Kuwait J. Sci. **45 (4)** pp 82 - 92, 2018

Integrated geoelectric and hydrochemical assessment of Ilokun dumpsite, Ado Ekiti, in southwestern Nigeria

Olayiwola G. Olaseeni[1], Oluseun A. Sanuade[1,*], Solomon S. Adebayo[1], Michael I. Oladapo[2]

[1]*Dept. of Geophysics, Federal University Oye-Ekiti, Ekiti State, Nigeria;*

[2]*Dept. of Applied Geophysics, Federal University of Technology Akure, Ondo State, Nigeria*

**Corresponding author: sheunsky@gmail.com*

Abstract

A geophysical and hydrochemical assessment of Ilokun dumpsite in Ado Ekiti, southwestern Nigeria was conducted to assess its impact on groundwater quality. Eighteen Vertical Electrical Sounding (VES) were carried out, 17 within the dumpsite and one outside the dump periphery as the control. Three dipole-dipole traverses were also established, two within the dump periphery and one as the control outside the dump periphery. Hydrochemical analysis was carried out on water samples. The geoelectric sections and inverted 2D resistivity structures delineated three subsurface geologic layers made up of topsoil, weathered layer and fractured/fresh basement. The topsoil and weathered basement aquifer units within the dumpsite possessed low layer resistivity values of <60 Ωm and <100 Ωm, respectively. Hydrochemical analysis of water samples from the area around the dumpsite confirmed the groundwater pollution from 2.5 to >15 m deep. The pollution migration showed a predominantly southerly flow in line with the regional direction of groundwater flow. This suggests that the groundwater within the study area may constitute a major health risk for humans and require immediate attention by the authorities.

Keywords: Dumpsite; geophysical; groundwater; hydrochemical; pollution.

1. Introduction

The pollution of groundwater in and around waste dumpsites generally occurs as a result of the contaminants potential of leachate from the wastes. These leachates include solutions and/or suspensions of stabilized, mostly organic or inorganic complexes of biodegradation of solid waste components. They flow out from the refuse dumps and, saturated with rainwater flowing through them (Ganiyu *et al*., 2016; Olaojo *et al*., 2016).

The geoelectric method is very suitable for this kind of environmental study. This is because the ionic concentration of leachate is generally much higher than that of groundwater, which results in a large contrast in electrical properties when the leachate enters the aquifer. In addition, this method is able to identify these zones as an anomaly that enables the leachate plume to be detected (Bayode *et al*., 2011; De Carlo *et al.,* 2013; Fajana, 2013; Lateef *et al.*, 2015; Ugwu *et al.,* 2016).

Groundwater is the major source of potable water in the study area. The quality of groundwater is very important since it is necessary to understand the possible effects of leachate emanating from Ilokun dumpsite on the surrounding aquifer units (Fajana, 2013; Ganiyu *et al.*, 2016). Local human populations depend on the groundwater, so it must be monitored for health and safety reasons.

This study assessed the impact of leachates from a dumpsite on the quality of groundwater around Ilokun, Ado-Ekiti, in southwestern Nigeria by delineating subsurface lithology, determining the overburden thickness/depth of the bedrock, mapping contaminated zones and identifying the potential plumes and their direction of migration.

2. Description and geology of the study area

The Ilokun dumpsite is located at Ado-Ekiti, Ekiti State, Nigeria, which lies between Northings 850100 to 850600 and Eastings 748600 to 749900 in UTM (Fig. 1). It is owned and maintained by the Ekiti State Waste Management Authority (ESWMA). This dumpsite has existed for more than 20 years and is still in use today. The study area falls within the tropical climate zone with two distinct seasons. These are the rainy season (April–October) and the dry season (November–March). Generally, the climate is characterized by high and low diurnal, monthly and annual temperatures, high relative humidity and low atmospheric temperature (Olayinka & Olayiwola, 2001). The temperatures in the study area range from 21^{o} C and 28^{o} C and the humidity is high (Kottek *et al.,* 2006).

The study area is part of the Precambrian Basement Complex rocks of southwestern Nigeria. The rock types in the study area include charnockite, granite, porphyritic granite, and migmatite gneiss. The major rock type in the area is migmatite-gneiss, which covers about 60% of the area (Fig. 2).

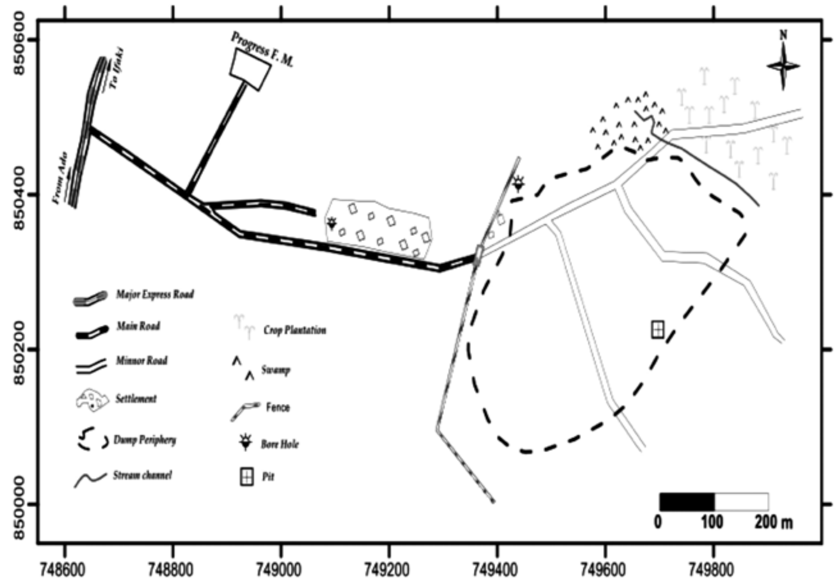

Fig. 1. Base map of Ilokun dumpsite Ado Ekiti

3. Data acquisition and processing

Geophysical investigations involving dipole-dipole and Vertical Electrical Sounding (VES) arrays were carried out using a Campus Ohmega resistivity meter. Dipole-dipole data were acquired along three traverses, with two traverses in the dump periphery and one outside the dump periphery serving as a control (Fig. 3). The lengths of the traverses are 250, 300 and 65 m for traverses 1, 2 and control, respectively. A station interval of 5 m was used for the survey. Eighteen VES locations were studied. The current electrode spacing (AB/2) varied from 1 m to a maximum spread length of 100 m. Seventeen of the VES sites were located in the dumpsite. One VES was located about 1 km away from the dumpsite to act as a control. The dipole-dipole data were processed and interpreted using computer assisted *DIPRO* software and presented as pseudosections. VES curves were quantitatively interpreted by partial curve matching and by a computer assisted 1-D forward modeling with the WinResist version 1.0 software (Adelusi *et al.,* 2013).

