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IMAGING FOR THE SPREAD OF CONTAMINANTS AROUND CHALLAWA RIVER

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ABSTRACTS

The electrical resistivity tomography data are collected here manually at 5m intervals, then 10m, 15m, 20m and 25m having a total of 40 electrodes covering a spread of 200m. Four profiles were covered and the data were processed to display the variations of electrical resistivities using the ZondRes2D software. There are four Profiles and they all crossed the river. The results of this survey in correlation with a geology of the area revealed four layers: The topsoil, which consists of resistivity range 1300 to 1500Ωm and changing laterally to resistivity range 2400 to 2800Ωm which indicates the presence of laterite and its thickness varies between 0.01 m to 10 m. 2100 to 2400Ωm, the resistivity then varies above this range to the left of the section. At the northern edge of the river from 110 to 175m, the layer has constant resistivity range 9000 to 11000Ωm. Its thickness ranges between 10 m to 15.00 m. The 2D Inversion delineated contamination plumes as zones with low resistivity values ranging between >350Ωm and 193Ωm, from the ground surface to varying depths of 0.6-1.6 m in profile 1 and in profile 3 the resistivity range 550 to 610Ωm have been detected at 200m, believed to be leachate derived from decomposed industrial effluents of higher concentrations. physico-chemical analysis was conducted from three samples, Protected Dug Well from Magasawa 350m from the edge of the River, Borehole from Yansama between profile 3 and 4 at the southern edge of the River, and Downstream from the River between profile 2 and profile 1. The water quality reports show that there are high concentrations of sulphur (164mg/l), chromium (0.81mg/l), and iron (1.10mg/l).

Keywords: Contaminants, Resistivity, Imaging, Effluents, Challawa River.

INTRODUCTION

The earths subsurface have become the safest and most abundant source of potable water as it is often shielded from direct human activities. However, any undetected contamination of this resource poses a threat not only to the well-being but the condition of the ecosystem as a whole (Enikanselu, 2008). During the last few decades, due to increased industrialization, urbanization and agricultural activities, quality of groundwater and surface water has deteriorated considerably in many parts of the globe. This has caused great concern particularly in the developing countries. Contamination of groundwater can take place either from a wider source like percolation from agricultural fields on account of the application of fertilizers and pesticides, or from a point source like waste disposal sites, tanneries etc. So, sources for water contamination can be natural, industrial, mining, municipal waste and radioactive waste disposals (Gebru, et al., 2012). One of the challenging issues facing mankind at this juncture is that of pollution of freshwater by various anthropogenic activities (Gaikwad, et al., 2014).

Tanneries use a large number of chemicals during the process, discharging toxic wastes (effluents) into the streams, which drain into rivers, thereby polluting the groundwater. Over the years the groundwater in the areas where tanneries are located, has become intolerably polluted (Ramesh and Thirumangai, 2014)

The water pollution is not only devastating to people but also to animals, aquatic life and birds. The impact of tannery waste water disposal leads to environmental problem, even though this problem persists for a long time, it has attracted serious attention only in recent time. The chemical characteristics of tannery waste water are enriched in synthetic chemicals, some less degradable solids and salts, in addition to the toxic and carcinogenic pollutant metal. The chemicals in leather processing which include ammonium sulphate,

formic acid, sodium bicarbonate, sodium silicofloride, sodium carbonate, sodium bisulphate, sodium sulphohydrate, chrome, celesal-k, sodium formate, nitric acid, sodium sulphide, potassium chloride, oxalic acid, hydrochloric acid, aluminium sulphate, caustic soda, lime powder, salt and sulphuric acid etc (Gebru, et al., 2012) .

AIM AND OBJECTIVES

Aim

The aim of the present work is to study the spread of contaminants around Challawa River as a result of influx of effluent from Challawa industrial estate using geoelectric imaging.

Objectives

The research seeks to determine:

1- The level and extent of groundwater pollution in the catchment area of the effluent.

2- To delineate the stratigraphic setting of the site.

MATERIAL AND METHODS

MATERIALS

Electrodes: these are terminals used for passing electric currents through the earth and received potentials; hence they are of two types; current electrodes and potential electrodes.

