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E-mail: jdrm@futminna.edu.ng Phone: 08034052367

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:

- Earth and Environmental Sciences
- Geography and Urban Studies
- Environmental Engineering and Technology
- Agricultural Sciences and Technology
- Environmental Health
- The Social Sciences
- Economic and Financial Management

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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Geophysical and Physico-Chemical Analysis of Soil and Water in the Vicinity of Waste Disposal Site, Kpakungu, Minna, Niger State, Nigeria

Rafiu A. A[1] and Mallam A.[2]

[1] *Physics Department, Federal University of Technology, Minna, Nigeria*
[2]*Phyics Department, University of Abuja, Abuja*

Abstract

The environmental pollution of groundwater around Kpakungu, under bridge due to contaminant potential of leachate from the waste disposal site was investigated. This was done using Schlumberger array of Electrical resistivity method. The result was interpreted using a computer iteration called IP2Win. The interpretation of electrical resistivity models revealed regions of very low resistivity of an average depth of 4.7 m to beyond an average depth of 9.0 m for both transverses. These regions of very low resistivity could be contamination zones of the subsurface beneath the profiles resulting from leachate seeping into the soil and or ground water from the waste dump. The Vertical Electronic Sounding (VES) points taken in the refuse dump show a low resistivity zone of 20.0 to 27.3 Ωm down to a depth of 9 m. The four VES points outside the dumpsite also reveal that the groundwater is free from pollution. The values of resistivity from control site show a low resistivity zone of 89.6 to 180 Ωm for maximum depth of 2.89 m. The concentrations of the heavy metals like zinc, lead, manganese, iron, copper, chromium, nickel, cobalt and cadmium in the soil and groundwater samples were determined using a 210 VGP Buck Scientific Atomic Absorption Spectrophotometer. Water in this area is found to be contaminated by Lead, Chromium and Cadmium with level of contamination exceeding WHO (2004) regulated guidelines. Integrating the results of the electrical resistivity survey and the heavy metal determination of soil and groundwater revealed probable ground water contamination zones and the heavy metals that could result in the contamination.

Keywords: Contamination, groundwater, leachate, resistivity, waste

1. Introduction

Electrical methods are used to investigate landfills due to the conductive nature of the leachate. Moreover, several geo-electrical based techniques exist to investigate leakage in geo-membrane lined landfills prior to their operation. Geo-electrical methods have been also proposed to study possible geo-membrane leakage in operating landfills. In this framework, geophysical investigation and particularly geoelectrical techniques are considered as a valuable tool in environmental management.

Solid wastes are produced on daily basis as a result of direct consequence of inevitable human activities (Ganiyu *et al.*, 2015). The intensity of man's activities has led to increasing volume of solid waste worldwide despite the current level of global technological advancement and industrialization. Landfill/dumpsite serves as the ultimate recipient of municipal solid waste. It is a common waste management practice employed by many nations in many parts of the world (Rafiu and Mallam, 2016). The waste dumped in this process causes various aesthetic and public health problems and also attracts insects, rodents and various disease vectors (Adeyemi *et al.*, 2007). Ground water pollution in and around an open waste dump site occur due to the contamination of ground water by leachate (Akanbi and Eze, 2014). Leachate presence from dumpsites leads to contamination of groundwater in the vicinity of the dumpsite as it percolates the ground and travels with groundwater (Popoola and Fakunle, 2014). Heavy metal pollution is a global issue, although the severity and levels of pollution differs from place to place. The increased number of industries, rural urban migration has brought about huge increase in the quantity of discharge and a wide diversity of types of pollutants reaching water bodies. The population explosion has resulted in huge generation and discharge of municipal waste. The waste disposal site is the uncontrolled open waste dump site, thus creates serious threats to local environmental quality and public health. Electrical resistivity method provides economic and non-destructive 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 (Akanbi and Eze, 2014). This is because leachate diminishes the electrical resistivity of the formation that contains them (Martinho and Almeida, 2006). Geoelectrical surveys of dumpsite have been carried out by numerous researchers on leachate contamination of soil and groundwater including the studies of (Rafiu and Mallam, 2015; Ganiyu *et al.,* 2015; Popoola and Fakunle, 2014). The aim of this study is to use electrical resistivity method and heavy metal determination of soil and groundwater at an open waste disposal site in order to determine the extent of groundwater contamination.

2. Location and Geology of the Area

The study area is Kpakungu located on latitude $9.6^{0}11^{1}$- $9.6^{0}17^{1}$ N and longitude $6.53^{0}14^{1}$- $6.53^{0}58^{1}$E (Figure 1). The size of the disposal site is 4,800 m^2. The area of survey lies directly within the northwestern part of the Nigerian Basement Complex, which is composed of three fold lithological units and forms a part of the large Pan-African mobile belt (Figure 2). Generally, the area mapped forms part of the Minna - granitic formation that consists of Metasediment and meta-volcanic. The Metasedimentary include quartzite and gneisses while meta-volcanic are mainly granites (Figure 3). Among the main rock groups are granites which occur at the central and northern parts of the area, while on the south and east, cobbles of quartzite are found especially along the channels and valley. However, the other bodies like pegmatite and quartz veins also occur within the major rock types. The rocks are mainly biotite – granites with medium to coarse grained, light colored rocks with some variation in biotite content.

