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AIM & SCOPE OF THE JOURNAL

The Journal of Disaster Risk Management (JDRM) is an international journal published bi-annually by the Centre for Disaster Risk Management and Development Studies (CDRMDS), Federal University of Technology, Minna, Nigeria. The Journal is focused on contemporary global issues of Disaster Risk Management (DRM) and Disaster Risk Reduction (DRR). The objectives are to promote research and development in DRM and DRR, provide a medium for the dissemination of research outcomes, facilitate sharing of experience on disaster management strategies and 'Best Practices', all with a view to reducing the impact of natural and technological disaster as well as building community resilience and promoting sustainable development. The journal therefore provides an information base for the academic community, professionals, policy makers, government officials and practitioners in the field of disaster management.

The Journal is a multidisciplinary one. It accepts well researched empirical papers, including case studies, from the following disciplines:

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EDITORIAL COMMENTS

Increases in the events and the cascading effects of both natural and human induced disasters have continued to attract the attention the global community. One major area of global efforts in the area of disaster management is research to promote science and technology for disaster risk reduction. The Sendai Framework for Disaster Risk Reduction 2015 – 2030 identified research as a priority and urged nations to strengthen the technical and scientific capacity to develop and apply methodologies, studies and models to assess vulnerabilities to the impact of natural and man induced disasters. The main objective of this journal is to publish valuable research outcomes that are capable of providing solutions for effective disaster management in human settlements.

The Volume 2, Number 1 edition of Journal of Disaster Management (JDRM) contains seven articles that cover the physical and socio-economic aspects of disaster management. The paper on geospatial assisted road network routing for fire service disaster response in Ibadan Nigeria considered route optimization for effective fire service delivery in Ibadan. The second article on integrated geology, mineralogy and geochemistry investigations of the Minna-Tegina-Makera road North, Western Nigeria is focused on the causes of road failure and it recommended engineering solution for effective road maintenance. The paper on the risk of water disasters and their impact on real estate investment in Lagos State examined the issues of vulnerability and effects of water related disaster on property values in the coastal areas of Lagos. The fourth paper is on housing characteristics and crime vulnerability in Ilorin, Kwara State while the fifth article considered the geophysical and physico-chemical analysis of soil and water in the vicinity of waste disposal site in Kpakungu area of Minna, Niger State, Nigeria. The sixth paper examined the risk factors and the nature of disaster in the physical distribution and utilization of liquefied petroleum gas in Port-Harcourt city, Nigeria. The last paper on the investigation of leachate migration from Banwuya public refuse dump site, considered groundwater contamination as a result of solid waste leachate accumulation in Bida, Niger State, Nigeria. These papers have carefully considered their respective subject matter and have proffered recommendations that are capable of solving the problems investigated.

This second edition of JDRM consolidates our efforts on the publication of quality researches in the area of disaster management. The journal welcomes more quantitative, qualitative and well-researched papers on disaster and environmental management issues for the next edition. The new Editorial Board is grateful to the Vice Chancellor – Prof. M.A Akanji for his encouragement in publishing this edition in order to sustain the journal. We hope our esteemed readers will find the articles contained in this edition interesting and useful for disaster management in human settlements.

Prof. A.M Junaid
Editor-in-Chief

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Investigation of Leachate Migration from Banwuya Public Refuse Dump Site, Bida, Niger State, Nigeria

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Abstract

Geophysical study involving electrical resistivity was conducted at Banwuya municipal solid waste disposal site in Bida metropolis, Niger state North central Nigeria. Two resistivity profiles both inside the dump and one profile outside the dump to serve as control were investigated with maximum length of 80 m. Results of the resistivity showed the leachate plume as low resistivity zones (4.06 – 48.5 Ωm). The resistivity values obtained for area without dump showed higher values which suggests that the low resistivity observed inside the dump might have responsible for that. Results of the physico-chemical analysis of water samples from existing hand dug wells samples reported elevation in concentration of some of the measured parameters (Cadmium 0.0582 = 0.0841 mg/l, Chromium 0.1597 – 1.5000 mg/l, Manganese 0.5875 – 0.875 mg/l indicating contamination of the groundwater as a result of solid waste leachate accumulation, consequently, complementing the geophysical data.

Keywords: Banwuya, Solid wastes, contaminant, geophysical, resistivity, VES,

1. Introduction

Solid wastes are generated by domestic, commercial and industrial activities. Various methods of disposing solid wastes include open dumps, wasteland – farms containment ponds, containment in rocks and deep underground injection (Ismail and Hashim, 2006). The most commonly practice method of waste disposal in Bida area is the open dump method. Disposed solid wastes get decomposed and degraded forming open dump gas and leachate. Leachate is formed by both intrinsic solid wastes moisture and water infiltration into the dump site; its generation and composition depends on factors such as climatic factors, open dump operation practice and waste nature (Manon *et al.*, 2011). Leachate presence from dump sites leads to contamination of groundwater around the dumpsite as it percolates the ground and travels with groundwater. It involves diffusion which is a molecular mass transport process in which solutes move from areas of higher concentration to areas of lower concentration (Popoola and Fakunle, 2014). The migration might also involve dispersion which is a mixing process caused by velocity variations in the porous media. It was found from grain size analysis and litho-geophysical logs that contaminated leachate can migrate through unsaturated zone into groundwater posing a threat to human health (Ismail and Hashim, 2006). Several models on groundwater and contaminant flow have been put forward by environmental engineers and scientists in their efforts to preserve natural resources. In this study, electrical resistivity soundings were conducted directly inside the refuse dumpsite at Banwuya in Bida to determine leachate accumulation and level of groundwater contamination. Electrical resistivity method provides economic and nondestructive means to identify and delineate leachate contaminant plumes from dumpsite because the electrical conductivity of leachate tends to be higher than that of natural water. This is as a result of the leachate diminishing the electrical resistivity of the formation containing them (Reynolds, 1997; Martinho and Almeida, 2006). The use of electrical resistivity method in groundwater pollution investigation have been documented in several studies including the studies of Akanbi and Eze (2014), Akintayo (2015) and Rafiu and Mallam (2016). Leachates migration from waste sites or landfills and the release of pollutants from sediments pose a high risk to groundwater resource. This study was carried out to assess the groundwater quality system around a dumpsite in Bida, Niger state, Nigeria. with the objective of assessing the impact of the leachates on the groundwater quality of the area.