Four water samples were collected. Two samples were collected from the pit dug within the dumpsite, while two others were collected from pits dug within a radius of about 600 m from the center of the dumpsite. Hydrochemical analysis was carried out on the water samples.

4. Data analysis and interpretation

4.1 Dipole-dipole pseudosections

4.1.1. Control traverse

The 2-D resistivity structure at the control transverse (Fig. 4) shows the presence of three types of lithologies; the topsoil, weathered layer and the basement bedrock. The topsoil contains a resistivity value of 149 to 527 Ωm, which suggests

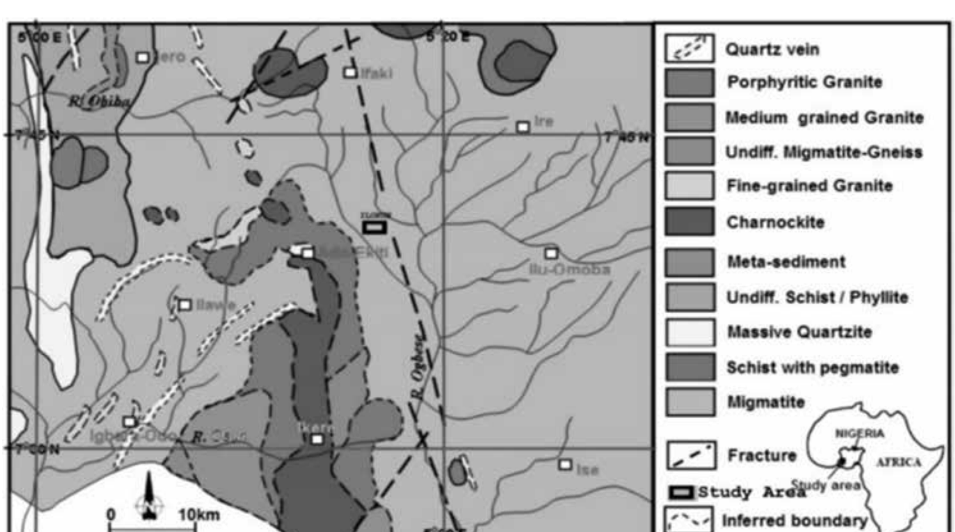

Fig. 2. Geological map of Ekiti showing the study area (Lateef *et al.,* 2015)

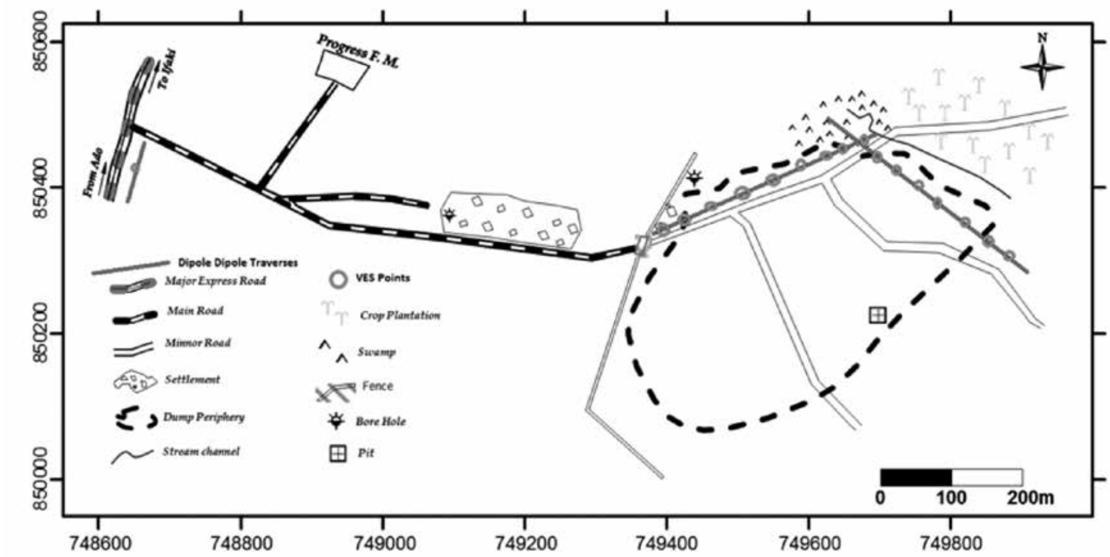

Fig. 3. Data acquisition map of Ilokun dumpsite

a lateritic layer (Loke, 2000). The lowest resistivity value (149 Ωm) was chosen as a reference resistivity to compare with other resistivity values in the topsoil of traverses acquired within the dumpsite (Pedro *et al.,* 2010; Sudha *et al.,* 2010). This lateritic layer extends from about 15 m of the profile to the end of profile. However, there is a different layer, which is probably a sand formation between 55 and 60 m. Furthermore, the underlying layer (weathered layer) exhibits resistivity of a fresh water-bearing zone with a value of 51.9 to 79.9 Ωm (Loke, 2000). This occurred between the depth of 5 and 12 m along the traverse, suggesting that the section had not yet become polluted with contaminants. Low resistivity values (52–79.9 Ωm) were noticed from 10 to 70 m sequentially along the profile. The lowest resistivity value (51.9 Ωm) was taken as the reference resistivity (background value) to be compared with those obtained from the dumpsite (Pedro *et al.,* 2010; Sudha *et al.,* 2010).

4.1.2. Traverse 1

The resistivity structures obtained along traverse 1 within the dump periphery show that the topsoil has virtually merged with the weathered layer. This is shown by the overlapping low resistivity values and a relatively small thickness of the layer. (Fig. 5).

Very low resistivity (<8 to <50 Ωm) zones occurred between stations 2 – 44 (10 – 220 m) particularly between stations 4-14 (20 – 70 m), 15 – 19 (75 -85 m) and 38 – 44 (190 – 220 m) along the traverse. The inverted resistivity section shows that the top soil consists of conductive materials from the beginning of the traverse (station 10 to station 44). Less resistive materials are found towards the end of the traverse line. In addition, the resistive materials (>102 Ωm) were disorderedly distributed towards the end of traverse within conductive material (<60 Ωm), suggesting a disturbed section. By comparing the exceptionally low resistivity value of the topsoil (9.78 Ωm) with the lowest resistivity value (149 Ωm) obtained from the control traverse, it was observed that there is a decrease in resistivity by 60%. This could imply the presence of pollutants in this zone. It further shows that the impacted area is migrating from this layer towards the deeper layer.