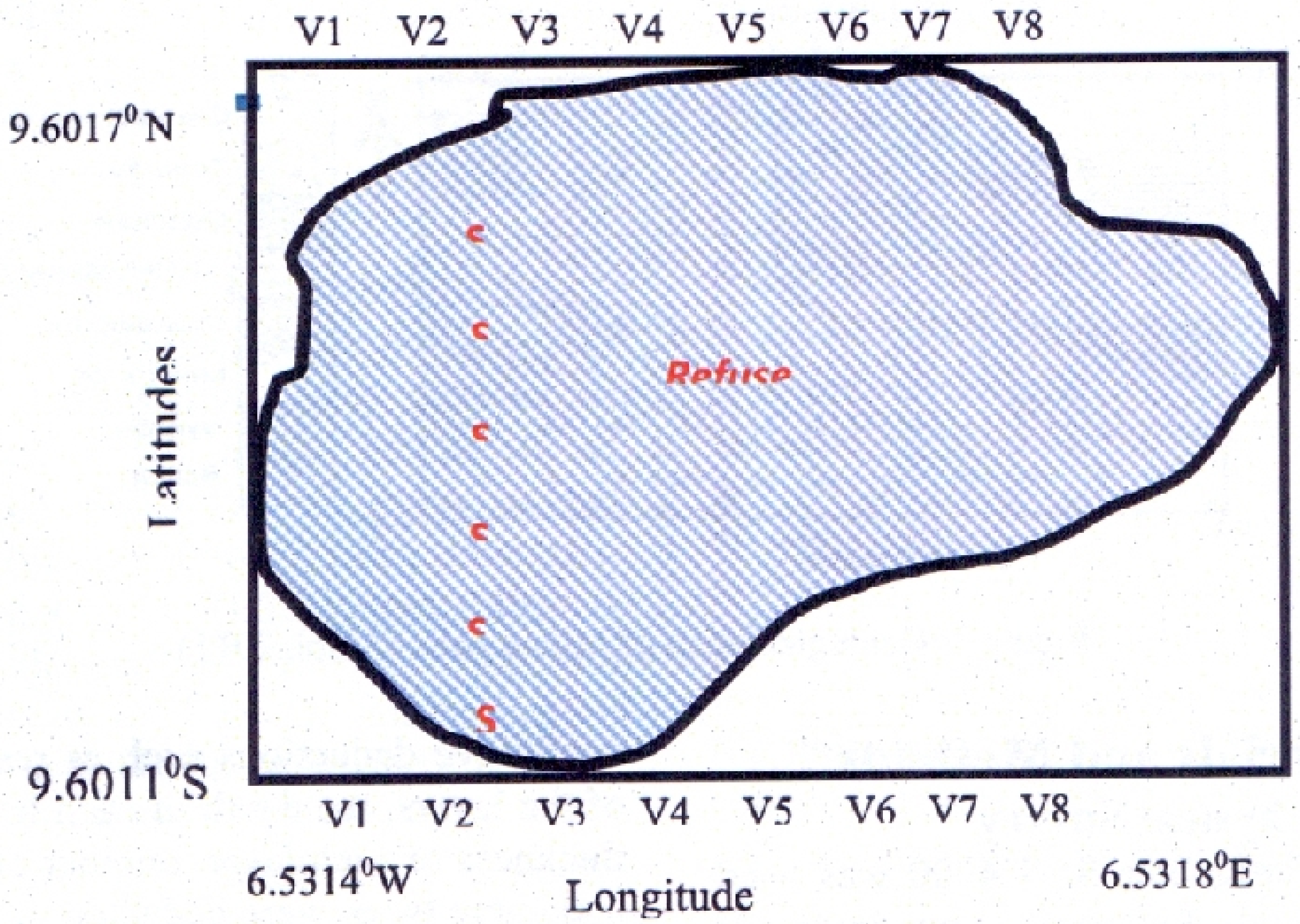


Figure 1: Map of Kpagungu dump site showing VES stations and soil sample layout
Source: (Authors' design)

