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Mapping of Groundwater Contamination Using Electrical Resistivity Tomography in Eguare, Uromi, Esan North East Local Government Area, Edo State

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Abstract

Water is the basic need for any life to exist in this world, since surface water is in short supply one has to depend partly or wholly on groundwater. The electrical resistivity tomography was utilized in mapping groundwater contamination in Eguare, Uromi, Esan North East Local Government Area, Edo State. The wenner-schlumberger array method employing the petrozenith earth resistivity meter was utilized for data acquisition. Current spread of 150metres was used to map the subsurface of the study area and the maximum imaging depth was 14.48 metres. The Res2Dinv was used for data interpretation while the Surfer 11 software was used to obtain the 3D elevation model of the survey location. The result revealed the presence of resistivity anomaly indicating leachate plume in the two survey profile carried out in the study area which corroborates with the presence of high nitrite concentration from the physicochemical analysis of groundwater samples taken from hand dug well.

Keywords: Leachate plume, Hand dug well, World Health Organisation (WHO)

1.0 Introduction

Groundwater is widely distributed under the ground and it is replenish able resource unlike other resources of the earth. Groundwater includes all water found beneath the earth's surface. Groundwater is an economic resource and more than 85% of the public water for consumption is obtained from groundwater. It is often used for industry, commerce, agriculture and most importantly for drinking [1]. Lack of public water system in the rural areas and the inability of water facilities to function effectively in the towns and cities of Nigeria have made it impossible for most of her population to have access to portable water [2], 52 percent of Nigerians have no access to improved drinking water supply [3]. Sources such as rivers, boreholes, streams, wells, ponds and rain are still very much depended upon for water needs. In recent times, the impact of leachate on groundwater has attracted a lot of attention because of its overwhelming environmental significance. Protection of groundwater is a major environmental issue since the importance of water quality on human health has attracted a great deal of interest lately. Assessing groundwater quality and developing strategies to protect aquifers from contamination are necessary for proper planning and designing water resources [4]. However, in the absence of pipe borne water the people of the study area depend on hand dug wells and therefore has no means of judging the safety and quality of water themselves. The study therefore aims to use the electrical resistivity tomography to map the subsurface contaminant plume evidence from the physicochemical analysis of groundwater samples taken from hand dug well in the study area.

2.0 Methodology

2.1 Water sample

Groundwater samples were collected from hand dug well in Eguare, Uromi, Esan north east local government area, Edo State with sterile polythene bottle. The samples for Nitrate and Heavy metals were pre-concentrated with tetraoxosulpahte (VI) (H_2S0_4) and trioxonitrate (V) ($HN0_3$) respectively on the field and were transferred to the laboratory to ensure quality

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assurance. The result from the physicochemical analysis of groundwater samples were compared with World Health Organisation (WHO) drinking water benchmark [5], to ascertain the health status of the water and also to identify inorganic chemical present in groundwater. The chemical characteristics include, pH, Total Dissolved Solids, Electric Conductivity, Total Suspended Solids, Hardness, Colour, Turbidity, Alkalinity, Nitrate, Nitrite, Zinc, Lead, Phosphate, Calcium, Copper, Iron, Magnesium, Manganese based on the procedures outlined in [6, 7, 8]. Their concentrations were established using standard laboratory procedures: pH meter, EC meter, Total Dissolved Solids meter, Turbidity meter, Titrometric method, Atomic Absorption Spectrophotometer (AAS) and UV Spectrophotometer.

2.2 Field Operations

The wenner-schlumberger array method utilizing the petrozenith earth resistivity metre was employed for the acquisition of data. Other essential components are hammer, measuring tape, cutlass, electrodes and the global positioning system device which was used to determine the geographic coordinates of longitude, latitude and altitude in metres of begin and end of survey line.