The underlying layer (weathered layer) has electrical resistivity value between 42 and <244 Ωm with a thickness of <5.0 to >15 m. The lowest resistivity value in this unit is

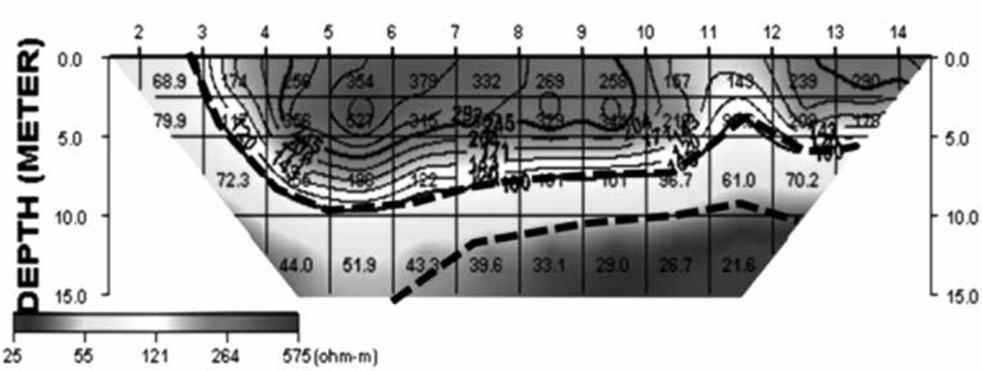

Fig. 4. 2-D resistivity structure along the control traverse.

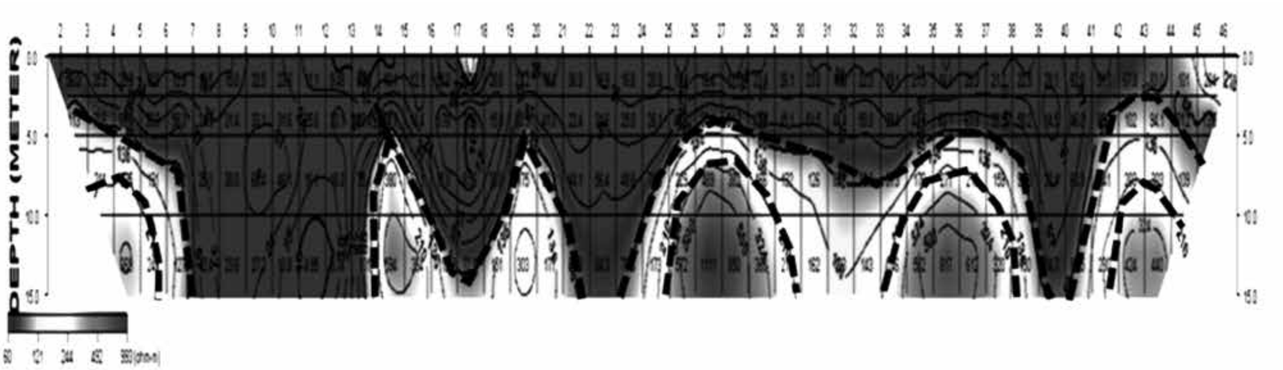

Fig. 5. 2-D resistivity structure within the dump periphery along traverse 1

42 Ωm and shows a decrease of 19% in comparison with the reference resistivity value in the control traverse. The reduction in the resistivity values might indicate that the weathered layer within the section has been polluted by the leachate.

The 2-D resistivity structure along this traverse also shows a series of basement ridge/suppressions between stations 2 – 6 (10 – 30 m), 14 – 21 (70 - 105 m), 29 – 33 (145 – 165 m) and 38 – 42 (190 – 210 m). A major discontinuity between stations 7-14 (35-70 m) along traverse 1 may be fractured/fault zones. The Ilokun dumpsite is located directly above the structural features delineated (fractures/ fault) along traverse 1. These structural features can serve as a conduit, thus allowing leachate produced within the dump periphery to migrate into the groundwater (Adebayo *et al.,* 2015). The bedrock material beneath this unit tends to be evenly distributed with an increased resistivity value (432 - 993 Ωm).

4.1.3. Traverse 2

The resistivity structures obtained along traverse 2 within the dump periphery show that the topsoil has virtually merged with the weathered layer. This is evident by the overlapping low resistivity values and a relatively small thickness of the layer (Fig. 6). There is also an irregular order of resistivity values (67 to 2300 Ωm). Pockets of resistive material (392 - >950 Ωm) were enclosed between station 2 to station 8 (10 - 40 m) within materials of low resistivity (<67 Ωm). This is indicative of the starting point of the dump periphery and could imply that the unit has been disturbed.

Low resistivity (<67 Ωm) zones between stations 8 – 57 (40 - 285 m) were also delineated as this signifies that the low resistivity topsoil within the identified zones may have been polluted by leachate from the dumpsite. A decrease of 55% was recorded when the lowest resistivity value (149 Ωm) was compared with the reference unit for the topsoil. This may indicate that this zone has been polluted by leachate from the dumpsite (Pedro *et al.,* 2010; Sudha *et al*., 2010).

The second layer is the weathered layer having resistivity values of less than 150 Ωm along traverse 2. This layer was characterized by patches with very low resistivity (<67 Ωm) beneath the traverse 2. The resistivity structures show the thickness of the weathered layer that ranges from <1.0 to >15 m. The third layer is the fresh basement bedrock. It exhibits a moderately high resistivity of about 2306 Ωm. Depth to the basement rock varies from about <2.0 - >15 m.