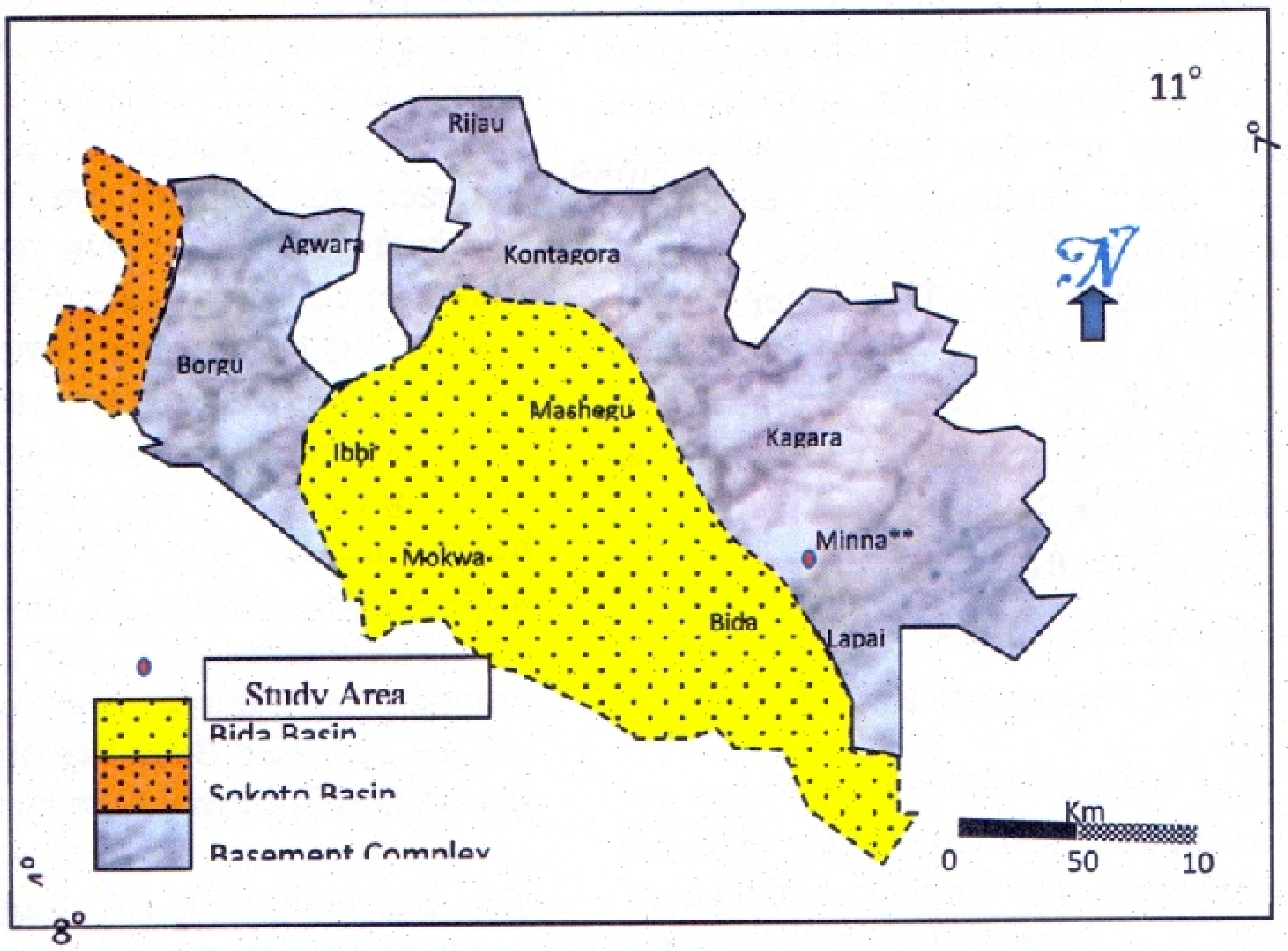


Figure 2: Geological map of Niger state showing the study area (Rafiu and Mallam, 2014)

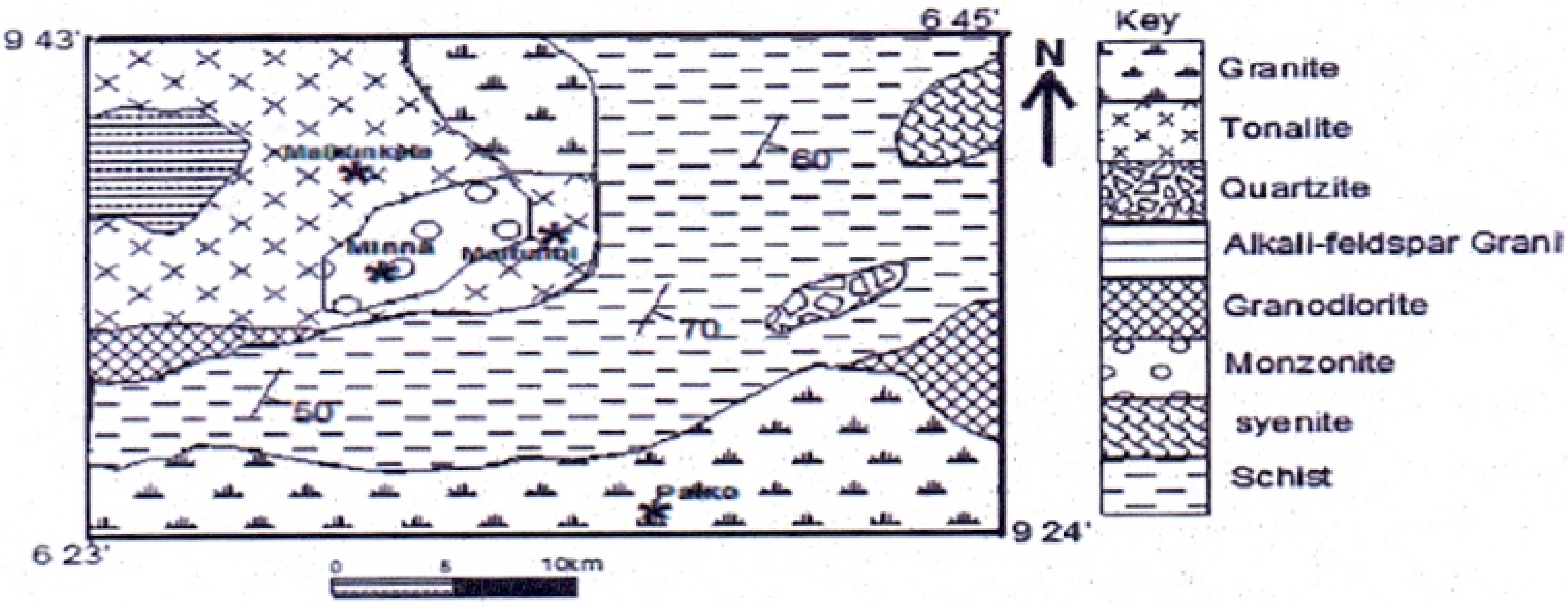


Figure 3: Geological map of Minna Area (Alabi, 2011)

3. Materials and Methods

3.1 Geophysical Survey

ABEM Terrameter SAS 4000 was used for Vertical Electrical Soundings. It comprises of three profiles, two by the edge of the refuse disposal and one at area free from waste dump. Twenty VES points were established, sixteen points inside the dumpsite and another four points in an area free from refuse dump using the Schlumberger electrode configuration. The resistance values displayed by the Terrameter were recorded in recording sheets which were later used to calculate apparent resistivity. The apparent resistivity was computed using equation

$$\rho = \left(\frac{V}{I}\right)\left(\frac{A}{L}\right) = RK \qquad 1,$$

ρ is apparent resistivity,

$R=\left(\frac{V}{I}\right)$, the earth resistance and

$K = \left(\frac{A}{L}\right)$ is the geometrical factor.