Theory

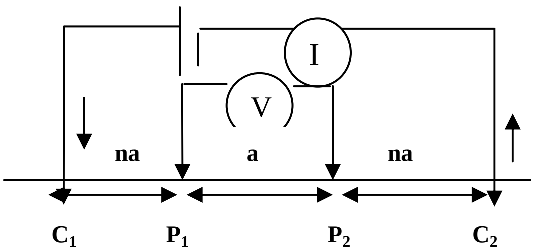


Fig. 1: Wenner-Schlumberger Array

The potential at P1 due to C1 and C2 is given by

$$VP1 = \rho_a \frac{I}{2\pi}\left[\frac{1}{na} - \frac{1}{(a+na)}\right] \quad (1)$$

Potential at P2 due to C1 and C2 is given by

$$VP2 = \rho_a \frac{I}{2\pi}\left[\frac{1}{(a+na)} - \frac{1}{na}\right] \quad (2)$$

Potential difference between P1 and P2 is given by

$$V = VP1 - VP2 = \frac{\rho_a}{2\pi}\left[\frac{1}{na} - \frac{1}{(a+na)} - \frac{1}{(a+na)} + \frac{1}{na}\right] \quad (3)$$

$$V = \rho_a \frac{I}{2\pi}\left[\frac{2}{na} - \frac{2}{(a+na)}\right] \quad (4)$$

$$V = \rho_a \frac{I}{\pi}\left[\frac{1}{a.n(a+na)}\right] \quad (5)$$

$$R = \frac{V}{I} = \frac{\rho_a}{2\pi}\left[\frac{1}{a.n\,(a+na)}\right] \quad (6)$$

$$\rho_{a=R\pi a.n\,(n+1)} \quad (7)$$

$$K = \pi an\,(n+1) \quad (8)$$

a = inter-electrodes spacing and n = data level

For measuring instrument indicating resistance the apparent resistivity ρ_a is given by:

$$\rho_{a=KR} \quad (9)$$

Where ***k*** is the geometrical factor for the Wenner – Schlumberger Array

Field parameters

Profile length	- **150 metres**
Number of profile	- **1**
Inter electrode spacing	- **5 metres**
Maximum data level	- **7**
number of electrodes	- **31**

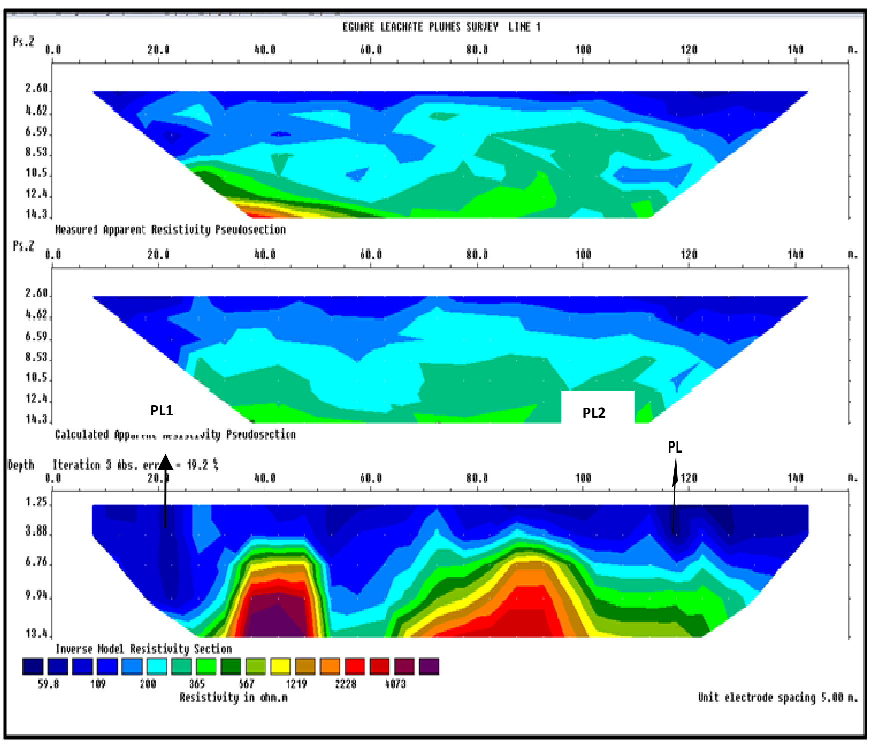
3.0 Results and Discussion

The physicochemical analysis of water sample taken from hand dug well in the study area is shown in Table 1. Apparent resistivity measurements recorded during the survey were entered into a text file in a format compactable with the Res2Dinv for data interpretation as shown in Figs. 2 and 3. The surfer 11.0 software was used to obtain the 3D elevation model of the survey area shown in Fig. 4.