Generally, traverses 1 and 2 show a percentage reduction in resistivity value, ranging from 19% to 60%. This suggests that the pollutants have infiltrated both the topsoil and weathered layer, leading to an increase in conductivity of this section. However, VES was conducted in order

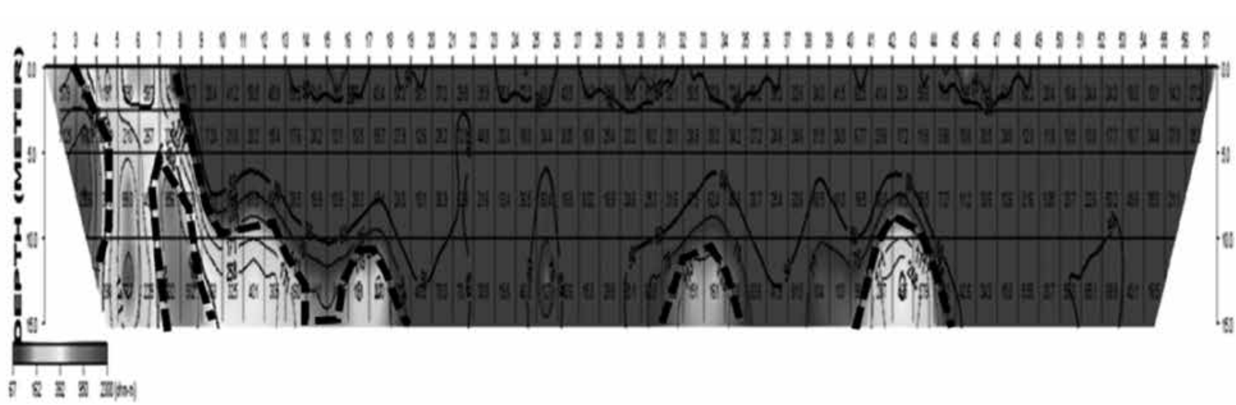

Fig. 6. 2-D resistivity structure along traverse 2.

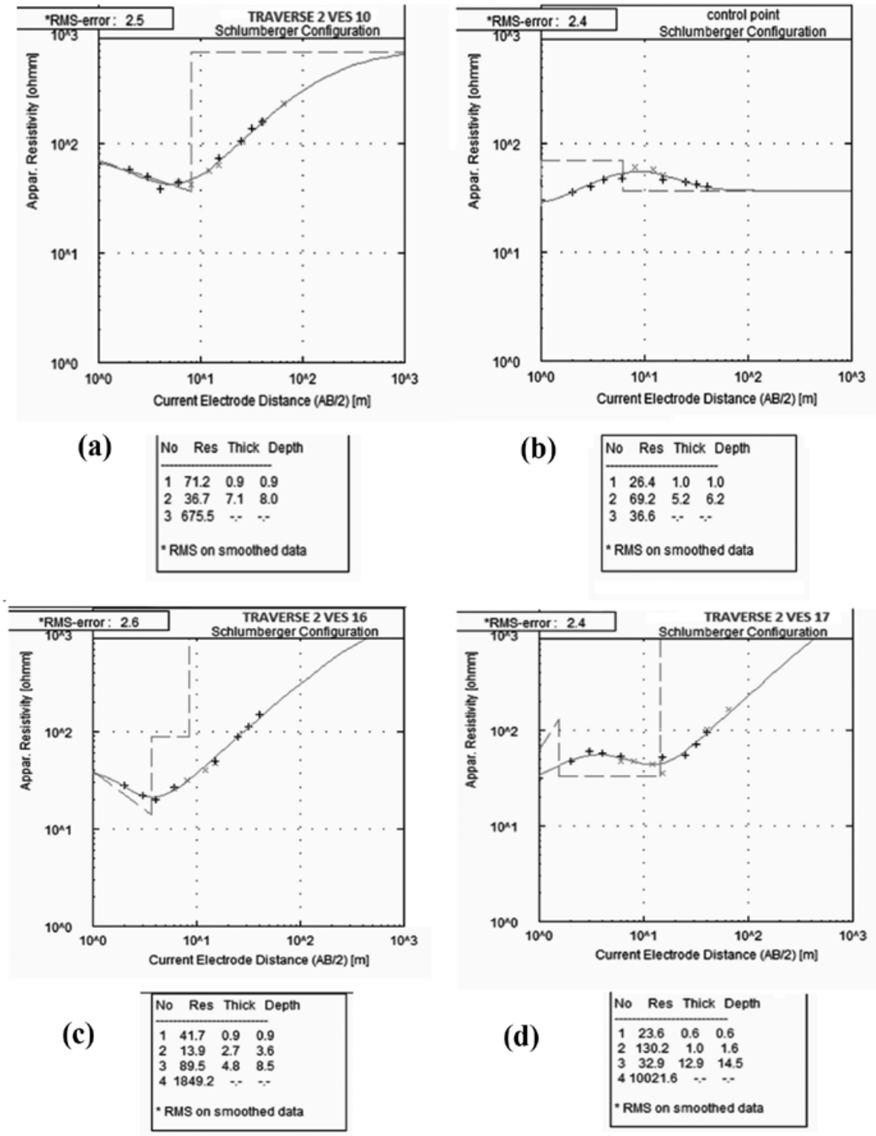

Fig. 7. VES curve types: (a) H-curve type, (b) K-curve type, (c) HA-curve type, and (d) KH-curve

to confirm the results generated from the inverted 2-D resistivity structure and to observe the vertical variations of any pollutants.

4.2. Vertical electrical sounding curves

The curve type varies from 3-layer H-type (50%), K-type (6%) to 4-layer HA (22%) and KH (22%). Selected sounding curves and their computer generated models are presented in Figure 7.

Figures 8-10 show the VES-derived columnal and geoelectric sections carried out along the three traverses established within the dumpsite and outside the dump at the control site. The sections generated within the study area delineated three major geologic layers: the top soil, the weathered layer, and the fresh basement rock.

The resistivity of topsoil ranges between 24 and 418 Ωm with a thickness range between 0.3 and 2.8 m. The weathered layer has resistivity values ranging between 7 and 246 Ωm and a thickness from 2.4 to 15.0 m. The bedrock shows resistivity values ranging from 253 to 10022 Ωm.

The VES-derived columnal section at the control point (Fig. 8) shows a three-layer sequence: top soil, clayey unit, and the fractured basement that serves as the control layer.

The resistivity of upper topsoil layer is 26 Ωm with a thickness of 1.0 m. The only resistivity value observed for topsoil in this unaffected section is 26 Ωm. It was selected as a comparison for other resistivity values obtained from the affected sections. The conductive weathered layer below the topsoil generally exhibits a fresh water resistivity of 69 Ωm (Loke, 2000). Its thickness reaches up to 6.2 m, which was used as a means of comparison with resistivity values obtained from the affected sections. This layer is characterized by a high water retention capacity that has low permeability. Beneath the clayey section is the fractured basement rock with a resistivity value of 37 Ωm.