The apparent resistivity values obtained from equation (1) were plotted against the half current electrode separation spacing using IPI2WIN software. From these plots, vertical electrical sounding curves were obtained and qualitative deductions such as resistivity of the layers, the depth of each layer, the thickness of each layer, number of layers and curve types were deducted.

3.2 Samples collection

Water samples were collected from three existing wells in the vicinity of the waste dump and one sample away from disposal site to serve as control were analyzed for physiochemical analysis. Leachate samples within waste dump were also collected at six different points from the centre of waste dump at interval of 10 metres and three samples away from the site to serve as control were also analyzed. The concentrations of the heavy metals: zinc, lead, manganese, iron, copper, chromium, nickel, cobalt and cadmium in the soil and groundwater samples were determined using a 210 VGP Buck Scientific Atomic Absorption Spectrophotometer.

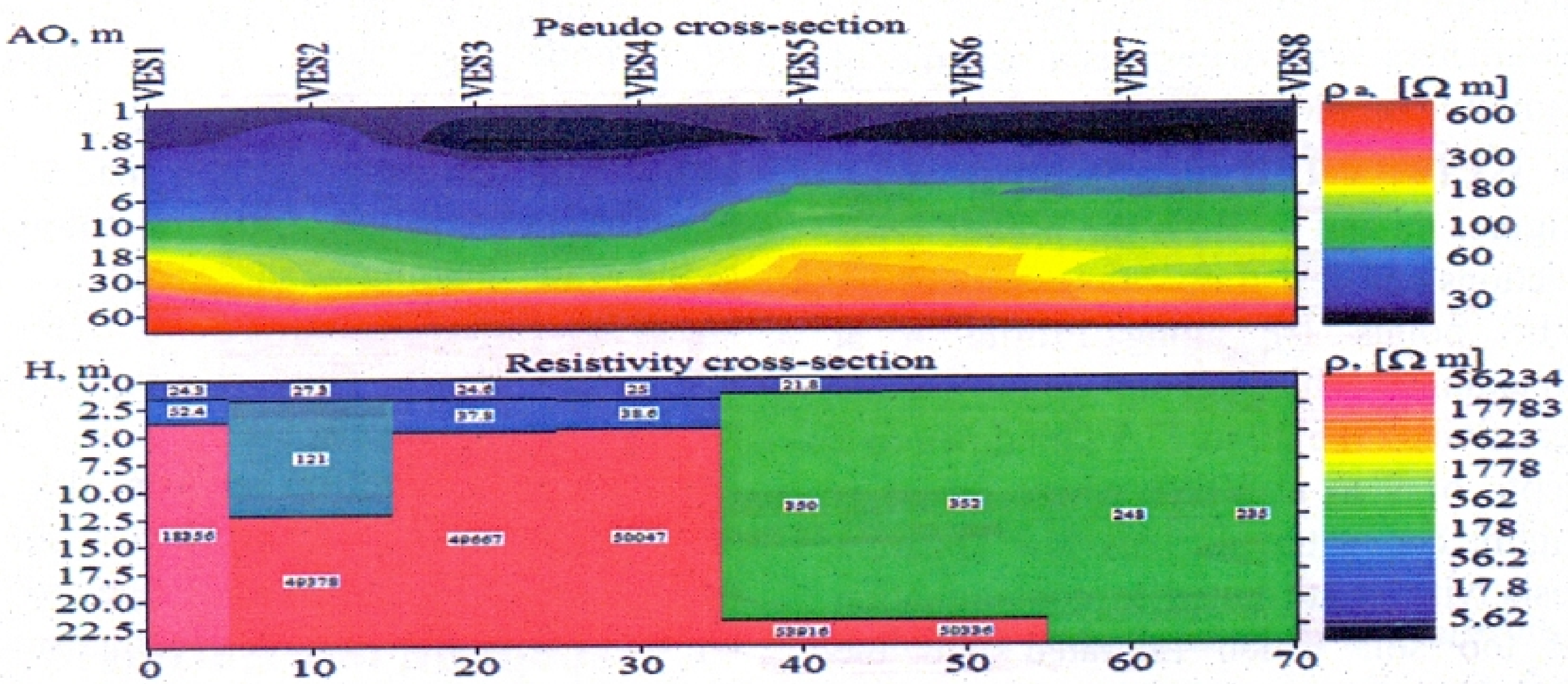
The temperature in (^{O}C) and electrical conductivity (µS/cm) of all groundwater samples were measured and recorded using a Jenway 4010 Conductivity meter. An Oyster Series pH meter calibrated using a buffer 7 solution was used to measure the pH of all groundwater samples. All these physical parameters were determined at time of sampling on the field.