2. Location and Geological Setting

Banwuya Refuse Dump, Bida (figure 1) lies between latitude 9.0859^0- 9.08602^0 N and longitude 6.5294^0- 6.5298^{0}E. The study area is situated in the central part of Bida basin, a major inland sedimentary basin in Nigeria (Figure 1). The Bida basin is a NW-SE trending structure which extends from Kontagora in the northern sector to Lokoja in the southern and covering a distance of about 400 km. It has a sedimentary fill of up to 4.7 km with an average of 3 km (Udensi and Osazuwa, 2004). Four lithostratigraphic successions were identified in the northern part of the basin (Adeleye, 1972). At the base is Bida Formation which comprorise of massive gravelly, coarse to very coarse sandstones of Doko Member overlain by fine to medium grained cross bedded sandstones and mudstones of Jima Member (Goro *et al.*, 2014). They were inferred to be deposited in braided and meandering river systems. Sapke Formation overlies the Bida Formation and consists of mainly ironstone with goethite (Okosun *et al.*, 2009). Enagi Formation comprises mainly siltstones, mudstones and very fine sandstones deposited in distal fan, flood plain and lacustrine environments; it is overlain by Batati Formation consisting mainly of ironstones with geothite and kaolinite.

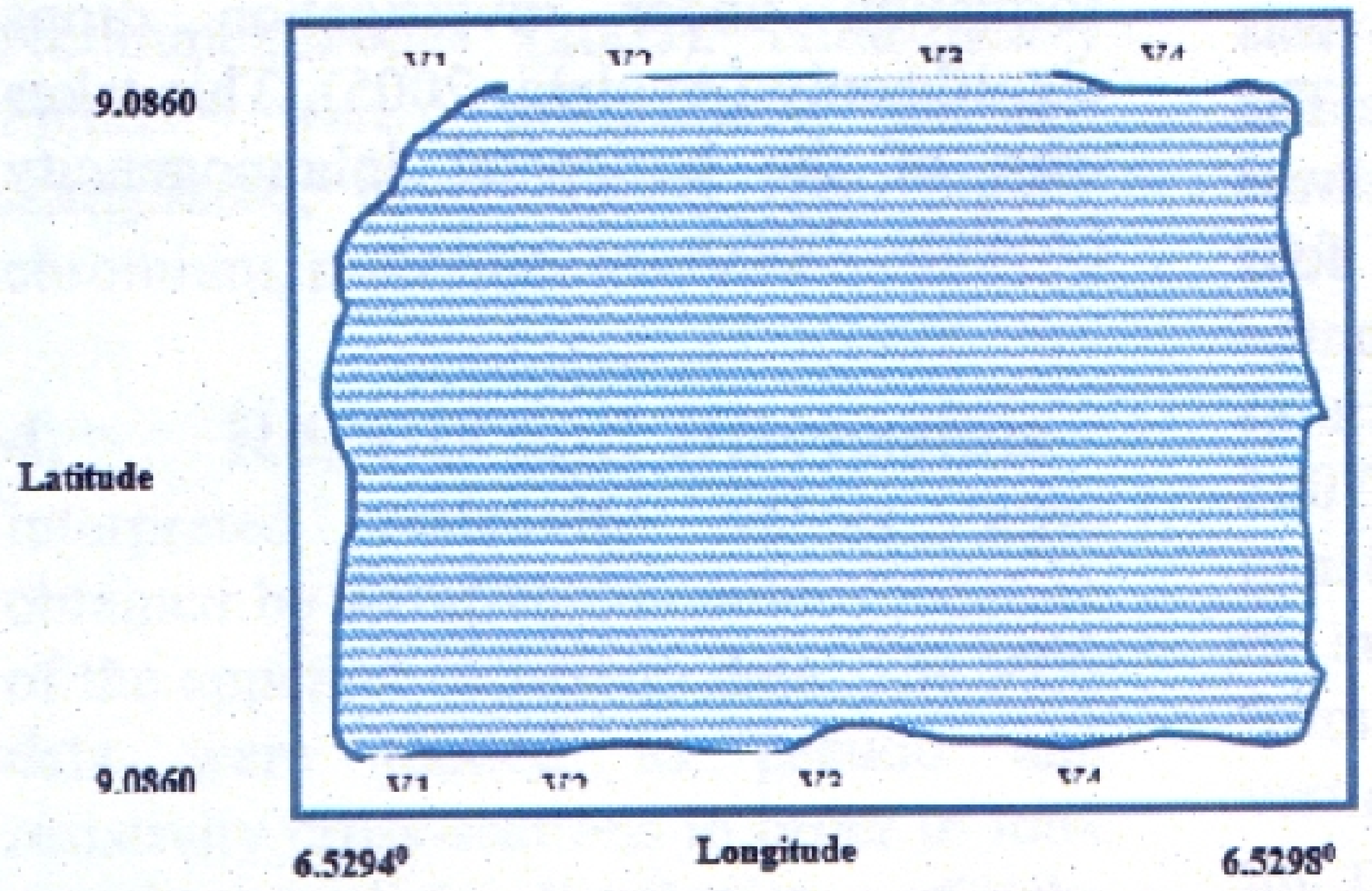

Figure 1: Banwuya dumpsite showing Vertical Electrical Sounding Points layout
Authors' Analysis, 2016