From the interpreted VES curves (Figure 9), the topsoil has

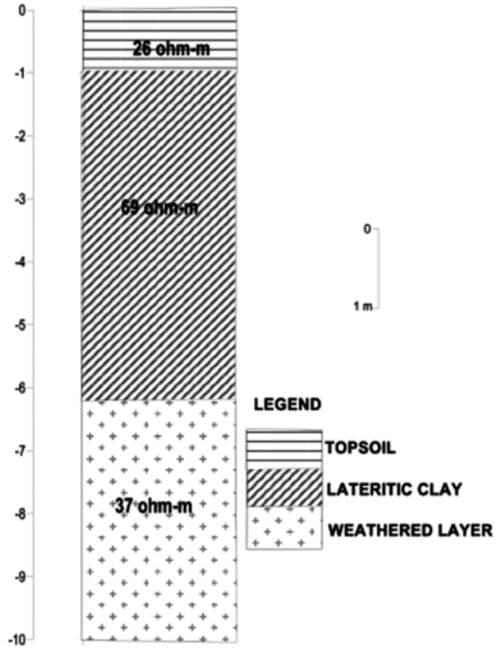

Fig. 8. Lithological characterization of the subsurface along the control point

resistivity values ranging from 24 to 418 Ωm and an average resistivity of 112 Ωm with an average thickness of 1.2 m. The weathered basement shows a resistivity value between 7 and 246 Ωm with an average resistivity of 37 Ωm. Its thickness ranges from 2.4 m to 15 m. Comparing the resistivity value from the control traverse (69 Ωm) with that obtained in this layer, there is a reduction in resistivity value between 8 m (at VES 1) to 200 m (at VES 8) along the traverse. This suggests that this unit was infiltrated by pollutants. The resistivity of the bedrock ranges from 253 to 10021 Ωm. The basement rock is fresh between station 15 (at VES 2) to station 20 (at VES 4), and it is fractured between station 8 (at VES 1) and station 23 (at VES 5). The fractured basement could serve as a conduit for transporting the pollutants into the groundwater system (Ayolabi *et al*., 2014; Ganiyu *et al*., 2016).

Along traverse 2 (Fig. 10), the VES-derived geoelectric section depicts a three-layer sequence. The resistivity of the topsoil is between 14 and 130 Ωm, and the resistivity value increases away from the central portion of traverse. The average resistivity is 80 Ωm and its average thickness is 1.0 m

The average thickness of the weathered layer is 12 m. The resistivity ranges from 7 to 246 Ωm and 59 Ωm is the average resistivity value. To ascertain whether or not this layer has been polluted, a comparison was made with the value obtained from the control layer (69 Ωm).

Juxtaposing the lowest resistivity value (7 Ωm) with that of the reference lithology (69 Ωm), a decrease in resistivity is apparent. This difference may be caused by pollutants migration. The basement underlies the conductive section, and its resistivity value ranges from 390 to 10022 Ωm, and it is fractured at station 50 (at VES 17). As stated, this could serve as a conduit for pollutants into the groundwater system. The real formations of the weathered layer have been highly distorted through the infiltration of contaminants.

It is observed that the leachate from waste materials have polluted the groundwater in the dump periphery. This is evident from the geoelectric sections of two traverses (Figs. 9-10) established within the dump periphery compared to the columnal section (Fig. 8) of the control point.

The inferences deduced from both the electrical resistivity imaging and VES suggest that the pollutants have infiltrated the subsurface materials, which implies that the pollutants have infiltrated the topsoil into the weathered layer within the section, therefore polluting the sections in the study area. Table 1 shows the well parameters around Ilokun. It was observed from the table that the water table around the dumpsite is relatively shallow between 0.5 – 3.7 m deep because of the shallow depth, it is possible that the groundwater is polluted. The 2-D resistivity structures for traverses 1 and 2 (Figs. 5 and 6) revealed that the geologic structures within the bedrock (fractures/faults) serve as a conduit aiding the migration of the leachate laterally and vertically around the investigated dumpsite as the dumpsite

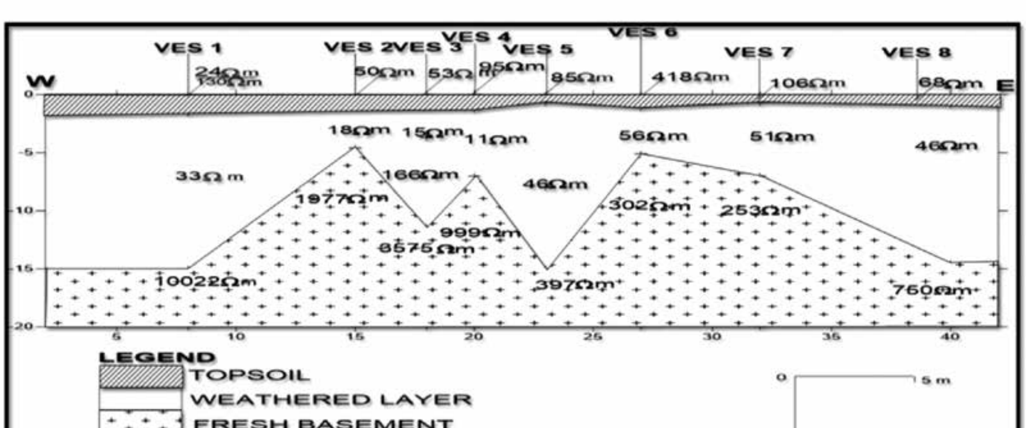

Fig. 9. Lithological characterization of the subsurface along traverse 1

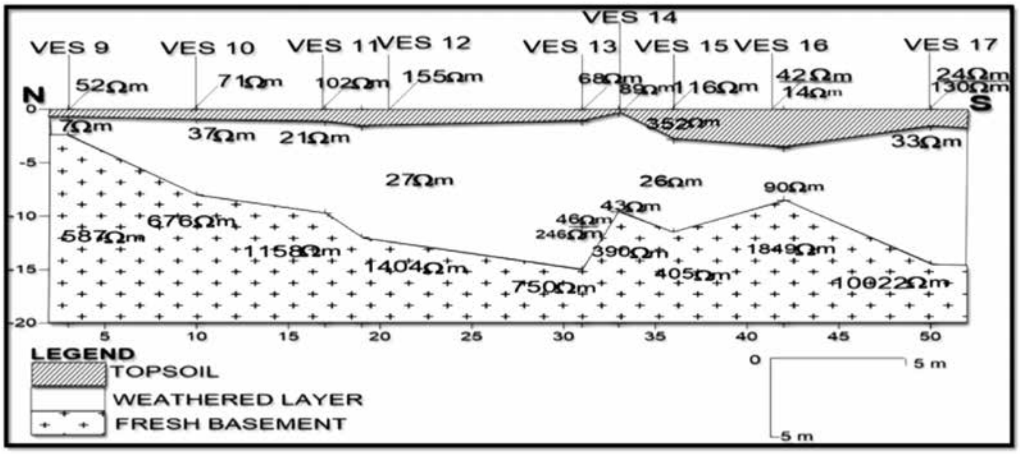

Fig. 10. Lithological characterization of the subsurface along traverse 2

increase in age.