4. Results and Discussion

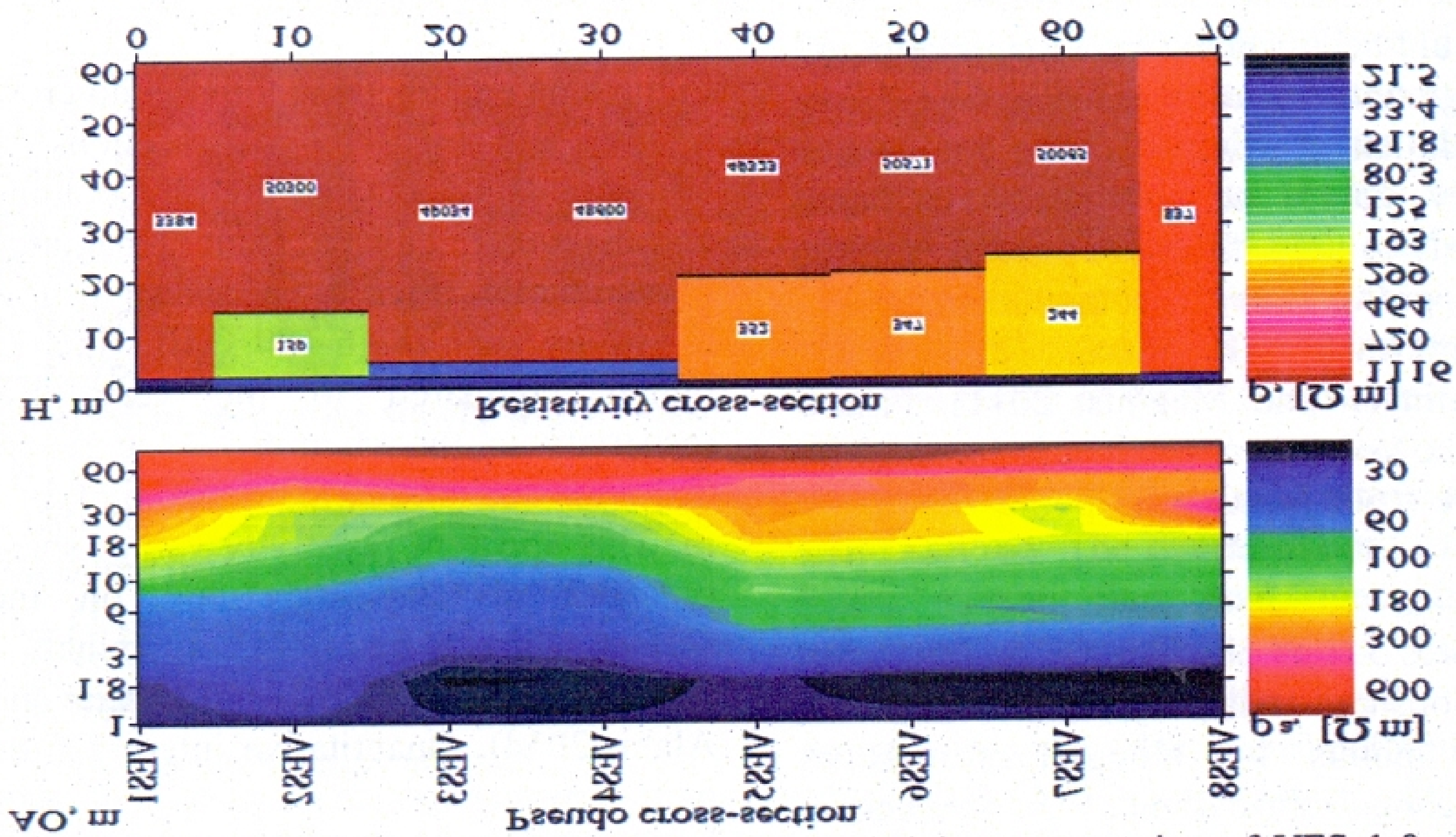
Figures 4a and 4b show the pseudo cross sections and resistivity cross sections for VES points 1-8 along Profile A at Kpakungu refuse dump show a low resistivity zone 20 to 27.3 Ωm down to a depth of 9 m at VES8 where refuse is highly concentrated. This low apparent resistivity is attributed to contamination of top soil which migrated into the second layers for VES 1, VES 3 and VES 4, due to accumulation of leachate (Akaninyen and Magnus, 2011). The low apparent resistivity values observed in the second layer for VES points 1, 3 and 4 could be attributed to contamination of the groundwater due to leachate invasion (Abdullahi *et al.,* 2010). The porous and sandy nature of the site contributes largely to the infiltration process leading to groundwater contamination of groundwater (Kaya *et al.,* 1996; Akaninyen and Magnus, 2011). Figure 4b showed three geo electric layers. The curve types for all VES points consist of A.

Figures 5a and 5b show the pseudo cross sections and resistivity cross sections for VES points 1-8 along Profile B at Kpagungu refuse dump. Figure 3a shows a low resistivity zone (20.4- 29.1 Ωm) to maximum of 4.71 m at VES points 3. The dark blue observed at VES points 1,3,4,6, 7 and 8 showed that most of the refuse were dumped at those area (Abdullahi *et al.,* 2010). These regions of very low resistivity could result from leachate seeping into the soil and or groundwater from the waste dump and is probably the contamination zone within the subsurface of the profiles (Ehirim *et al.,* 2009; Abdullahi *et al.,* 2010; Ekeocha *et al.,* 2012; Ogungbe *et al.,* 2012). The horizontal horizon made up of green, grey, yellow and pink colours is the water bearing zone (Abdullahi *et al.,* 2010). Figure 5b showed two to three geo electric layers. The curve types for all VES points consist of type A. The low resistivity values of between 21.4 – 44.6 Ωm observed in second layer could be as a result of leachate seepage from top most layer mixed with decomposing waste which implies contaminants and pollute surrounding soil and shallow aquifer, this is similar to the work of Mahmoud *et al.* (2009), Ehirim *et al.* (2009) and Adabanija and Alabi (2014).