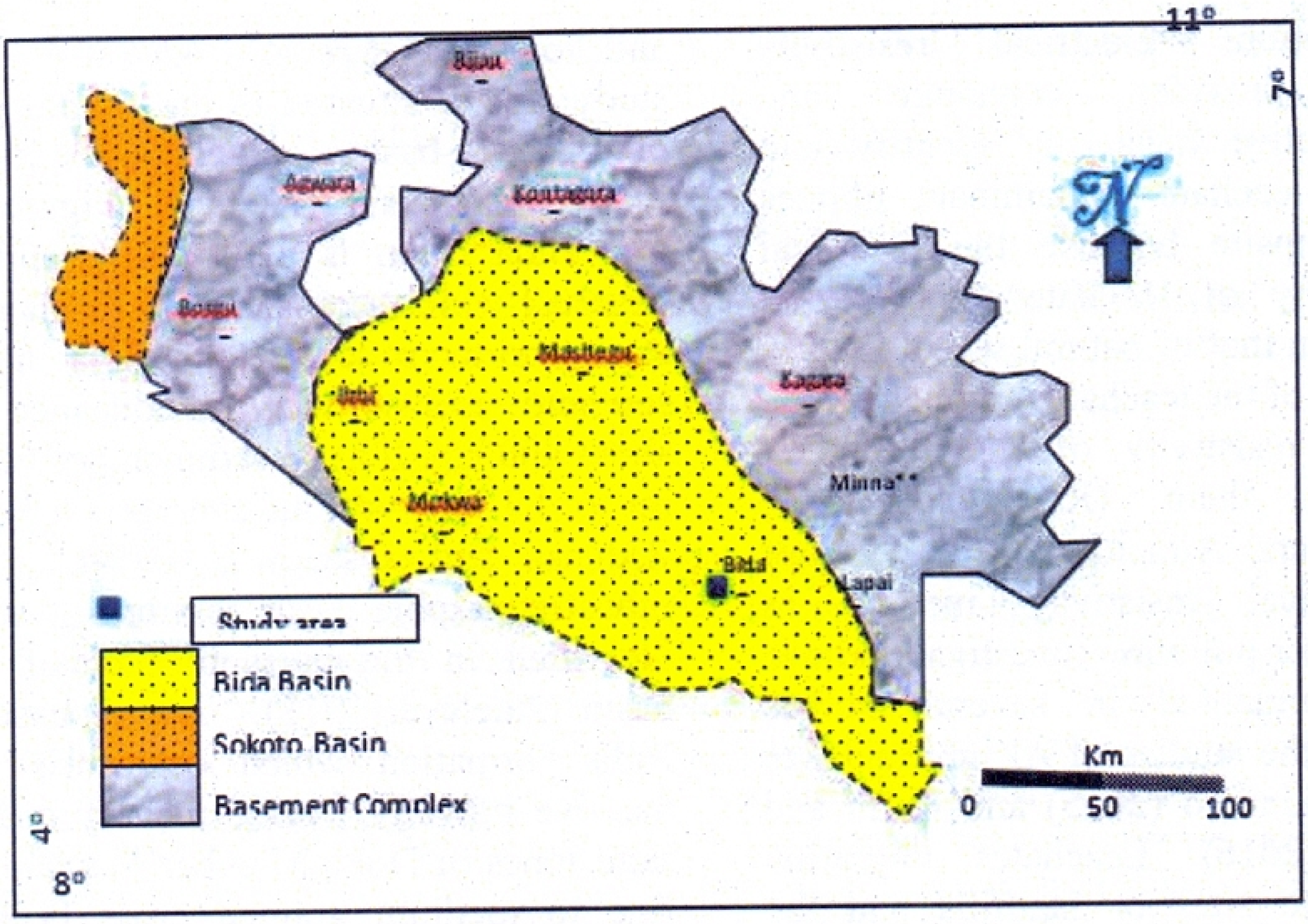

Figure 2: Geology Map of Niger state showing the position of Bida
Source: Rafiu and Mallam 2014

3. Materials and Methods

The instrument used in this research work is the ABEM Terrameter SAS 4000. A total of fourteen Vertical Electrical Soundings (VES) along three prof were carried out in the study area. Two profiles made up of eleven VES were taken at the edges of waste disposal site while another profile consisting of three VES were taken outside the dump to serve as control. The three traverses are represented as Profiles A- C. A maximum spread of 80 m (AB) was covered as a result of built- up areas. The Schlumberger configuration was employed. With this configuration, four electrodes were pinned firmly into the earth along a straight line with the outer electrodes connected to the current source and the inner electrodes connected to the potential terminals of the terrameter. The Schlumberger array requires that the two potential electrodes are kept constant for some soundings to be made while the current electrodes are moved further away after each sounding to ensure that $AB/2 \geq 5MN/2$ (Figure 3). The potential electrodes are moved only when the value of the resistivity of the formation under investigation drops significantly (Ayolabi, 2005). This takes care of the horizontal inhomogeneity (Atakpo, 2009).

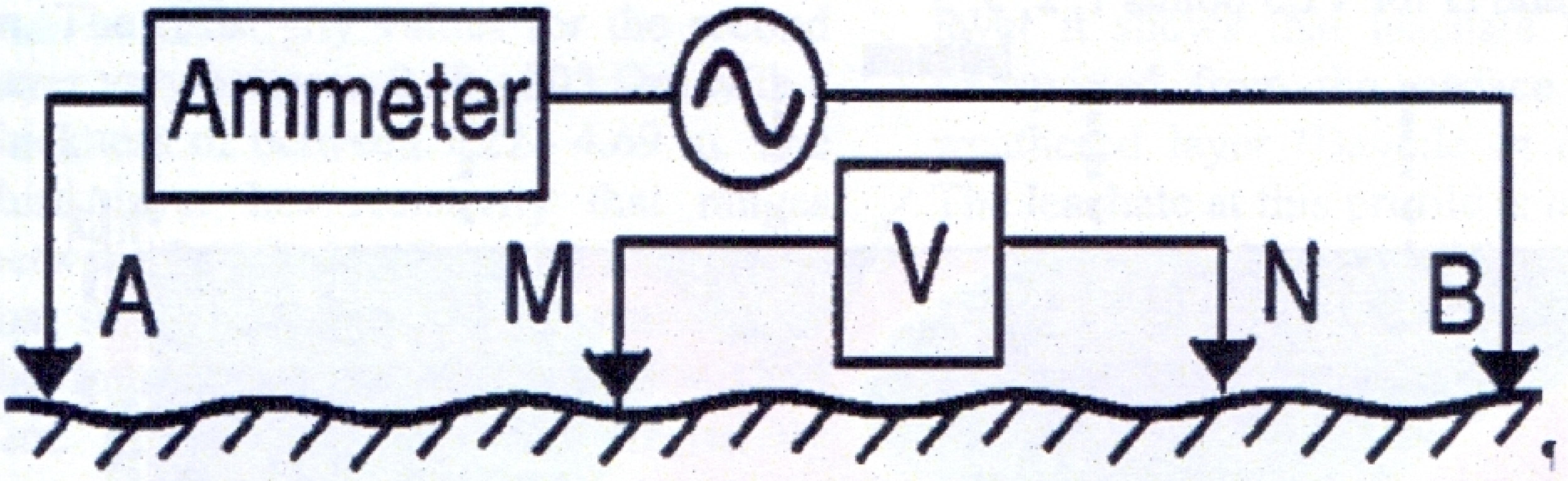

Figure 3: General configuration of the four surface electrodes in linear resistivity surveys. Current is delivered through the electrodes *A* and *B*, and voltage readings are made with electrodes *M* and *N*. Source: Adapted from Reynolds (1997).

Three wells were sampled from the dumpsite at Banwuya, Bida area and another water sample not close to the refuse site to serve as control was also sampled. Field measurements include physicochemical parameters such as Electrical Conductivity, temperature and pH. Other physical parameters measured include: total dissolved solids, total hardness and turbidity. Global Positioning System was used to perform geo-referencing of each sampling point. Samples were refrigerated to prevent any reactivity and laboratory analyses were carried out within 48 hours. Heavy metals analyses were carried out using Atomic Absorption Spectrophotometer. All tests were carried out in accordance with the prescription of the American Public Health Association recommendations (2005). Nine heavy metals were quantified, namely: manganese, iron, copper, zinc, cobalt, chromium, cadmium, lead and nickel.

