	Control mean
4.75	–	–	–	–	–	–
3.35	–	–	–	–	–	–
1.18	4.2	1.21	2.705	–	0.54	0.27
1	2.5	7.86	5.18	–	3.24	1.62
0.452	52.5	45.6	49.05	55.41	60.42	57.915
0.3	14.4	12.64	13.52	21.2	11.43	16.315
0.212	18.1	15.51	16.805	19.53	18.1	18.815
0.125	4.8	3.72	4.26	3.34	4.22	3.78
0.106	1.2	1.33	1.265	0.32	0.77	0.545
0.075	0.8	1.5	1.15	0.02	0.45	0.235
0.053	–	–	–			
<0.053	1.5	10.63	6.065	0.18	0.83	0.505
TOTAL	100	100	100	100	100	100

Table 2: Soil erodibility values (K values for different soils)

Soil type	K–Factor
Clay	0.30
Concretionary clay	0.17
Sandy clay	0.20
Sandy loam	0.13
Sandy	0.02
Loam sand	0.04

skin, blood, lungs, muscle tissues, liver, tissues, and organs, which causes various diseases. Nickel had a concentration of 0.079. The overall contribution of nickel to the environment is about 150,000 and 180,000 metric tons per year of natural and anthropogenic sources, including emissions from fossil fuel consumption and industrial production. Lead, mainly derived from the escaped fumes of the car, is still used as petrol additives in various automotive lubricants in Nigeria. It is estimated that about 2,800 metric tons of vehicle lead emissions are deposited each year in the urban areas of Nigeria.

Table 3: Results of the physiochemical parameters and their mean distribution

Parameters	Soil Sample 0–15 cm	Soil Sample 15–30 cm	Soil Sample Mean	Control 0–15 cm	Control 15–30 cm	Control Mean	FMENV/SPDCEIA/ JAPAN EVM Standards
pH	4.6	5.2	4.9	6.5	6.2	6.35	6–8
Temperature	26	27.8	26.9	27.5	25.6	26.55	20–30
Conductivity, µs/cm	130	140	135	88	58	73	100
Salinity, mg/L	4538.1	4708.8	4623.45	6491.1	5842.4	6166.75	–
Sodium, mg/L	6.328	7.482	6.905	6.877	7.875	7.376	–
Calcium, mg/L	13.893	15.909	14.901	13.763	12.323	13.043	–
Total Chloride, mg/L	4730.4	7548.8	6139.6	3875.7	2548.5	3212.1	–
Nitrate (NO), mg/L	69.8	47.8	58.8	25.5	5.2	15.35	–
Nitrate –Nitrogen (NON), mg/L	16.5	7.8	12.15	5.8	1.8	3.8	–
Potassium, mg/L	6.219	5.128	5.635	5.328	6.376	5.852	–
Phosphorus (P), mg/L	18.2	16	17.1	9.8	7.6	8.7	–
Iron, mg/L	0.045	0.053	0.049	0.019	0	0.0095	–
Manganese, mg/L	0.432	0.248	0.34	0.086	0.018	0.052	–
Copper, mg/L	1.065	0.849	0.957	0.464	0.567	0.5155	–
Zinc, mg/L	0.054	0.066	0.06	0.045	0.036	0.0405	10–120
Arsenic, mg/L	0.054	0.064	0.059	0	0	0	5–50
Cadmium, mg/L	0.016	0.020	0.018	0.003	0.01	0.0065	0.01–1.4
Mercury, mg/L	0.138	0.289	0.2135	0.067	0.007	0.037	0.1
Lead, mg/L	0.028	0.019	0.0235	0.013	0.008	0.0105	0.01–20
Nickel, mg/L	0.079	0.115	0.097	0.022	0.019	0.0205	25
Bulk density, g/mL	1.354	1.202	1.278	1.412	1.305	1.3585	–
Organic matter, %	8.8	5	6.9	2	4	3	–
Total Organic Carbon, %	7.48	8.52	8	0.57	2.64	1.605	–

Table 4: Soil texture

Textural Class Percentage	Soil Sample 0–15 cm	Soil Sample 15–30 cm	Soil Sample Mean	Control 0–15 cm	Control 15–30 cm	Control Mean
Pebble stone	0	2.35	1.175	0	0	0
Very coarse sand	3.85	1.23	2.54	0	0.38	0.19
Coarse sand	2.54	7.55	5.045	0	2.69	1.345
Medium sand	62.75	54.5	58.625	75.45	69.54	72.495
Fine sand	19.55	25.24	22.395	19.85	22.8	21.325
Very fine sand	0.72	1.5	1.11	0.06	0.35	0.205
Silt	1.56	12.16	6.86	0.18	0.75	0.465

CONCLUSION AND RECOMMENDATION

This study revealed significant higher values in changes in chemical-physical, resistivity, and variables of the mechanical village laboratory which of the soils mainly controlled by automatic mechanical work activities, such as service, maintenance, and elimination of exhausted oils and exhausted lubricants. This can lead to danger to the environment due to the possibility of pollution of water resources nearby through the outflow. Heavy metals had higher values in the automatic mechanical soil than on the control. This has shown that the removal of engine oil used on the ground negatively affected the quality of the soil. Furthermore, the soil data generated by this research has actually provided empirical needs for sustainable soil and management planning near the study area for better non-contamination and sustenance pollution. Therefore, it is recommended that exhausted oil is adequately unleashed by the sustainable environment in the Surulere Mechanic Village. There should be a supervision and constant legislation to stop the indiscriminate spillage of oil and exhausted lubricants on the ground surface without adequate control on such plans.

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