Electric Wire: this served as a current carrier, used in connecting battery with electrodes, also connecting Ammeter with battery and electrodes.

DC Battery: is the source of power where the current is generated. Its volt is 12V and Amps hour is 100.

Ammeter: a meter used in measuring currents. Digital multi-meter; it takes readings as low as 0.01 and analog ammeter which has the same range.

Voltmeter: a meter used in measuring voltages. Digital multi-meter; it takes readings as low as 0.01 and analog ammeter which has the same range.

Hammer: used in fixing electrodes.

Salt solution: this is used to add the earth's conductivity when poured around the electrodes, so that the current will be detected in the Ammeter.

Tape rule: this is used for measuring the length of profiles and distance between them.

METHODS

The electrode array used for data acquisition was Wenner array. The first profile was initially set with 5m spacing between the electrode positions. Measurements started by placing the first current electrode (C_1) at position one, the first potential electrode (P_1) at position two, the second potential electrode (P_2) at position three and the second current electrode (C_2) at position four (Figure 2.3). Measurement was repeated by shifting the electrodes by 5.0m to the next set of points. The procedure was repeated until the pegged out points on the profile was covered.

The next set of readings were taken by increasing the spacing between the electrodes to 10.0m until was covered. The remaining measurements were conducted by extending the electrodes spacing by 5.0m until a maximum of 25.0m was achieved.

In the course of field work, the Multimeters were used to record the current (A) and voltage (V) alongside the electrode spacing as shown in Table 3.2.

In a typical survey, most of the fieldworks are in laying out the cable and electrodes. The currents used in surveys described as 'direct current' or *DC* are seldom actually unidirectional. Reversing the direction of flow allows the effects of unidirectional natural currents to be eliminated by simply summing and averaging the results obtained in the two directions. DC surveys require current generators, voltmeters and electrical contact with the ground. Cables and electrodes are cheap but vital parts of all systems, and it is with these that much of the noise is associated.

RESULTS

Table 1: Data collected in Profile 1 (5m spacing)

Spacing, a = 5m				
S/N	I(A)	V(V)	R (Ω)	ρ(Ωm)
1	7.90	99.40	12.58	395.08
2	6.40	172.70	26.98	847.31
3	6.00	85.10	14.18	445.36
4	0.10	4.20	42.00	1318.80
5	8.70	64.90	7.46	234.24
6	0.10	141.70	1417.00	44493.80
7	1.00	246.00	246.00	7724.40
8	1.00	97.50	97.50	3061.50
9	1.00	0.30	0.30	9.42
10	1.00	1.50	1.50	47.10
11	0.19	0.10	0.53	16.53
12	0.01	0.10	10.00	314.00
13	0.10	0.10	1.00	31.40
14	0.02	1.60	80.00	2512.00
15	0.10	0.30	3.00	94.20
16	0.10	2.70	27.00	847.80
17	0.10	0.20	2.00	62.80
18	0.10	1.40	14.00	439.60
19	0.10	0.40	4.00	125.60
20	0.60	1.20	2.00	62.80
21	0.40	2.00	5.00	157.00
WIDTH OF THE RIVER = 57m				
22	0.10	0.20	2.00	62.80
23	0.10	0.10	1.00	31.40
24	0.30	0.10	0.33	10.47
25	0.10	0.10	1.00	31.40
26	0.20	0.20	1.00	31.40
27	0.10	0.20	2.00	62.80
28	0.10	0.20	2.00	62.80
29	0.20	0.10	0.50	15.70
30	0.30	0.30	1.00	31.40
31	0.10	0.60	6.00	188.40
32	0.10	0.20	2.00	62.80
33	0.10	0.10	1.00	31.40
34	0.30	0.20	0.67	20.93
35	0.10	0.20	2.00	62.80
36	0.10	0.10	1.00	31.40
37	0.10	0.10	1.00	31.40

Table 2: Borehole log of Kayi Kumbotso Local Govt. **(**Millenium Development Goal (MDG), 2012).

S/N	Lithological layers	Depth(m)
1	Top soil	0 to 6m
2	Laterite	6 to 10m
3	Weathered basement	10 to 15m
4	Fractured basement	15 to 25m
5	Fresh basement	<25m

.