4. Results and Discussion

Interpreted resistivity values were obtained by iterative computer modeling of the apparent resistivity data. The VES data were plotted as pseudo and resistivity cross-sections in order to look at the spatial distribution of the contaminant plumes. The field resistivity data was interpreted using IPI2Win .2.1 version

Figures 4a and 4b show (a) Pseudo cross-section and (b) Resistivity cross-section of VES 1-6 along Profile A in Banwuya Refuse dump, Bida. Figure 3a showed Pseudo cross-section of profile A, the low resistivity observed on the top soil ranging between (12.7 – 22.7 Ωm) is as a result of leachate accumulation, this similar to the results of Abdullahi *et al.* (2010), Alabi *et al.* (2010). The dark blue and blue colouration showed the areas that have been affected by the leachate as observed by Olorode and Alao (2013). A very low resistivity zone (12.7 to 48.5 Ωm) is visible at the topmost layer along this profile, which might be associated with leachate plume originating from the waste disposal site (Kaya *et al.,* 2007). The drastic decrease in resistivity values from 12.7 – 48.5 Ωm on the surface to 0.2 Ωm at a depth of 39.1 m at VES5 can only be explained by contamination both in unsaturated and saturated zones in the area. (Kaya *et al.*, 2007, Enikanselu, 2008). Due to the low resistivity values observed in all layers, it is suspected that leachates generated from the dumpsites have migrated vertically downward from the topsoil to the maximum depth of 80 m at VES 2. Figure 3b showed two to four geoelectric layers. The resistivity values and the curve type for this profile consist of AK, A, H, HK and H for VES points 1, 2, 3, 5 and 6 respectively (figure 5).

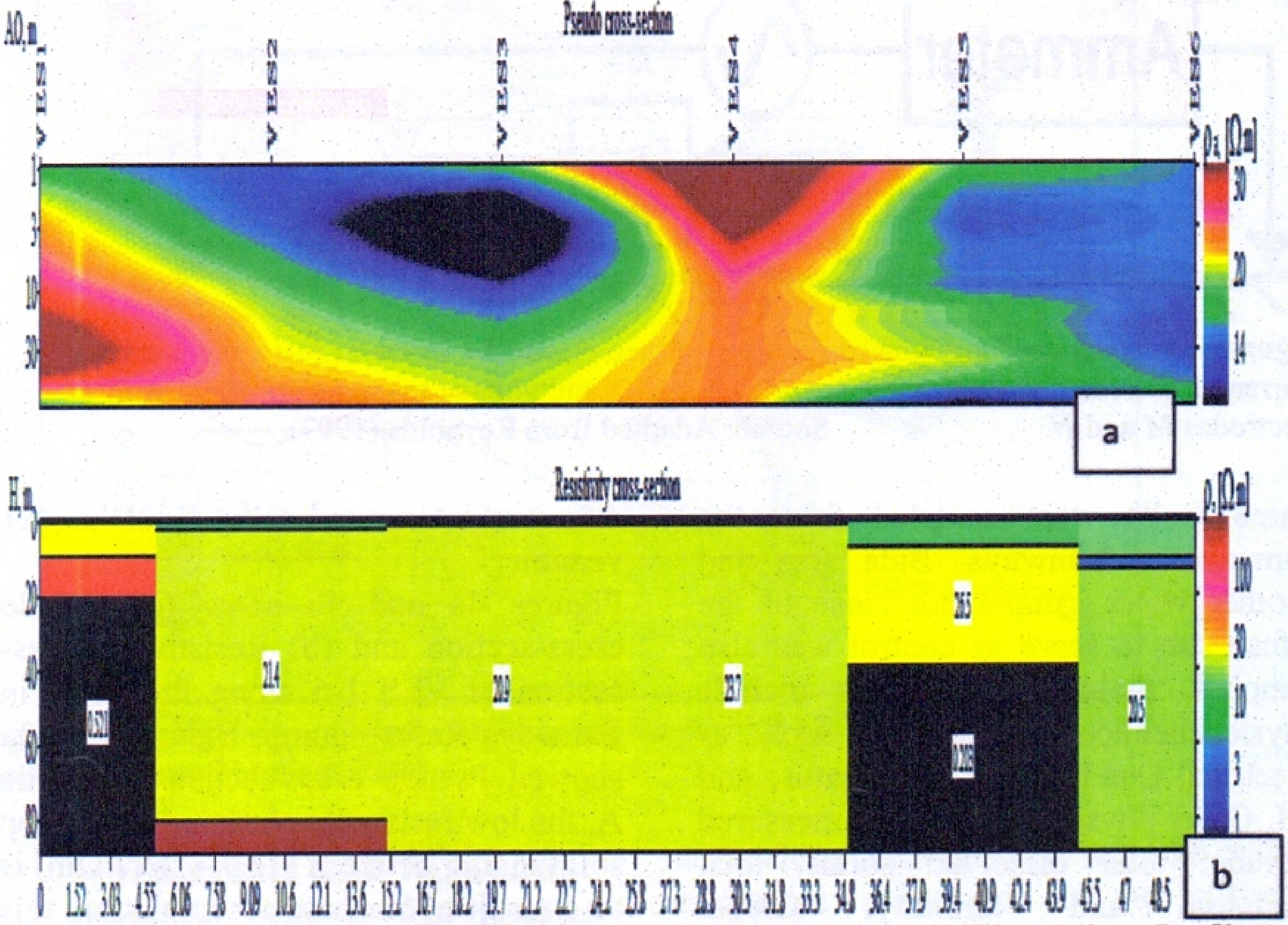

Figure:4(a) Pseudo cross-section and (b) Resistivity cross-section of VES 1-6 along Profile A in Banwuya Refuse dump. Source: Authors' Analysis, 2016