4.3. Physico-chemical analysis

Table 2 shows this study's physico-chemical water analysis results along with the World Health Organization (WHO) limit guidelines.

The temperature of water samples outside the dump periphery range between 25.2° C and 25.4° C, while temperatures in Pits 1 and 2 were 28.5° C and 29.5° C, respectively. The temperature value for water sample located within the dump periphery was found above the 25° C given by WHO for domestic water, which could therefore indicate the presence of pollutants (Jaji *et al.,* 2007; Meme *et al.,* 2015).

The presence of turbidity is also an indication of pollution in an area and shows leachate movement into the soil (Ogedengbe & Akinbile, 2004; Mohamed *et al*., 2009). Turbidity of the samples within the dumpsite were discovered greater than the values given by the WHO. Samples located outside the dump periphery contained the average turbidity of 0.001 and 3.5 nephelometric turbidity units (NTU), while the pit samples located within the dump periphery were 5-10 NTU. The WHO (2017) recommended a value of 5 NTU as the maximum value, above which disinfection is inevitable. Turbidity in Pit 2 was twice the recommended WHO limit. This may be suggesting a higher sediment flow compared to other samples. Animal wastes from the nearby abattoir and the related bone disposal at the dumpsite may be the reason for the high values recorded for turbidity in the analyzed water samples.

The pH values in the samples ranged from 6.12 to 6.43. These values fall within the WHO recommended values (6.0 to 8.5). The sample from Pit 2 were more acidic (6.12). This result requires immediate attention as it indicates the presence of metals in the samples, especially toxic metals including zinc, lead, and mercury (Ikem *et al*., 2002; Akinbile, 2006; Longe & Balogun, 2010).

Most ions from the samples outside the dump periphery were found to be below the WHO limits. Samples from within the dump periphery showed high ion contents above the WHO limits; hence, these site areas require treatment. Furthermore, high chloride values above 250 mg/L can result in detectable taste. Chloride values measured from 71 to 298 mg/L, with Pit 2 being the most affected. Despite having a value below the WHO levels outside the dumpsite, the high value above the limits set by WHO within the dump periphery indicates pollution and requires treatment before further use (Igbinosa & Okoh, 2009; Meme *et al.,* 2015).

The high values of total hardness do not have any associated adverse health-related effects but indicate the presence of Ca and/or Mg ion deposits. The presence of these ions will prevent the water from forming lather easily with soap, thereby hindering economic management of water resources (Akinbile, 2006; Ganiyu *et al.,* 2016). Although Ca levels in the area are low (with the exception of the dumpsite water sample), with ranges from 14 to 180 mg/L,

Table 1. Well parameter for Ilokun water samples.

Well Number	Distance to Landfill (m)	Depth to Water table(m) (Dry Season)	Depth to Water table (m) (Wet/raining Season)
1	75	2.8	0.7
2	120	3.2	0.5
3	185	5.7	2.1
4	270	2.5	1.5
5	420	3.7	2.2

Table 2. Summary of physical and chemical parameters of surface and groundwater in the study area.

Parameter	Characteristics	Control Point	Hand Dug Well (100 m Away)	Pit 1(Depth of 4.8 m)	Pit 2 (Depth of 4.5 m)	WHO (2017)
Physical	Temperature	25.2	25.4	28.5	29.5	25.00
	Turbidity	0.001	3.50	5.00	10.00	5.00
	Conductivity	142.5	140.5	890	2230	1000
Chemical	pH	6.235	6.26	6.43	6.12	6.0-8.5
	Total dissolved solid (TDS)	76.535	79.815	140	1056	1000
	Total solids (TS)	90.05	94.425	156	903.46	
	Total suspended solids	13.515	14.61	95.00	152.5	30
	Total alkalinity	54.5	60.00	65.00	91.5	30-55
	Total hardness	50.3	52.515	79.00	88.5	100
	Chloride	71.005	128.69	195.00	298	250
	Nitrate	4.21	5.725	9.40	16.40	10
	Sulphate	5.2	5.35	15.50	30.00	200
	Phosphate	3.15	3.5	14.50	18.00	
	DO	4.2	3.25	6.25	16.8	
	BOD**	1.3	1.11	5.9	6.21	10
	COD	2.25	2.35	7.8	9.32	40
Minerals	Na	11.35	12.3	31.20	48.2	200
	K	9.15	11.4	155.50	175	15
	Ca	14.215	14.735	125.60	179.5	75
	Mg	12.615	13.23	100.90	141	30
	Zn	1.15	1.225	7.29	13.9	4.0
	Fe	0.015	0.04	8.55	17.1	1.0

the levels can still portend the danger of water hardness (Chauhan & Rai, 2010). They are also slightly higher than the values recommended by WHO.

The total dissolved solids (TDS) obtained ranged from 76 to 1056 mg/L. These values are lower than the standard given by WHO outside the dumpsite. However, a higher TDS value than recommended by the WHO was recorded in Pit 2, indicating pollution (Ayolabi *et al.,* 2014; Adebayo *et al.,* 2015). Nitrate values ranged from 4.2 to 16.4 mg/L. The values increase when closer to the dump, indicating source pollution. Nitrate values outside the dump periphery were found to be below the WHO standard for potable water, while the values in the dump periphery were higher than the recommended value. This could also indicate pollution.

The presence of iron and zinc in the analyzed samples shows the presence of toxic wastes. Probable sources could be discarded batteries and aerosol cans. Iron and lead range from 0.015 to 17.1 mg/L and 1.11 to 1.2 mg/L respectively, indicating the presence of toxic wastes in the landfill. The WHO suggests values from 1 to 3 mg/L for iron metals in water. Above these levels, an objectionable and sour taste can be observed (Ayolabi *et al*., 2014; Lateef *et al.,* 2015). Apart from that, zinc that ranges from 1.15 to 13.9 mg/L also gives the indication of pollution (Ikem *et al*., 2002; Shyamala *et al*., 2008; Longe & Balogun, 2010; Lateef *et al.,* 2015).