Table 3: locations of the Profiles

S/N	Profile	Start point	Start point	End point	End point
		Latitude	Longitude	Latitude	Longitude
1	1	11°52′22.32″N	8°29′4.56″E	11°52′5.44″N	8°28′56.32″E
2	2	11°52′36.07″N	8°28′54.85″E	11°52′25.42″N	8°28′38.75″E
3	3	11°52′42.23″N	8°28′38.27″E	11°52′30.73″N	8°28′27.43″E
4	4	11°52′46.68″N	8°27′57.36″E	11°52′37.02″N	8°27′58.75″E

Table 4: Generated Resistivity values

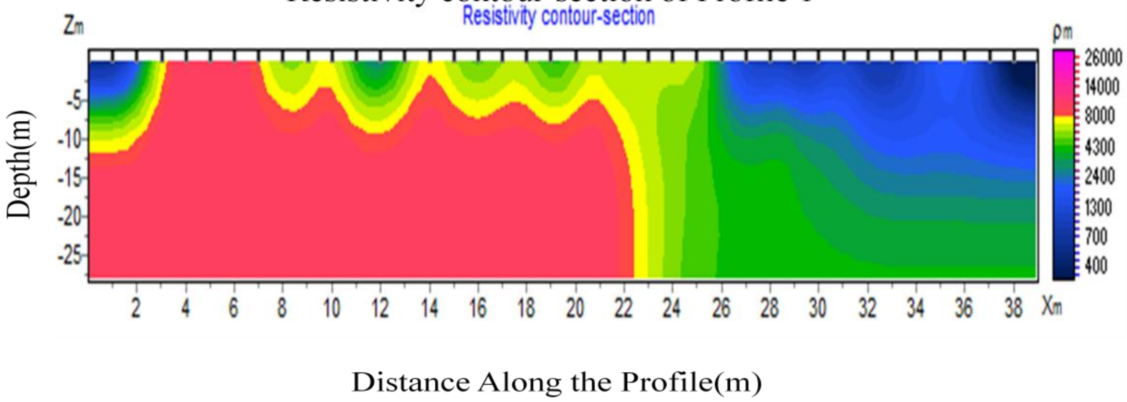
S/N	**Resistivity(Ωm)**	**Depth(m)**	**Rock Type**
1	800-3200	0-15	Top Soil(loose sand)
2	3200-3700	15-18.5	Laterite
3	3700-4300	18.5-20	Weathered Basement
4	4300-5000	20-25	Fractured Basement
5	5000-5900	>25	Fresh Basement

DISCUSSIONS ON THE RESULTS

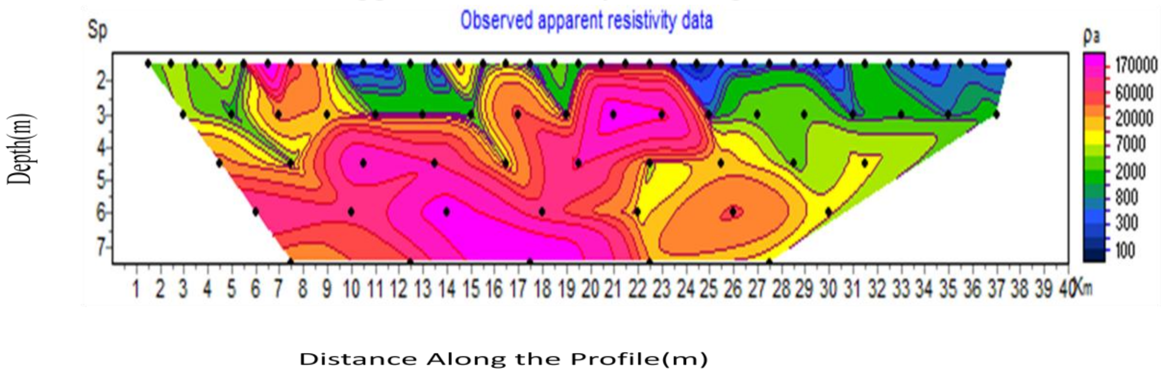
The models obtained from 2D inversion of the field data using different starting models mainly showed that the inversion algorithm was stable. After that, comparison of the measured apparent resistivity pseudosection and the calculated apparent resistivity pseudosection and Geological sections resulted in a reasonably good agreement with the inverse model resistivity section or contour section. As a result, this demonstrates the stability of the 2D inversion algorithm that can give reliable models. The results of this survey revealed five layers: the topsoil, which consists of loose sand, has resistivity values between 500Ωm and 5000Ωm and its thickness varies between 0.01m to 10.00m. The second layer, is the laterite, and has resistivity values between 800Ωm and 1500Ωm. Its thickness ranges between 10m to 15.0m. The resistivity of the weathered sphalerite which forms the third layer ranges between 1000Ωm to 10000Ωm.Also the fourth layer is the fractured basement that has the same resistivity range with the third one. Then the fresh basement which is greater than 9000Ωm. The 2D Inversion delineated contamination plumes as zones with low resistivity values ranging between greater than 350Ωm and 193Ωm, from the ground surface to varying depths of 0.6-1.6 m in profile 1 and in profile 3 the resistivity range 550 to 610Ωm have been detected at 200m, believed to be leachate derived from decomposed industrial effluents of higher concentrations (Reynolds, 1997).