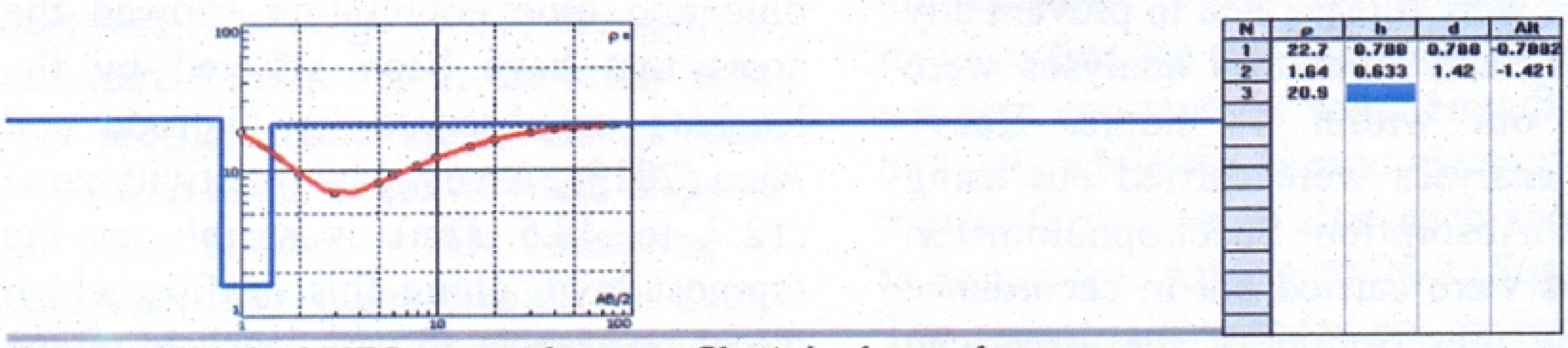

Figure 5: Typical VES curve along profile A in the study area
Source: Authors' Analysis, 2016

Figure 6 (a) Pseudo cross-section and (b) Resistivity cross-section of VES 1- 5 along Profile B in Banwuya Refuse dump showed how the plume moved from VES 2 through VES 3 and percolate vertically to a depth exceeding 4.94 m. The dark blue and light blue showed leachate accumulation with resistivity ranged between 4.06 and 31.1 Ωm (Rana, 2009; Jegede *et al.,* 2011). This suggests plume leachate migration from the surface down to the fractured aquifer at the basement (Ehirin and Ofor, 2011; Jegede et *al.,* 2011). The decrease in the resistivity from 31.1 Ωm to 0.58 Ωm noticed between VES 1 and 2 could be attributed to groundwater contamination due to leachate plume accumulation (Matias, 1994; Oladunjoye *et al.,* 2011), Figure 4b shows three to four geoelectric layers. The geoelectric layer for this profile shows H, HK, K curve type (Figure 6). The first layer has resistivity ranging between 4.06- 31.1

Ωm with thickness of between 0.5 – 7.39 m. The resistivity values for the second layer vary between 0.58 - 303 Ωm with a thickness of between 1.22– 4.69 m. The third layer has resistivity that ranges between 0.926- 644 Ωm with a thickness that is 3.07 - 4.2 m. The resistivity for the fourth layer is between 28 - 1868 Ωm. As a result of low resistivity observed on the topsoil and weathered layer it shows that leachate have been transported from the surface in to the weathered layer (Bayode *et al.*, 2011). The leachate at this profile is migrated to a depth of 77.9 m at VES point 2; this shows that the water at this depth is not safe for consumption.

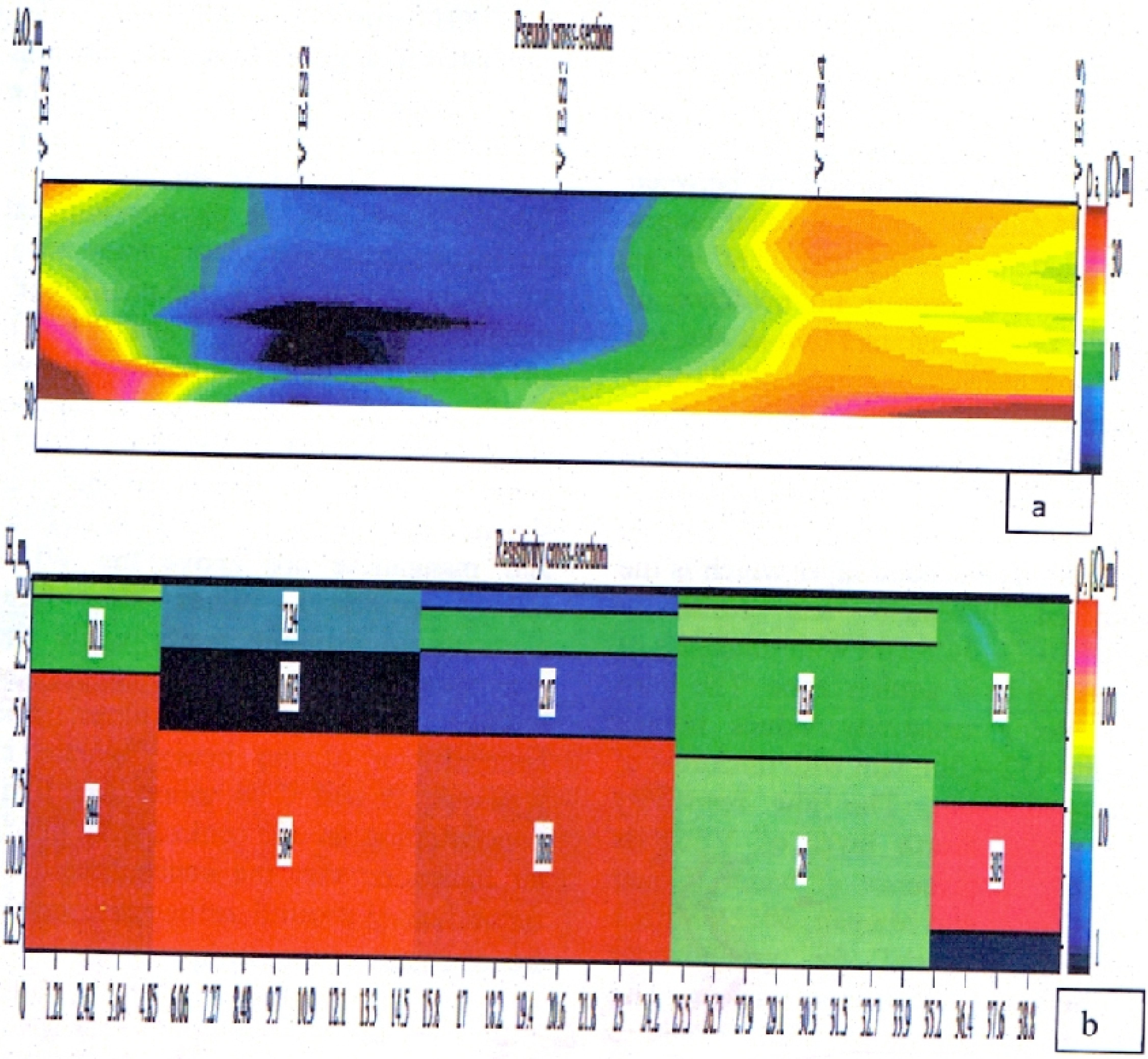

Figure 6 (a) Pseudo cross-section and (b) Resistivity cross-section of VES 1- 5 along Profile B in Banwuya Refuse dump.
Source: Authors' Analysis, 2016