5. Conclusion

Geophysical and hydrochemical methods were employed for assessing and investigating pollution and groundwater contamination around Ilokun dumpsite. The study area is underlain by migmatite-gneiss of the Precambrian Basement Complex in southwestern Nigeria.

Geophysical investigations involving dipole-dipole were carried out along three traverses in the study area. Eighteen VES using a Schlumberger array were acquired along established traverses, and 2-D resistivity geoelectric sections were generated. Two traverses were located within the dump periphery and one traverse was chosen as the control point located about 500 m away from the dumpsite.

The geoelectric section and the 2-D resistivity structures showed the presence of topsoil, a weathered layer and fractured/fresh basement rock. The weathered layer was the major aquifer unit, having low resistivity values of 7 – 246 Ωm and thickness range of 2.4 - >15.0 m. The 2-D resistivity obtained within the dump periphery shows that the topsoil almost merged with the weathered layer. This was shown by low resistivity values and a relatively small thickness of the layer. The 2-D structures revealed that the depth of migration of leachate ranged from 2.5 to >15 m along the two traverses. Comparing the control to the dumpsite data, it can be summarized that the topsoil and the weathered layer have been contaminated by leachate. It also indicates that the topsoil was disturbed and contaminated, leading to the migration of leachate from the topsoil to the weathered layer.

Furthermore, the presence of fractured/fault bedrock characterized by 23- 46 Ωm shown by geoelectric section could serve as a conduit through with leachate migrates both laterally and vertically into the groundwater system. Data confirm this because the resistivity value of the weathered layer increases away from the central portion to the southern part of the traverse.

As the dumpsite ages, there is a possibility of contamination of shallow groundwater system in the southern part due to the observed relatively shallow water table of 0.5 – 3.7 m. In addition, the polluted groundwater around the dumpsite is believed to have resulted from leachate migration. 2-D resistivity structures for both traverses also revealed that geologic structures within the bedrock (fractures/faults) could serve as a conduit through which leachate can flow laterally and vertically as the dumpsite ages.

Hydrochemical analysis revealed that the Chloride concentrations were from 71 – 298 mg/L, and nitrate concentrations were from 4.21- 16.4 mg/L. However, the concentration of chloride and nitrate within the dump periphery were observed to be above the WHO standard. (>250 and >10 mg/L, respectively), indicating pollution. However, the higher concentrations of these parameters discovered in Pits 1 and 2 could be the result of leachate migration close to the dumpsite, agricultural run-off, and fertilizer applications. These values were observed to be higher than the maximum permissible values suggested by the WHO and could confirm the presence of groundwater pollution in the area. Moreover, the 2-D resistivity structures revealed that the depth of migration for the suspected leachate could be from 2.5 to >15 m beneath the dumpsites. The migration of pollutants could predominantly be in the southern direction of the dumpsite due to the regional direction of the groundwater flow.

ACKNOWLEDGEMENTS

The authors acknowledge Prof M.O. Olorunfemi of the Department of Geology, Obafemi Awolowo University for his technical advice regarding this manuscript.

References

Adebayo, A.S., Ariyibi, E.A., Awoyemi, M.O. & Onyedim, G.C. (2015). Environmental assessment of old domestic dumpsite using 2D electrical resistivity imaging: A case study from Olubonku dumpsite in Ede, Osun State, southwestern Nigeria. Arabian Journal of Geosciences, **8**(6): 4075-4081.

Adelusi, A.O., Akinlalu, A.A. & Nwachukwu A.I. (2013). Integrated geophysical investigation for post-construction studies of buildings around School of Science area, Federal University of Technology, Akure, Southwestern, Nigeria. International Journal of Physical Science, **8**(15): 657-669.

Andrea, T.U., Vagner, R.E., Giulliana, M., Lazaro, V.Z., & Heraldo, L.G. (2012). Case study: A 3D resistivity and induced polarization imaging from downstream in waste disposal site in Brazil. Environmental Earth Science, **66**(3): 763–772.

Akinbile, C.O. (2006). Hawked water quality and its health implications in Akure, Nigeria. Botswana Journal of Technology, **15**: 70–75.

Ayolabi, E.A., Oluwatosin, L.B. & Ifekwuna, C.D. (2014). Integrated geophysical and physicochemical assessment of Olushosun sanitary landfill site, southwest Nigeria. Arab Journal of Geoscience, **8**: 4101-4115.

Bayode, S., Omosuyi, G.O., Mogaji, K.A. & Adebayo, S.T. (2011). Geoelectric delineation of structurally-controlled leachate plume around Otutubiosun dumpsite, Akure, southwestern Nigeria. Journal of Emerging Trends in Engineering and Applied Sciences, **2**(6): 987-992.

Chauhan, J. & Rai, J.P.N. (2010). Monitoring of impact of ferti-irrigation by post-methanated distillery effluent on groundwater quality. Clean–Soil, Air, Water, **38**(7): 630–638.

De Carlo, L., Perri, M.T., Caputo, M.C., Deiana, R., Vurro, M. & Cassiani, G (2013). Characterization of a dismissed landfill via electrical resistivity tomography and mise-à-la-masse method. Journal of Applied Geophysics, **98**: 1- 10.

Fajana, A.O. (2013) Integrated geophysical characterization of subsurface conditions around Ilesha dumpsite: Case of Southwestern Nigeria. Asian Journal of Applied Science & Engineering, **2**(2): 84-95.

Ganiyu, S.A., Badmus, B.S., Oladunjoye, M. A., Aizebeokhai, A. P., Ozebo, V. C., Idowu, O.A. & Olurin, O.T. (2016). Assessment of groundwater contamination around active dumpsite in Ibadan southwestern Nigeria using integrated electrical resistivity and hydrochemical methods Environmental Earth Science, **75**(8): 643-661.

Igbinosa, E.O. & Okoh, A.I. (2009). Impact of discharge wastewater effluents on the physico-chemical qualities of a receiving watershed in a typical rural community. International Journal of Environmental Science and Technology, **6**(2): 175-182.

Ikem, A., Osibanjo, O., Sridhar, M.K.C. & Sobande, A. (2002). Evaluation of groundwater quality characteristics near two waste sites in Ibadan and Lagos, Nigeria. Water, Air, and Soil Pollution, **140**(1-4): 307–333.