The presence of Iron in the three samples is unacceptable, the borehole contains (0.5 mg/l), protected dug well, 0.00mg/l and that of river, 1.10mg/l, Nigerian Industrial Standard, NIS, 0.30mg/l World Health Organization (WHO), 0.1mg/l. The analysis of chromium according to NIS is 0.05mg/l which is equivalent to WHO, for borehole is 0.32mg/l protected dug well is 0.31mg/l and for the river is 0.81/l (World Health Organization Guidelines for Drinking-water Quality in third edition (2008) and fourth edition (2011)).

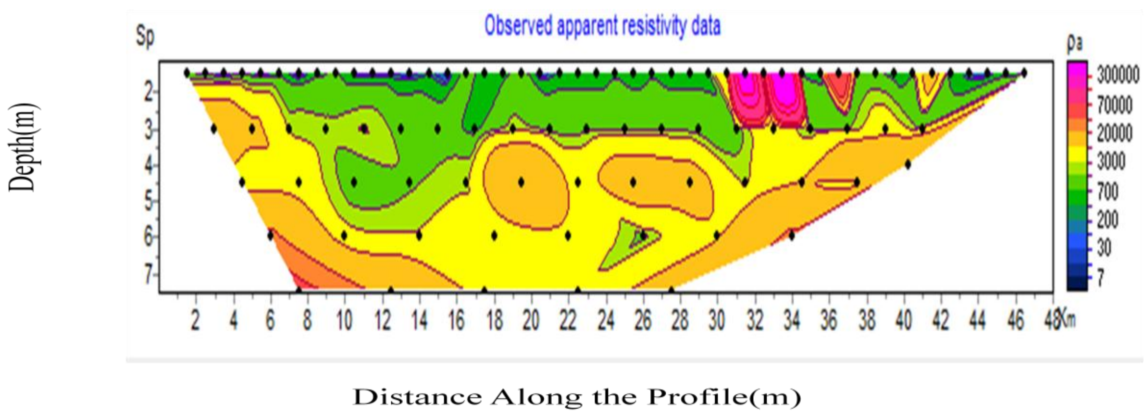
Resistivity contour-section of Profile 1



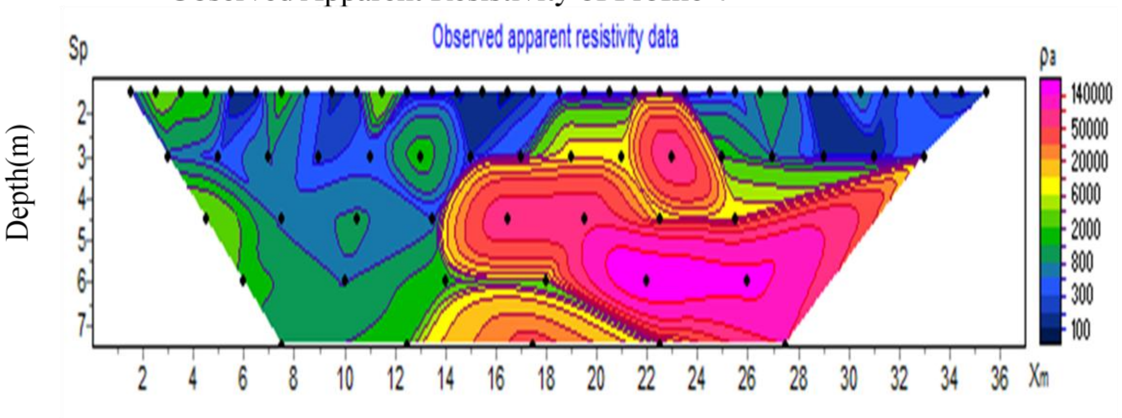
Observed Apparent Resistivity data of profile 2