Table 1: Test Results of Physicochemical Parameters

Parameters	**Units**	**Sample 1**	**WHO Limit**
pH		6.93	6.5-8.5
EC	$\mu s/cm$	85.60	1000
TDS	Mg/l	56.30	1000
TSS	Mg/l	Nil	N/A
Total Hardness	Mg/l	4.80	100-500
Turbidity	FAU	1.00	5.0
Colour	Mg/l Pt/Co	2.00	5.0
Alkalinity	Mg/l	68.00	500
Fe	Mg/l	0.03	0.3
Zn	Mg/l	0.02	5.0
Mg	Mg/l	0.39	50
Mn	Mg/l	BDL	0.1
Cu	Mg/l	BDL	1.0
Ca	Mg/l	1.28	75.0
NO_2	Mg/l	**4.96**	3.0
NO_3	Mg/l	0.05	10.0
Pb	Mg/l	BDL	0.05
PO_4	Mg/l	0.18	N/A

The physicochemical analysis from Table 1 shows that all the parameters analysed for water sample collected from hand dug well were within the World Health Organisation (WHO) drinking water benchmark apart from nitrite with a high value of 4.96 mg/l as against 3.0 mg/l World Health Organisation (WHO) benchmark for drinking water.



Survey Aim: To locate contaminant leachates plumes

Site Description: Eguare

State/Town/ LGA: Edo/Uromi/Esan North East

Begin/End Coordinates: N06^{0} 67.186′, E006^{0} 63.314 / N06^{0} 67.190′, E006^{0} 53.301′

Fig. 2: Geoelectric image of profile Line 1 Eguare

The resistivity anomaly labelled PL1 and PL2 is about 59.8 Ωm indicating the presence of leachate plume. PL1, hemispherical in cross section is laterally located between 20 metres and 23 metres marks and extends vertically to a depth of 9.94 metres. PL2 is laterally located between 116 metres and 118 metres marks and extends vertically to a depth of 3.88 metres. PL1 and PL2 occur at 1.25 metres below the ground surface and are separated by a distance of 95 metres.