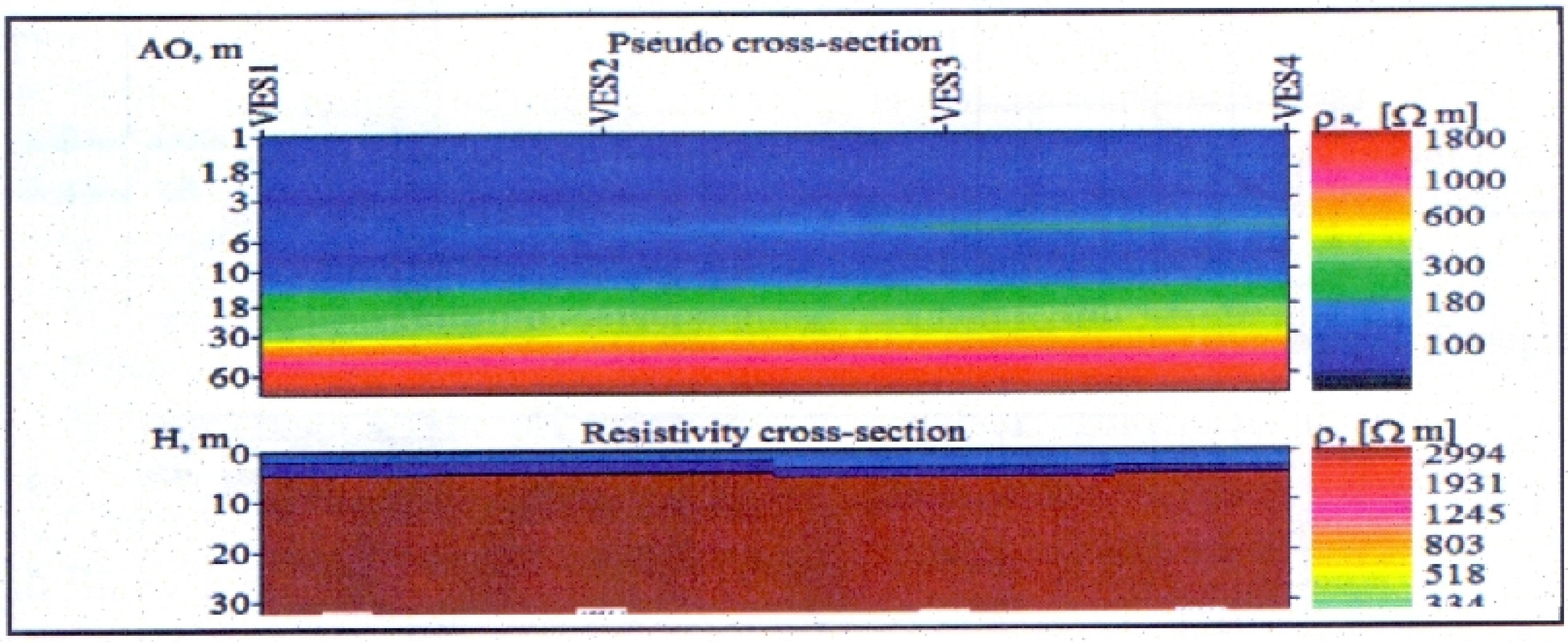
Figures 6a and 6b show the pseudo cross sections and resistivity cross sections for VES points 1-4 outside the refuse dump about 200 m away from Kpagungu refuse dump. Figure 6a shows a low resistivity zone (89.6-180 Ωm) which is higher compared to the very low resistivity in the vicinity of the refuse disposal sites for maximum depth of 2.89 m. This apparent resistivity values show presence of clay/sandy soil on the surface which is free from contamination (Ogungbe *et al.,* 2012, Adabanija and Alabi, 2014). Quantitative interpretation of VES of the control site revealed that it has lowest resistivity value of 89.6 Ωm. Geo–electric sections revealed that second layer in all the VES points were mainly clayey sand of low resistivity values. The curve interpretation for this profile shows curve type A for all VES points. The groundwater here may likely free from contamination due to the relatively high resistivity values compared with the refuse disposal site.



Figures 4 (a) and (b): Pseudo cross-section and Resistivity cross-section of VES 1-8 along Profile A in Kpakungu Refuse dump.
Source: Authors' Analysis, 2017



Figures 5 (a) and (b): Pseudo cross-section and Resistivity cross-section of VES 1-8 along Profile B in Kpakungu Refuse dump.
Source: Authors' Analysis, 2016



Figures 6 (a) and (b): Pseudo cross-section and (b) Resistivity cross-section of VES 1- 4 at control site in Kpakungu Refuse dump. (Authors' result)

Figures 7 to 9 showed typical curves along profile A, profile B and at control site. It showed three geologic sections of mostly A curve types at refuse site and H curve types at the control site. Figure 7 consists of three layers with varying resistivity values and thickness. The values of resistivity observed at first and second are probable risk for groundwater contamination because these resistivity values indicate contaminant plumes. Figure 8 also consists of three layers, the values of resistivity along this profile also indicate contaminant plumes and to a depth of 14.3 m. Figure 9 shows the VES curve which was taken away from refuse dump site. The resistivity value observed at the top layer is high compared to those observed at the refuse dump. This high resistivity values are an indication that the area is not contaminated.

Table 1 shows the results of analysed soil within the vicinity of the refuse disposal site compared with the control site. The heavy metals investigated in this study include: Zinc, Lead, Manganese, Iron, Copper, Chromium, Nickel, Cobalt and Cadmium. Based on the results obtained, there was a gradual decrease in the concentration of heavy metals from the centre of the dumpsite to the bottom of the slope. In most cases from locations (1 - 6), there was a significant difference between the concentrations of most metals at the centre of the dumpsite to the bottom of the slope. The variation in different parameters values in this study may be attributed to the fluctuations in waste type and characteristics (Abd El-Salam and Abu-Zuid, 2014). The results indicated that the soils collected in this survey were contaminated by Cd, Ni, Pb, Zn and Cr.Table 2 shows the results of analysed water near the disposal and control well compared with WHO (2004)