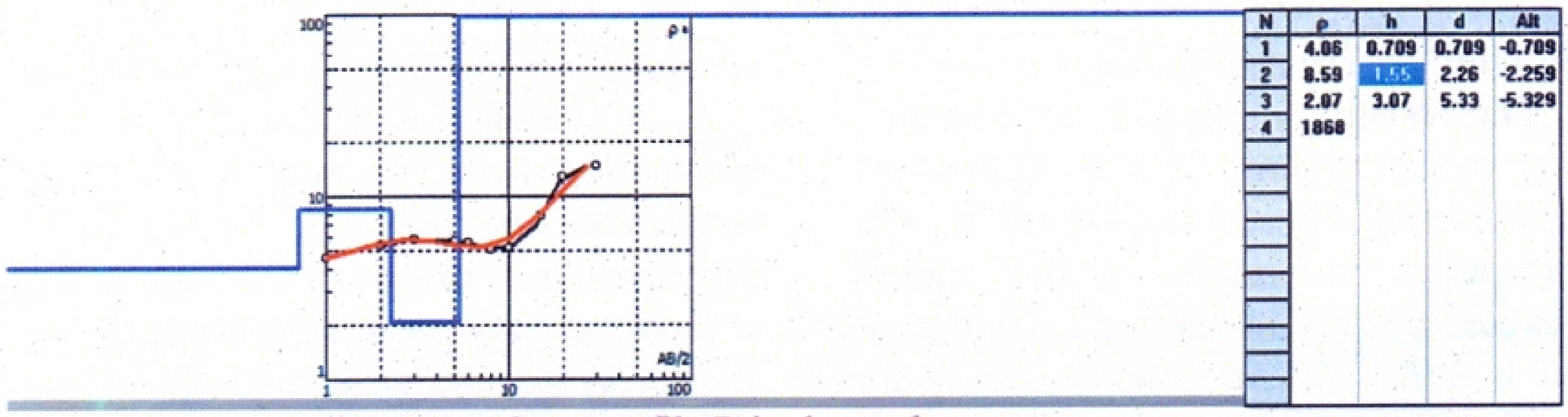

Figure 7: Typical VES curve along profile B in the study area
Source: Authors' Analysis (2016)

Figure 8(a) Pseudo cross-section and (b) Resistivity cross-section of VES 1-3 at control site about 200 m away from in Banwuya Refuse dump show low resistivity values at topsoil of between 127 - 166 Ωm with thickness that ranges between 0.561- 0.844 m. This is an indication that here is no evidence of leachate plume accumulation at the top soil along the profile based on its near surface resistivity values (Bayode *et al.*, 2011; Olorode and Alao; 2013). Figure 4(b) revealed three to four geoelectric layers, with curve types QH and H (figure 8). The second layer which is the weathered basement has resistivity ranged 10.7 – 56.6 Ωm with thickness of 0.39 – 8.6 m is aquifer zone. The third layer has a resistivity values ranged between 172 – 306 Ωm with thickness of 0.68 – 6.98 m. The low resistivity observed at fourth layer of VES1 is attributed to presence of water (Coker 2012; Okafor and Mamah, 2012). VES 1 has high potential for groundwater exploitation considering its thickness and depth with respect to VES 2 and 3 (Lateef, 2012 and Coker, 2012). The H and KH curves which are often associated with groundwater possibilities (Omosuyi, 2010) are pertinent to the study area.

Table 1 represents the physicochemical parameters measured in the study area. All these values were compared with standards for drinking water (WHO, 2011). The concentration of these heavy metals are higher in the three sample water when compared to WHO (2011) guideline values for these elements, it is shown that lead, iron, chromium, cadium and manganese are above the WHO (2011) guideline values for these elements in drinking water while the concentration of zinc and copper are within the permissible values. The concentration of the heavy metals in wells A, B and C is more than their concentration in the control well, this is an indication that the concentration of these heavy around refuse site could be as result of the dump.