Observed Apparent Resistivity data of Profile 3



Observed Apparent Resistivity of Profile 4



Distance Along the Profile(m)

In profile 1 there are two zones that have low resistivity due to presence of decomposed rocks to weathering. The model of the area shows different outcrops and the rock was granite but due to the exposure of the rock to weathering it decomposed to rhyolite and phyolite then to trichate which is silicious finally to schist and migmetite as indicated in the geology and the borehole of the area. This decomposition was solely due to the Industrial contaminants that are passing through porous materials in the subsurface.

The water quality reports of borehole which is about 250m from the fourth profile, downstream river which contain the contaminants from the effluent of the industrial, and protected dug well which is about 350m from edge of the river to Magasawa town, show that there are high turbidity in river and protected dug well 1310 Nephelometric Turbidity Units (NTU) which exceeded the NIS (5.00NTU), for the borehole (2.32NTU) is acceptable also for that of protected dug well is acceptable according to NIS, but the World Health Organization (WHO) standard is 1.5 NTU which is the only borehole turbidity accepted (World Health Organization Guidelines for Drinking-water Quality in third edition (2008) and fourth edition (2011).

The physico-chemical analysis shows that there are high concentrations of sulphur, chromium, and iron. The presence of sulphur in the three samples shows the level of leaching to fractured zone and that is why we have very high resistivity in the layers which indicates the presence of ore mineral, sphalerite.

CONCLUSION

Geo-electrical imaging has been useful in mapping resistivity variations at the axis of Challawa River. Leachate could be inferred from the inverse model sections and geological sections in comparison with borehole data and water quality results: Results suggest leachate migration into the subsurface as well as its ingress into the surrounding soils. This result is supported by a geology of the area and the water quality. The study area is mostly characterized by five (5) layered geologic sections which include the Topsoil, Weathered basement, fractured basement and Fresh basement. The 2D Inversion delineated contamination plumes as low resistivity zones with resistivity values ranging between 350Ωm and 193Ωm, from the ground surface to varying depths of 0.6-1.6 m in profile 1 and profile 3, the resistivity range 550 to 610Ωm have been detected at 200m, believed to be leachate derived from decomposed industrial effluents of higher concentrations.

The results of water quality show that there are presences of heavy metals like Chromium and Iron in the river, protected dug well, and borehole, further research is highly advisable.

RECOMMENDATION

Based on the result of this research work, the following are recommended:

a) In order to obtain an overall picture of the leachate plume, an integrated approach employing the Seismic method, Vertical Electrical Sounding, induced Polarization and Electromagnetic method should be applied at the axis of the River around the industrial effluents.
b) Time-lapse resistivity technique, which is, measurement taken at least twice in a year spaced over a long period of time at the same grid point, should be applied in order to determine the rate of migration of the leachate.
c) Detailed geophysical survey should be conducted before the construction of any facility for dumping of domestic and industrial refuse. The result of the detailed geophysical studies will reveal subsurface structures that will be responsible for hydraulic contact between the leachate and the ground.
d) The populace should be sensitized on the danger of drinking leachate contaminated groundwater.
e) Government should as a matter of national priority discourage the practice of discharging of contaminants into the rivers most especially in residential areas, instead the Industries should maintain the policy of recycling of their effluents. This will go a long way in preserving the abundant natural groundwater as well as safeguarding the health of the nation, thereby preventing waste of public funds on health

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