IJNRD.ORG ISSN : 2456-4184

INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Evaluation of Groundwater Potential Using Electrical Resistivity Method, in University of Eldoret, Uasin Gishu County, Kenya

[1]Franklin Kipkoech Chelule, [2] Daniel Mogaka Nyaberi and [3]Loice J. Kipkiror

[1]Msc Student, [2]Dr(Phd), [3]Dr (Phd)

[1]Department of Environmental Sciences,

[1]University Of Eldoret, Eldoret, Kenya.

Abstract: The deployment of electrical resistivity method in mapping the subsurface has been instrumental globally in understanding groundwater occurrence. In this study Vertical Electrical Sounding (VES) interpreted results have been instrumental in mapping the possible structural controls of groundwater in University of Eldoret. The apparent resistivity data collected from the area, was inverted by use of the AGI Earth Imager ID inversion automated computer program, resulting unto resistivities and thicknesses of geoelectric models. The analyzed VES data was further interpreted by curve matching technique whose results indicates the existence of curve types; H-type $\rho_1 > \rho_2 < \rho_3$; A-type$\rho_1 < \rho_2 < \rho_3$; representing 3-Layer subsurface. There are four points mapped with each having five VES points, and the analysis shows distinctly a change from point to point. The analysis in general shows a deeper aquifer from the depth of about 206 metres to 251 metres. There also exists shallow aquifers though presents different depths from point to point, indicating a possible undulation in the subsurface which can be explained by possible existence of old land surfaces.

Keywords: Resistivities, Groundwater, geoelectric models, inversion, Curve matching

1. INTRODUCTION

Increase in student population, staff, infrastructural and agricultural activities in the study area have increased water demand in the study area. This has advised exploitation of alternative water source which is mainly ground water. Exploring the groundwater potential in the research area is crucial given the significance of groundwater to the local human population. The ability to provide information on the depth, thickness of the aquifer, and overburden that will lead the abstraction of high-quality groundwater in any particular region makes detailed evaluation of groundwater potential vital (Muchingami et al., 2012)

Due to its relatively low levels of biological and chemical pollutants, groundwater is believed to be a more reliable source of drinkable water. Before usage, it often needs little to no purification. Groundwater supplies are less impacted by physical elements like odor, coloration, and temperature than surface water is. Moreover, compared to surface water, groundwater has a substantially higher storage capacity per unit area (Ademilua and Talabi, 2012) The quantity and quality of groundwater have been proven to be adequate for a nation's sustainable growth. Globally, almost 2 billion people rely on groundwater for drinking (Mygatt, 2006). Due to their dispersed nature, groundwater resources, according to Boakye and Dapaah-Siakwan (1999), are the most practical and economical source of potable water supply for the rural settlement.

According to Nyaberi, (2022) Groundwater investigations are increasingly being applied together with the steady deployment of geophysical tools for subsurface characterisation. In many cases, especially for extensive study areas, a geophysical survey is the most efficient and quick way to gather subsurface data. Given that a rock's resistivity is extremely sensitive to its water content, the electrical resistivity method is one of the most effective methods for groundwater hydrological exploration (Nyaberi, 2022). Prior to drilling, it is crucial to obtain and evaluate as much data as you can on the aquifer, its structures, and the level of saturation in order to keep development costs to a minimum (Iserhien-Emekeme,2014).

This study therefore aims to examine subsurface structures using geoelectrical resistivity techiques to depict the best aquifers for development in the study area.

2. MATERIALS AND METHODS

2.1 STUDY AREA

The study area lies within Uasin Gishu county. It is bound by coordinates 36M 755600, UTM 62800; 36M 755600, UTM 64800; 36M 757600, UTM 62800 and 36M 757600,UTM 64800.The location of the area is presented in **Figure 1** below.