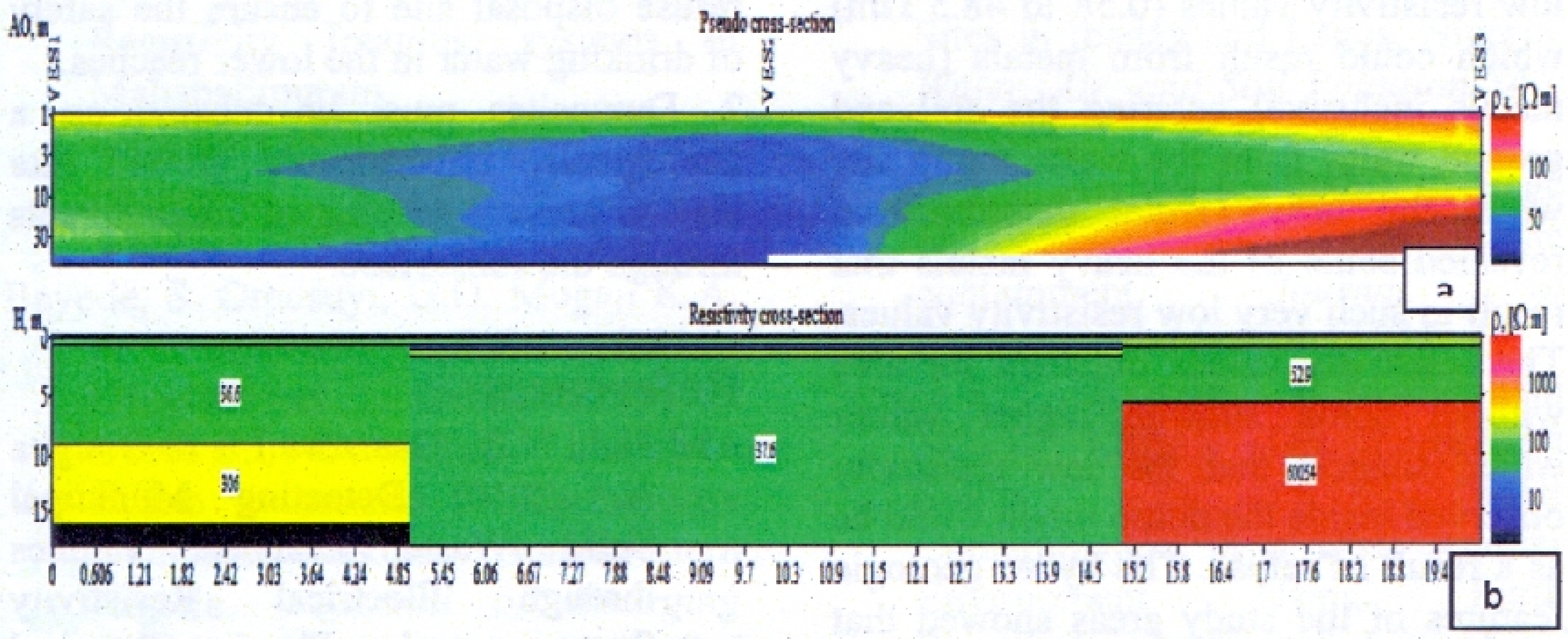

Figure 8(a) Pseudo cross-section and (b) Resistivity cross-section of VES 1-3 at control site about 200 m away from in Banwuya Refuse dump.
Source: Authors' Analysis, 2016

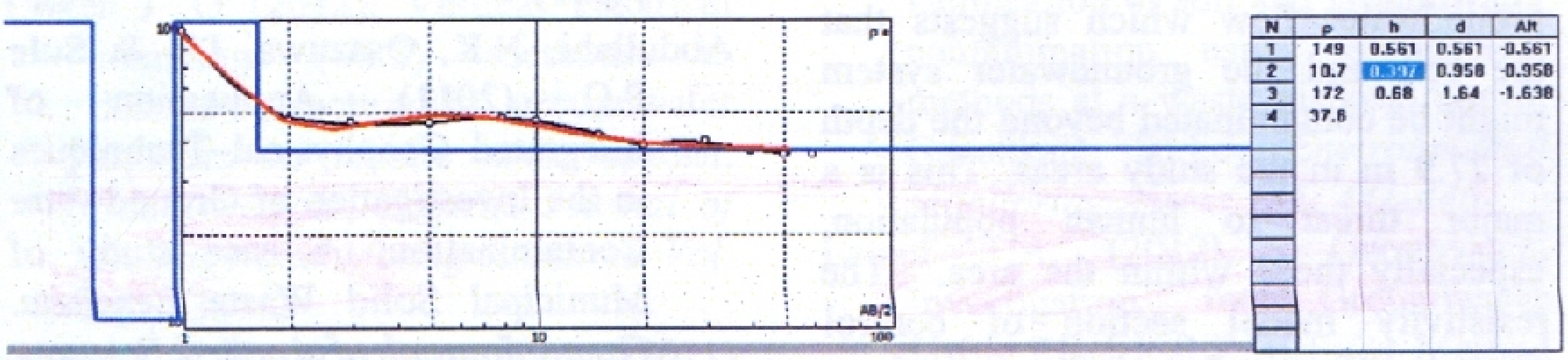

Figure 9: Typical VES curve at the control site in the study area
Source: Author's Analysis, 2016

Table 1: Physio-Chemical Analysis of Hand Dug Wells in Banwuya refuse dump, Bida

Parameter	Unit	Well A	Well B	Well C	Control Well	WHO(2011)
Temp	^{o}C	26.0	29.5	26.3	28.3	35-40
pH		6.75	6.56	6.92	7.2	6.5-9.2
Conductivity	µS/cm	705	582	718	83	100
Alkalinity	mg/l	1,180	570	650	80	200
Acidity	mg/l	92	93	92	34	NA
TDS	mg/l	1020	1210	1500	360	500-550
Total Hardness	mg/l	56	63	58	38	500
Zinc	mg/l	0.0758	1.931	1.5163	0.346	3.0
Lead	mg/l	0.653	0.363	0.16500	0.0000	0.001
Manganese	mg/l	0.875	0.7843	0.5875	0.076	0.5
Iron	mg/l	1.6757	1.3378	1.4732	0.04	0.3
Copper	mg/l	0.8500	0.5800	0.7500	0.0353	2.0
Chromium	mg/l	1.5000	0.1597	0.4758	0.0094	0.05
Nitrogen	mg/l	0.1000	0.20000	0.27000	0.0000	NA
Cobalt	mg/l	0.04925	0.2429	0.05363	0.0071	NA
Cadmium	mg/l	0.0637	0.0582	0.0841	0.0032	0.003

5. Conclusion

Electrical resistivity sounding has revealed probable contamination zone beneath the subsurface where the waste dumpsite is located and this contamination zone is a region of very low resistivity values (0.58 to 48.5 Ωm) which could result from metals (heavy metals inclusive) entering the soil and ground water from the waste dump site while the heavy metal determination revealed some of the heavy metals that result in such very low resistivity values. The resistivity values obtained for area without dump showed higher values which suggest that the low resistivity observed inside the dump might could be as a result of refuse. The hydro geologic features of the study areas showed that contaminants derived from the waste disposal site infiltrate through vulnerable sandy formation and hence to the groundwater flow which suggests that the soil and the groundwater system might be contaminated beyond the depth of 77.9 m in the study areas. This is a major threat to human population, especially those within the area. The resistivity model section of control traverse (Figure 7 and 8) showed an increasing near surface resistivity values of 127-166 Ωm from the surface to depth of about 1 m along the profile. This is an indication that there is no evidence of leachate plume accumulation at the top soil along the profile based on its near surface resistivity values. This study showed that electrical method, integrated with water analysis method, can be used for the investigation of groundwater contamination. Finally, the findings of this study call for attention and can contribute to the efforts of groundwater protection and remediation to reduce environmental hazards from the dumpsite.

6. Recommendations

1. Constant monitoring of the groundwater quality is highly recommended especially around refuse disposal site to ensure the safety of drinking water in the lower reaches.
2. Dumpsites must be located on a geologically impermeable ground like clay to prevent seeping of contaminants through the subsurface.