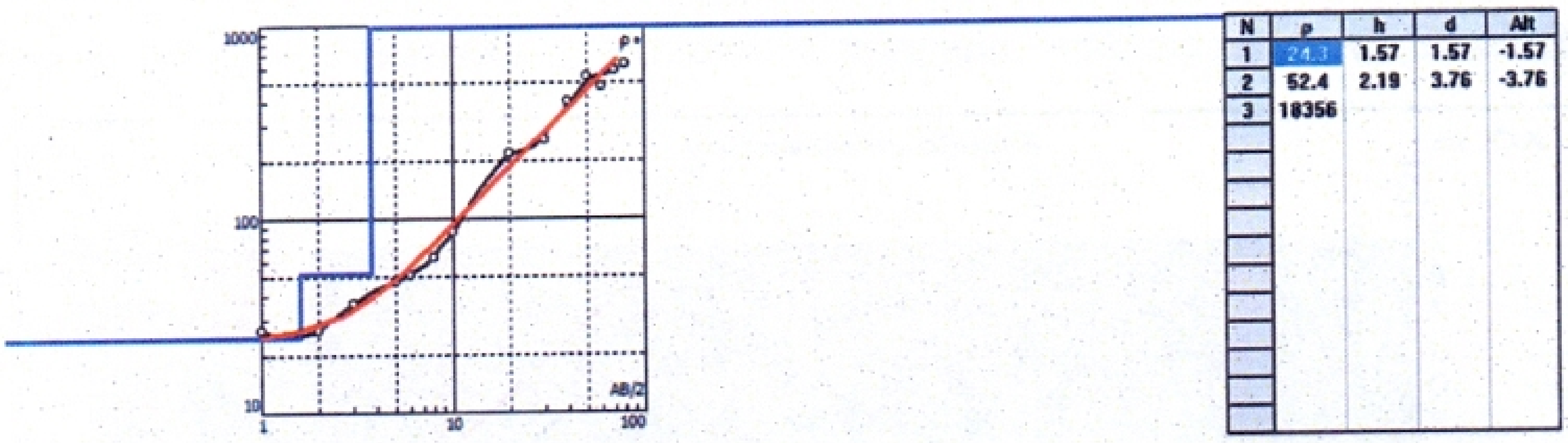


Figure 7: Typical curve along Profile A (Authors' result)

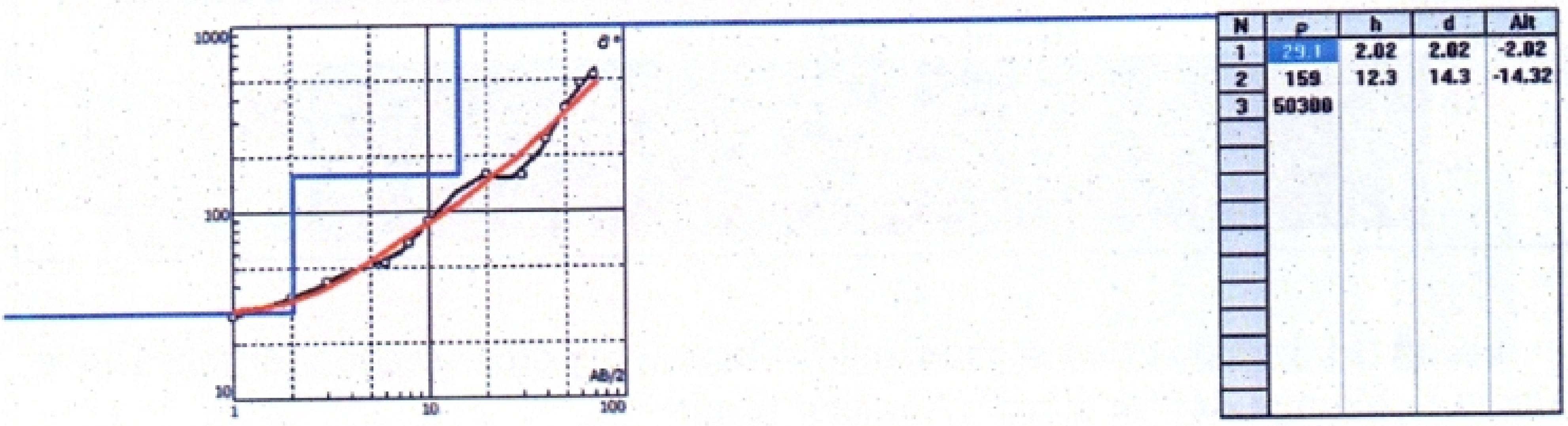


Figure 8. Typical curve along Profile B (Authors' result)

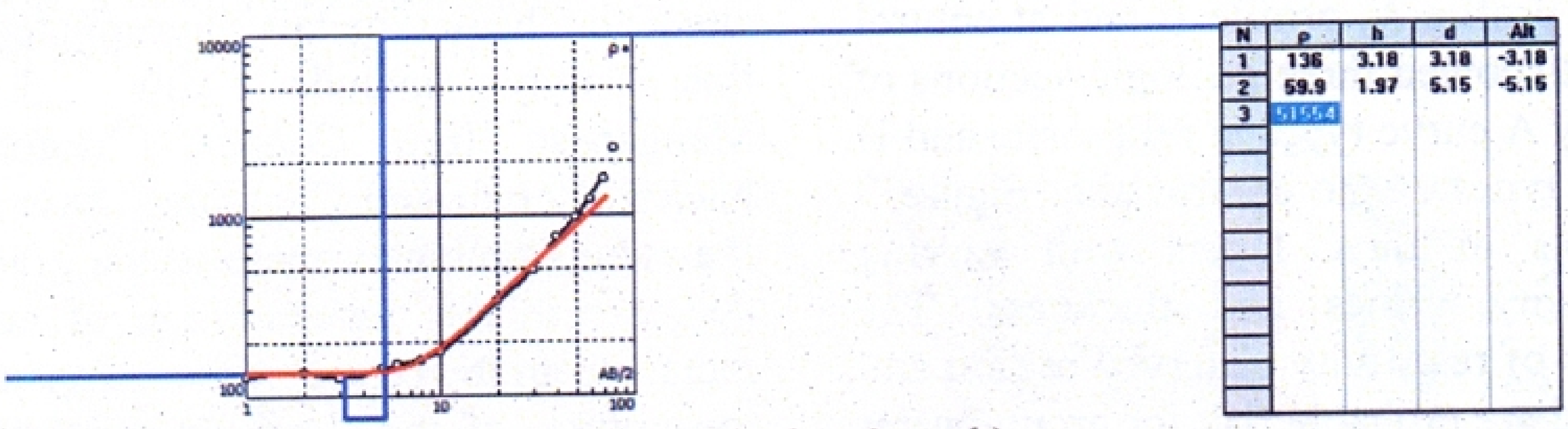


Figure 9. Typical curve at control site (Authors' result)