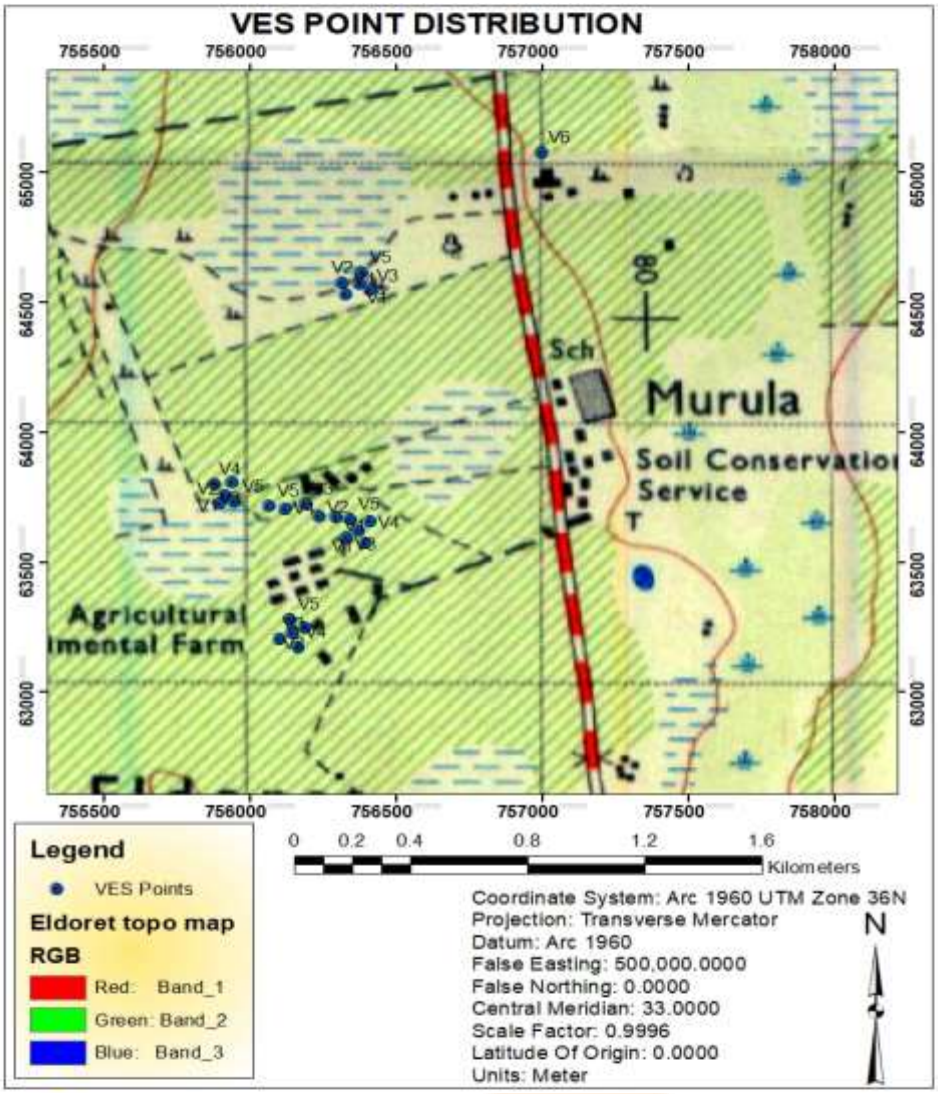


Figure 1: Topographic map extract of the study area showing VES collection points

The study area is found in the Uasin Gishu plateau and the Great Rift Valley is found 20 miles to the east. The geology of the area is determined by two rock groups: metamorphic rocks of the basement system and tertiary lavas and tuffs. Basement systems rocks forming southern Cherangani hills consist of pre-Cambrian para-gneisses and schists of originally sedimentary origin and are accompanied by crystalline limestone and quartzites. Basement rocks do not outcrop in the study area and deeply seated. The Middle Miocene (the geologic era or age, 24 million to 5 million years ago), when the contemporary ocean currents were developed and Antarctica was frozen, is when the eruptions that produced the volcanic rocks in the project region began. The lower strata, which are made of basaltic and were formed by numerous different flows, are typically interspersed by tuffs and sediment.