References

Abdullahi N.K., Osazuwa I.B & Onugba A. (2010) Detecting Municipal Solid Waste Leachate Plumes through Electrical Resistivity Survey and Physico-Chemical Analysis of Groundwater Samples *Journal of American Science 6(8). Pp 1-9*

Abdullahi, N.K, Osazuwa, I.B & Sule P.O (2011). Application of Integrated Geophysical Techniques in the Investigation of Groundwater Contamination: A case study of Municipal Solid Waste Leachate. *Ozean Journal of Applied Sciences 4 (1)*. pp 7- 25

Adeleye D. R. (1972) *Stratigraphy and Sedimentation of the Upper Cretaceous Strata around Bida Nigeria*, An unpublished Ph.D thesis, University of Ibadan,

Akintayo O. O (2015). Detection of Leachate Plumes Migration Depth Using Vertical Electrical Sounding Method. *The African Review of Physics. Pp257-264*

Alabi A. A, Bello, R. Ogungbe & A.S Oyerinde H.O (2010). Determination of Groundwater Potential in Lagos State University, Ojo; Using Geoelectric Methods (Vertical electrical sounding and horizontal profiling). *Report and Opinion; 2(5)*

Antony R. A. & Mohammed A. P. H. (2012). Groundwater exploration study using Wenner-Schlumberger electrode array through W-4 2D

Resistivity Imaging systems at Mahapallipuram, Chennai,Tamilanadu, India. *Research Journal of Recent Sciences 1(11), 36-40, November.*

Bayode, S. Omosuyi, G.O. Mogaji K.A. & Adebayo S.T. (2011). Geoelectrical Delineation of Structurally-Controlled Leachate Plume around Otutubiosun Dumpsite, Akure, Southwestern Nigeria. *Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS) 2 (6). Pp 987-992*

Coker J. O (2012). Vertical electrical sounding (VES) methods to delineate potential groundwater aquifers in Akobo area, Ibadan, South-western, Nigeria. *Journal of Geology and Mining Research Vol. 4(2), 35-42*

Ehirim C.N & Ofor W., (2011) Assessing Aquifer Vulnerability to Contaminants near Solid Waste Landfill Sites in a Coastal Environment, Port Harcourt, Nigeria, *Trends in Applied Sciences Research 6 (2). Pp 165-173*

Enikanselu P. A (2008); Detection and Monitoring of Dumpsite – Induced Groundwater Contamination using Electrical Resistivity Method; *the Pacific Journal of Science and Technology; 9(1): 254 – 262.*

Goro A.I., Salihu H.D., Jibrin B.W., Waziri N.M. & Idris-Nda A.I (2014). Characterization of a Massive Sandstone Interval: Example from Doko Member of Bida Formation, Northern Bida Basin, Nigeria. *Universal Journal of Geoscience 2(2)*: 53 – 61.

Ikem A, Osibanjo O, Sridhar MKC, Sobande A (2002). Evaluation of Groundwater Quality Characteristics near Two waste Sites in Ibadan and Lagos, Nigeria. *Water, Air, and Soil Pollution* 140: 307-333.

Ismail, Z & Hashim R. (2006). Seepage of contaminants from waste containment. *Journal of Environmental hydrology. 14: 2*

Jegede S. I., Osazuwa I. B & Abdullahi N. K (2011), Geoenvironment Study of Groundwater Contamination in a Dual Aquifer Environment Using Earth Resistivity Imaging. *Journal of American Science 7(2). Pp 367-377*

Kaya, M. A, Gülçin Ö & Ebru Ş. (2007), Delineation of soil and groundwater contamination using geophysical methods at a waste disposal site in Çanakkale, Turkey. *Environmental Monitoring Assess 135: 441-446*

Lateef T.A. (2012). Geophysical Investigation for Groundwater Using Electrical Resistivity Method - A Case Study Of Annunciation Grammar School, Ikere LGA, Ekiti State, South-Western Nigeria. *Journal of Applied Physics (IOSRJAP)*

Manon, C; Marquez, L; Hernandez, M. C & Lopez, A. (2011). Model to estimate the volume of leachate from MSW: Comparative analysis of multiple regression and artificial neural network. Fourth International Workshop ''Hydro – Physico Mechanics of landfill. Santrandel Spring; 1

Matias M. Senos, M. Marques S., P. Ferreira, E & Ramalho (1994). Age of physical and Hydrogeological Study of aquifers contamination by a landfill. *Journal of Applied Geophysics 32: 155-162*

Oladunjoye M. A., Olayinka A I. & Amidu S. A (2011). Geoelectrical Imaging at an Abandoned Waste Dump Site in Ibadan Southwestern

Nigeria. *Journal of Applied Sciences 11 (22). Pp 3755-3764*

Okosun, E. A., Goro, A. I., Olobaniyi, S. B., Shekwolo, P. D.& Nwosun, J. E. (2009). Stratigraphy of Bida Formation, Bida Basin, Nigeria, *Borno Journal of Geology, 4(9):21-37*

Olorode D. O. & Alao A O., (2013) Geo-electrical investigation of underground water contamination by solid waste: Case study of Solous III Dumpsite, Igando, Lagos, Nigeria. *Pelagia Research Library Advances in Applied Science Research, 4(4):420-443. Available online at* www.pelagiaresearchlibrary.com

Omosuyi, G.O. (2010). "Geoelectric Assessment of Groundwater Prospect and Vulnerability of Overburden Aquifers at Idanre, Southwestern Nigeria". *Ozean Journal of Applied Sciences.* 3(1):19-28

Popoola I.O, & Fakunle, M.A (2011), Investigation of Leachate Migration from Majo Public Refuse Dump Site (Ajakanga) in Ibadan, Nigeria. *Nigerian Journal of Physics (NJP) 22 (1).*pp 80-90

Popoola I.O, Adegoke J.A & Fakunle, M.A (2014), Estimation of Average Leachate Velocity of flow from Lapite Public Dump Site, Ibadan, Using Electrical Resistivity Method. *Nigerian Journal of Physics (NJP) 25 (1). Pp 16- 24*

Rana A, A, Rawa S, A & Zaid A. (2009). Preminary Investigation of Al-Jahra Waste Disposal Site Using Electrical Resistivity (ER) Surveys. 2nd Kuwait Waste Management Conference and Exhibition 14th-16th April 2009. Pp 1-8

Rafiu A.A & Mallam A. (2014). The Impact of a Waste Disposal Site on Soil and Groundwater in Dusten-Kura Gwari, Minna, Niger State, Nigeria *IOSR Journal of Applied Physics (IOSR-JAP) 2(8,) ISSN: 2278-4861.Volume 6, Issue 6 Ver. II PP 01-05* Available at *www.iosrjournals.org*

Rafiu A. A and Mallam A. (2016). Vertical Electrical Resistivity Evaluation at Solid Waste Disposal Site, Dusten kura, Minna, Niger State. *Nigerian Journal of Physics.* Pp 86-94

Reynolds, J.M., (1997). *An Introduction to Applied and Environmental Geophysics*. John Wiley and Sons New York. P 796

Udensi, E. E. & Osazuwa, I. B. (2004). Spectral determination of depths to magnetic rocks under the Nupe Basin, Nigeria, *Nigeria Association of Petroleum Explorationists* Bulletin, 17, 22-37.

World Health Organization (2011).Guidelines for Drinking-water Quality.4th Edition. Geneva Switzerland.