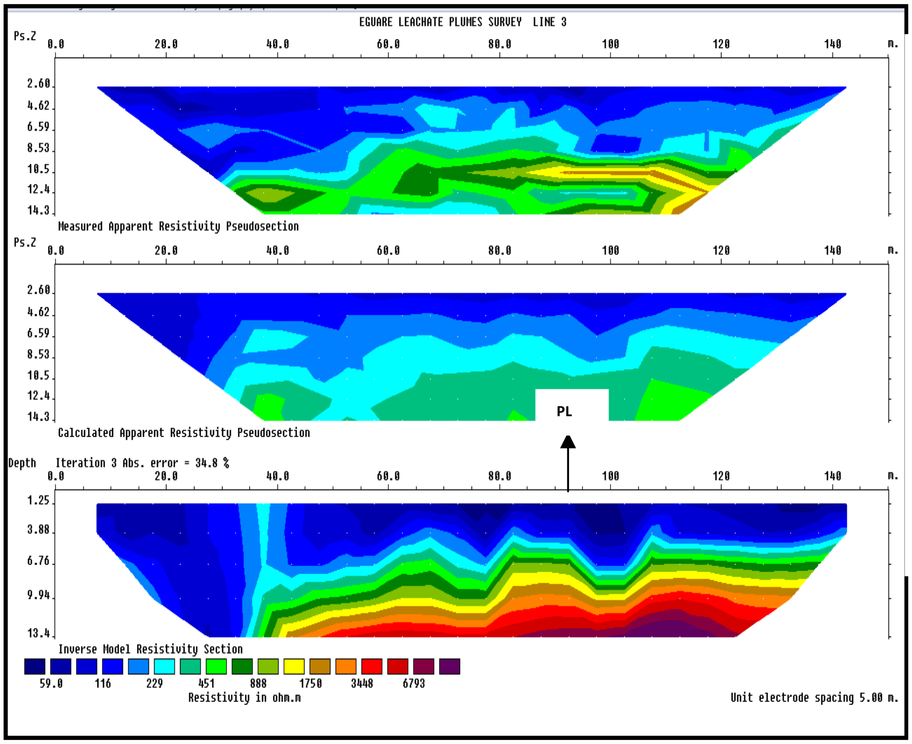


Fig. 3: Geoelectric image of profile Line 2 Eguare

Survey Aim: To locate contaminant leachates plumes

Site Description: Eguare

State/Town/ LGA: Edo/Uromi/Esan North East

Begin/End Coordinates: N06^0 67.184′, E006^0 63.314 / N06^0 67.194′, E006^0 63.305′

The resistivity anomaly present in the model section labelled as PL is about 59.0 Ωm indicating the presence of leachate plume. PL which is hemispherical in cross section is laterally located between 95 metres and 102 metres marks, occurs at 1.25 metres below the ground surface and extends vertically to a depth of 4.03 metres.
This gives a 3D view of the survey location. Showing the topography of the area. i.e the flow of water from a higher elevation to a lower area around the hand dug well location.

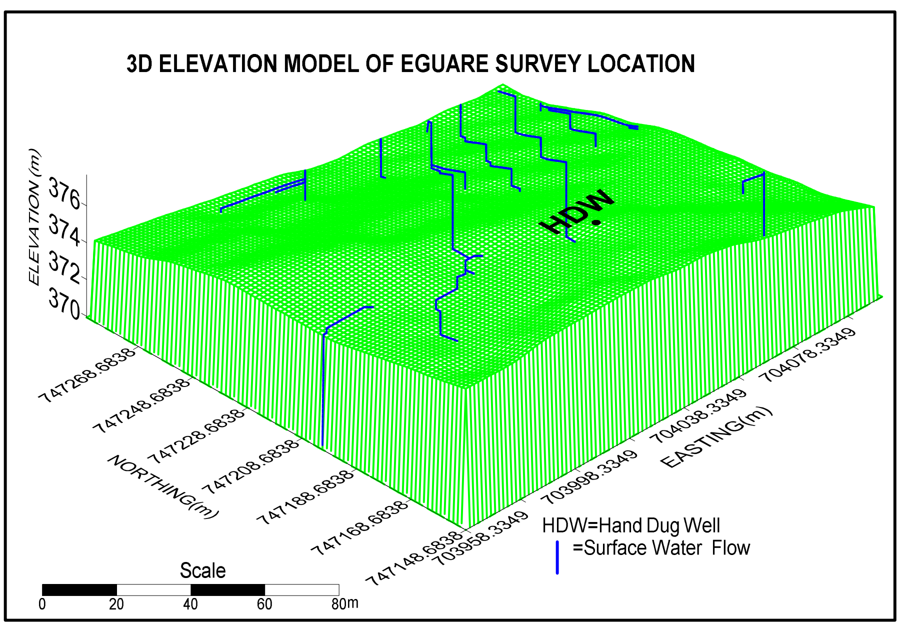


Fig. 4: 3D elevation model of Eguare survey location.

4.0 Conclusion

The wenner schlumberger array have been successfully deployed to delineate the geometry of the plumes in the subsurface which agrees with the presence of inorganic materials evidence of the physicochemical analysis taken from hand dug well in the study area. The high nitrite concentration value measured from hand dug wells were not within the World Health organisation (WHO) benchmark of 3.0 mg/l. The high level of nitrite concentration was due to the clusters of septic tanks and dump site around the hand dug well location and this could have adverse health implication such as the blue baby syndrome (BBS). However, with the absence of pipe borne water the people of the study area will continue to depend on hand dug well. It's therefore recommended that hand dug wells should not be sited along potential pollution sources, there should be periodic analysis of hand dug well water in the study area to provide early warning of consuming polluted water, ion exchange should be used to treat water with high nitrite concentration.

5.0 References

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