The Uasin Gishu Plateau forms the most important recharge area for the aquifers in the area where rainfall reaches 1500mm/year. Here water percolates directly into the faults and cracks within the Pleistocene rocks of the Uasin Gishu Plateau through the soil or via the local stream system, which act as a recharge conduit to deeper aquifers.

The topsoil is reddish brown derived from weathering of lava eruption rocks that characterize the project area. The study area is within the Uasin Gishu Phonolites volcanic suite which is of Pleistocene to Miocene eras.

In general, the research area has good drainage. It also has a modest slope that tends to slope eastward toward Marura Swamp (Metto, 2021). It is drained by Marura swamp

2.2 MATERIALS

The following materials and instruments were used; ABEM SAS 300 digital Tetrameter, Computer, Hammers, Global Positioning system(GPS), Tapes, ABEM SAS External battery, charger and adapter.

2.3 METHODOLOGY

The Schlumberger array, which uses four (4) collinear electrodes to measure electrical resistivity, was adopted for this research. The VES stations were chosen in the 4 stations, the electrical cables were laid along the profile, and the electrodes were used to connect the wires to the ground using the cable jumpers. Correct connections between the electrode cables, electrode take-outs, and cable jumpers were examined.

In the Schlumberger configuration, two electrodes, A and B, are placed on the surface of the ground, and a current is passed between them. The resulting electrical field induces a voltage in the subsurface, which is measured by two additional electrodes, M and N, placed at a greater distance from the current electrodes. The distance between the current electrodes is gradually increased, and the process is repeated at each new distance as illustrated in **Figure 2.0**

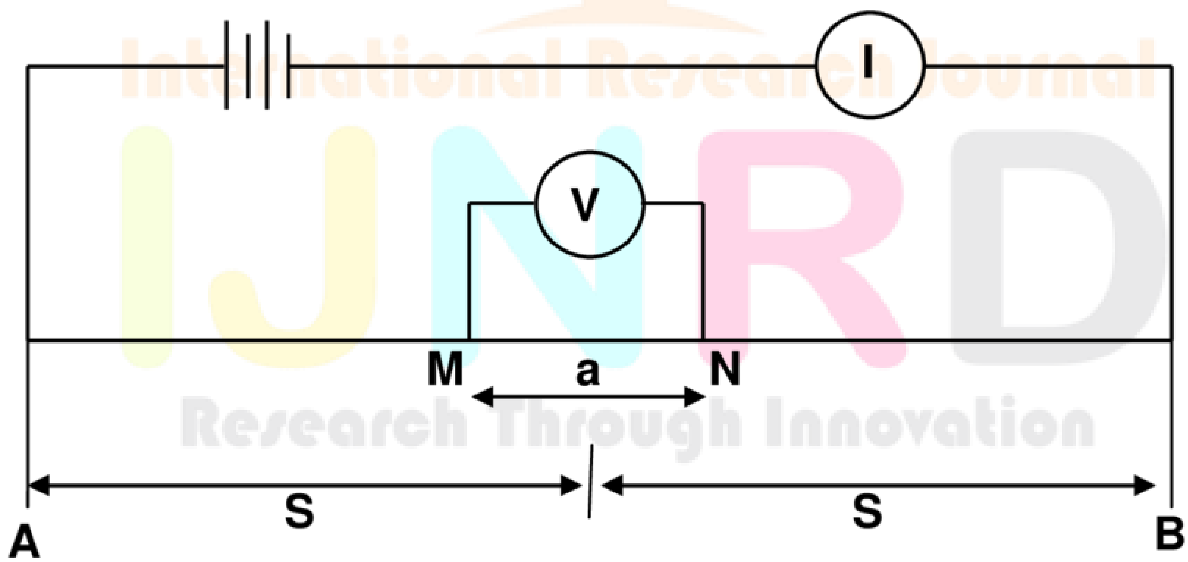
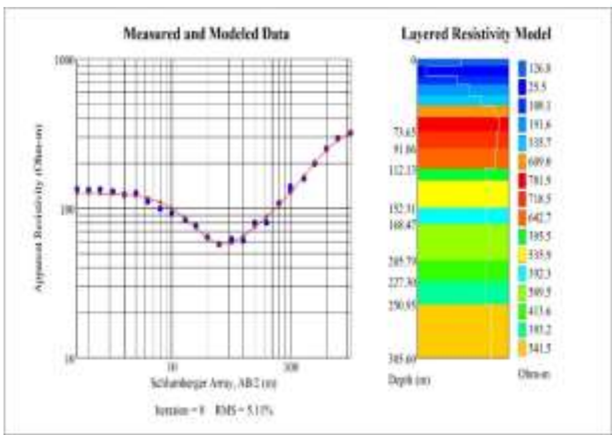