Jaji, M.O., Bamgbose, O., Odukoya, O.O. & Arowolo, T.A. (2007). Water quality assessment of Ogun River, south west Nigeria. Environmental Monitoring and Assessment, **133**(1-3): 473–482.

Kottek, M., Grieser, J., Beck, C., Rudolf, B. & Ru, F. (2006). World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift, **15**(3): 259-263, 2006.

Lateef, T.A., Eluwole, A.B. & Adewale D.J. (2015). Geoelectrical assessment of the impact of the Ilokun dumpsite, Ado-Ekiti Southwestern Nigeria, on surrounding groundwater aquifers. International Letters of Natural Sciences, **40**: 41-47.

Loke, M.H. (2000). Electrical imaging surveys for environmental and engineering studies: A practical guide to 2-D and 3-D surveys. http://www.heritagegeophysics.com.

Longe, E.O. & Balogun, M.R. (2010). Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. Research Journal of Applied Sciences, Engineering and Technology, **2**(1): 39–44.

Meme, F.K., Arimoro, F.O. & Nwadukwe, F.O. (2014). Analyses of physical and chemical parameters in surface waters nearby a cement factory in north central, Nigeria. Journal of Environmental Protection, **5**: 828-836.

Mohamed, A.F., Yacob, W.Z.W., Taha, M.R. & Samsudin, A.R. (2009). Groundwater and soil vulnerability in the Langat Basin Malaysia. European Journal of Scientific Research, **27**(4): 628–635.

Ogedengbe, K. & Akinbile, C.O. (2004). Impact of industrial pollutants on quality of ground and surface waters at Oluyole Industrial Estate, Ibadan, Nigeria. Nigerian Journal of Technological Development, **4**: 139–144.

Olaojo, A.A., Oladunjoye, M.A. & Sanuade, O.A. (2016). Geochemical assessment of groundwater pollution from sewage effluents in the university campus of Ibadan, southwestern Nigeria. Journal of Geological Society of India, **88**: 648-653.

Olayinka, A.I. & Olayiwola, M.A. (2001). Integrated use of geoelectrical imaging and hydrochemical methods in delineating limits of polluted surface and groundwater at a landfill site in Ibadan rea, Southwestern Nigeria. Journal of Mining and Geology, **37**(1): 53 – 68.

Pedro, M., Ángel**, F.C, Gerson, R.R. & Ana, B.O. (2010).** 2-D electrical resistivity imaging to assess slurry pond subsoil pollution in the southeastern region of Murcia, Spain. Journal of Environmental and Engineering Geophysics, **15**(1):29 - 47.

Shyamala, R., Shanti, M. & Lalitha, P. (2008). Physico-chemical analysis of borewell water samples of Telungupalayam area in Coimbatore District, Tamilnadu, India. E-Journal of Chemistry, **5**(4): 924–929.

Sudha, B., Tezkan, B., Israil –Singhal, D.C. & Rai, J. (2010). Geoelectric mapping of aquifer contamination: a case study from Roorkee, India. European Association of Geologists & Engineers. Near Surface Geophysics, **8**: 33-42.

Ugwu N.U., Ranganai R.T., Simon R.E., Ogubazghi G. (2016). Application of geoelectrical resistivity method to the assessment of groundwater pollution: a case study of Onibu-Eja active open dumpsite, Osogbo, Southwestern Nigeria, **6**(1): 160-174.

WHO (2017). Guidelines for drinking-water quality. Fourth edition incorporating the first addendum. Recommendations, Geneva, World Health Organisation.

Submission : 10/03/2017
Revision : 29/04/2017
Acceptance : 21/05/2017

تقييم جيولوجي كهربائي ومائي كيميائي متكامل لموقع جمع النفايات إيلوكون، أدواكيتي في جنوب غرب نيجيريا

أولايولاج أولاسيني[1]، أولوسون سانود[2*]، سولومون أدبايو[3]، مايكل أولادابو[4]

[1،2،3] قسم الجيولوجية الفيزيائية، جامعة أويي أكيتي الفيدرالية، ولاية أكيتي، نيجيريا
[4]قسم الجيولوجية الفيزيائية التطبيقية – جامعة أكور الفيدرالية، ولاية أوندو، نيجيريا
sheunsky@gmail.com [*]

الملخص

تم عمل تقييم جيولوجي فيزيائي ومائي كيميائي لموقع جمع النفايات في إيلوكون لتقدير تأثيره على جودة المياه الجوفية. هذا الموقع موجود في إيلوكون، أدواكيتي، جنوب غرب نيجيريا. تم عمل 18 سبر كهربائي رأسي منهم 17 في داخل موقع جمع النفايات وواحد خارج نطاق الموقع لاستخدامه كمرجع. تم استخدام ثلاثة مقاطع ثنائية القطب منهم اثنين داخل موقع جمع النفايات وواحد خارج المنطقة يستخدم كمرجع. تم جمع 4 عينات مياه: اثنان منهم من داخل الموقع واثنان من مواقع على بعد 600 متر من الموقع. تم عمل تحليل مائي كيميائي لعينات الماء. المقاطع الكهروجيولوجية وهياكل المقاومة ثنائية الأبعاد العكسية رسمت ثلاثة طبقات جيولوجية تحت سطح الأرض هي طبقة التربة السطحية وطبقة جافة وطبقة سفلية متشققة. تمتعت التربة السطحية والمياه الجوفية السفلية في داخل موقع النفايات بطبقة منخفضة من المقاومة بقيم أقل من 60 أوم/م و100 أوم/م على التوالي بالمقارنة مع الطبقات المقابلة خارج موقع النفايات. اتسمت نتائج التحليل المائي الكيميائي لعينات المياه في المنطقة المحيطة بموقع النفايات بتوصيل كهربائي قدره 2230 µs/cm، وتركيز كلورايد أكبر من 250 مج/لتر وتركيز نيترات أكبر من 10 مج/لتر مما يؤكد تلوث المياه الجوفية في هذه المنطقة. ولذلك يمكن استنتاج تلوث المياه الجوفيه في منطقة الدراسة وأن المنطقة الملوثة تقع على عمق من 2.5 - 15 متر. وينتقل التلوث في اتجاه الجنوب متوافقاً مع اتجاه تدفق المياه الجوفية. ويوضح ذلك أن المياه الجوفية في منطقة الدراسة تمثل مصدر خطر للإنسان وتحتاج إلى عناية فورية من الجهات المسئولة.