Table 1: Physio-Chemical Analysis of Soil Samples in Kpagungu refuse dump

Location	pH	Zn (mg/kg)	Pb (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Co (mg/kg)	Cd (mg/kg)
KG1	6.81	6.81	9.62	18.57	6.76	50.00	125.00	30.00	8.57	0.74
KG2	6.62	4.88	9.43	15.00	5.36	37.50	62.50	25.00	5.29	8.57
KG3	6.51	4.24	9.15	11.43	4.97	25.00	57.30	20.00	4.86	5.29
KG4	6.41	3.60	8.73	7.86	3.39	20.00	41.67	15.00	3.53	0.23
KG5	6.92	3.26	8.10	4.29	2.81	16.50	36.63	10.00	2.43	0.17
KG6	6.42	2.96	7.84	3.21	1.69	12.50	20.83	6.00	1.62	0.09
Min	6.41	2.96	7.84	3.21	1.69	12.50	20.83	6.00	1.62	0.09
Max	6.92	6.81	9.62	18.57	6.76	50.00	125.00	30.00	8.57	0.74
Mean	6.62	4.29	8.80	10.06	4.16	26.92	57.32	17.67	4.38	0.36
S.D	0.21	1.43	.7.38	6.06	1.87	14.23	36.36	9.09	2.48	0.33
KGC1	6.18	0.002	0.000	0.007	0.001	0.00	1.006	0.00	0.0056	0.0004
KGC2	6.25	0.013	0.006	0.0156	1.001	3.50	2.00	1.00	0.0084	0.0003
KGC3	6.30	0.001	0.000	0.0018	0.003	5.00	4.67	2.00	0.0064	0.0011
Min	6.18	0.001	0.000	0.0018	0.001	0.0000	1.0057	0.0000	0.0056	0.0003
Max	6.30	0.013	0.006	0.016	1.001	5.0000	4.6667	2.0000	0.0084	0.0011
Mean	6.24	0.005	0. 002	0.008	0.3352	2.8333	2.5575	1.0000	0.007	0.0008
S.D	0.06	0 .007	0. 003	0.007	0.58	2.57	1.89	1.00	0.002	0.0004

KG: Kpakungu, KGC: Kpakungu Control
Authors' Analysis, 2016

The temperature for the groundwater in the study area ranged between 22.7 ^{O}C and 27.0 ^{O}C which is below WHO limits (Table 3) and the control well has a temperature of 30.7 ^{O}C. The Groundwater pH value for Kpakungu well averaged 7.24, while pH value for control well is 7.64. The pH values for both wells as well as control well meet the WHO standard. The value of alkalinity for wells A and B are above WHO limits, while the value for Well C is within allowable limits. The Total Dissolve Solid and Total Hardness are lower than WHO allowable limit. Water in this area is found to be contaminated by Lead, Chromium and Cadmium with level of contamination exceeds WHO regulated guidelines, this is similar to work of Jegede *et al* (2011) and Ozasuwa and Abdullahi (2008).

Table 2: Physico-Chemical Analysis of Hand Dug Wells in Kpakungu refuse dump, Minna

Parameter	Unit	Well A	Well B	Well C	Control Well	WHO(2004)
Temp	^{O}C	22.7	27.0	0	30.7	34
pH		7.02	7.57	7.14	7.64	6.5-9.2
Conductivity	µS/cm	793	787	793	87	100
Alkalinity	mg/l	1,150	1,440	1,180	169	200
Acidity	mg/l	33	88	83	37	NA
TDS	mg/l	800	1400	1320	362	500-550
Total Hardness	mg/l	66	66	63	50	500
Zinc	mg/l	0.059	0.085	0.072	0.001	3.0
Lead	mg/l	0.192	0.207	0.385	0.000	0.001
Manganese	mg/l	0.229	0.157	0.086	0.002	0.5
Iron	mg/l	0.686	0.648	0. 785	0.013	0.3
Copper	mg/l	0.300	0.250	0.250	0.001	2.0
Chromium	mg/l	1.250	0.417	0.833	0.006	0.05
Nickel	mg/l	0.030	0.060	0.020	0.000	NA
Cobalt	mg/l	0.0286	0.0260	0.026	0.0001	NA
Cadmium	mg/l	0.097	0.068	0.061	0.0012	0.003

Authors' Analysis, 2016

5. Conclusion

An attempt was made in delineating groundwater contamination of a refuse dump in Kpakungu area of Minna using electrical resistivity method and Physico-chemical analysis. The sixteen VES points inside the dump showed that the extent of pollution of the groundwater is as a result of waste dump. The VES points in this study show a low resistivity zone (20.-27.3 Ωm) down to a depth of 9 m. The four VES points outside the dump also reveal that the groundwater is free from pollution. The values of resistivity from control site show a low resistivity zone (89.6-180 Ωm) for maximum depth of 2.89 m. This is an indication that the very low resistivity value in the vicinity of refuse dump is cause by the effect of the waste. The Physicochemical analysis of soil and groundwater samples around the refuse dump show elevation in some parameters analysed while samples analysed for the control site are within the tolerable limit, this shows that the elevation observed around the dump area is caused by the effect of dump.

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