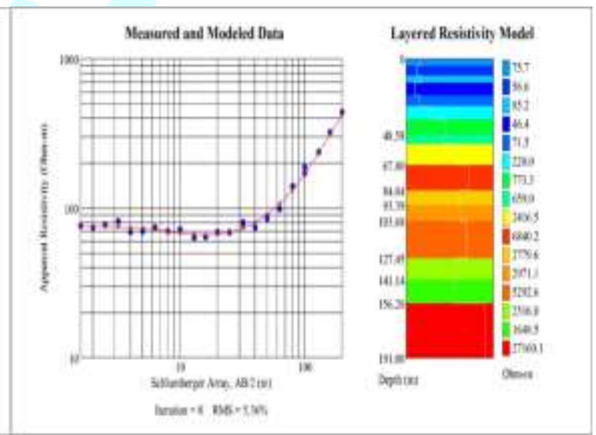
Figure 2.0: Schlumberger configuration

3. RESULTS AND DISCUSSION

VES was conducted in four stations in the study area. Electrical resistivity data was processed and quantitatively interpreted by using a personal computer and AGI Earth Imager 1D Inversion software. True resistivity values were obtained through inversion modelling. The aim of this processing and interpretation was to determine a resistivity model of the ground beneath a sounding point, e.g. number of ground layer, their resistivity and thicknesses. Through the curve matching technique, which is a process where the resistivity curves are correlated with standard curves, interpretation of the VES curves was conducted.



(a)



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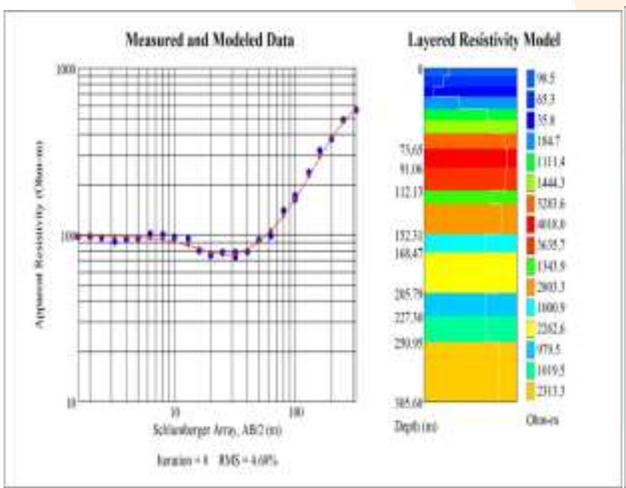
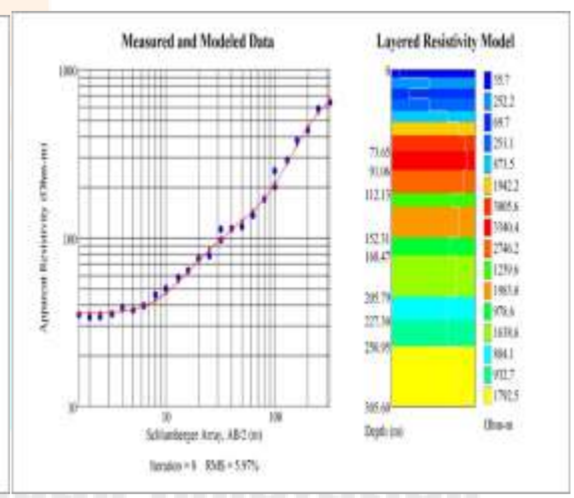


(c)



(d)

Figure 3.0: Randomly selected sounding Profiles of the four stations showing measured (blue dots) and modelled (red line and dots) VES data.

Station one is represented by (**Figure 3.0:a)** above.This sounding station comprises of both shallow and deep aquifer. There is noted consistency in the 3 layered H-type curve indicating the possibility of an equal subsurface formation. Though with different resistivities, all points showed potential for the presence of a shallow aquifer as justified by the second or third geoelectric layers with as low resistivity as 25.5Ω. Deep aquifers are approximated to be found at a depth of 112m-130m, 205-250m with resistivities of 71.7Ω-2803Ω and 126Ω-3432Ω respectively. The area is underlain by dry basement system justified by the extremely high resistivities.

Station 2 represented by (**Figure 3.0:b**)comprises of 3 four layered KH curve type, 1 H-type and 1 A-type curve showing heterogeneity in the underlying material. This station is located south of the study area near Tana Hostels. The area has a potential of 3 aquifers at a depth between 112-120m, 152m-168m and 205m-250m with resistivities of 301Ω-2100Ω, 357Ω-1986 Ω and 324 Ω-2085 Ω respectively with the deepest just above the basement system.

The third station is at the animal science farm as depicted by **(Figure 3.0:c).** The five VES points depicted 2 A-type curves, 2 H-type and 1 KH-type curves. This depicted a difference in the underlying material. The area is mainly characterized by two aquifer regimes; shallow and deep aquifers. There is presence of shallow aquifers below 73m with as low resistivity as 34.5Ω.In all the points in this station, the deep aquifer is found between 205.79-250.95m with a resistivity range of 979-1475Ω. This station has the lowest resistivities compared with the other station making it the most suitable region for groundwater development with an aquifer depth of 45m.

All VES points in the station behind school of education complex depicts presence of shallow aquifers below 73m as shown by the representative curve in**(Figure 3.0:d).** This is strongly justifies by the low resistivity values below 100Ω in all the 5 sounding points in the station. Deeper aquifers are found at a depth of 112m in all points. Dryer conditions are experience with increased depth characterized by the high resistivity values with depth. This suggests that the basement system is compact thereby not forming conditions for the best aquifers.

The station has 2 four layered H-type curves, 2 four layered KH-type curves and one 3-layered A-type curve. The lithology the station is underlain by a varying geological material. This is from the interpretation of geo-electric layers.

The VES curves (Table 1.1) interpreted from the 25 soundings in the study area are categorized as H-type, KH-type and A-type. Their occurrence in percentage dominance is KH-type curve at 44%, H-type curve at 40% and A-type curve at 16%. These variation in percentages shows that the geologic and lithological nature of the study area is heterogeneous and therefore, because of their character

POINT	**VES**	**CURVE TYPE**	**NO. OF LAYERS**
1	a	H	3
	b	H	3
	c	H	3
	d	H	3
	e	H	3
2	a	KH	4
	b	KH	4
	c	KH	4
	d	H	3
	e	A	3
3	a	A	3
	b	A	3
	c	H	3
	d	H	3
	e	KH	4
4	a	KH	4
	b	KH	4
	c	H	3
	d	H	3
	e	A	3

Table 3.1: VES Curve types of the study area

4. CONCLUSION

University of Eldoret area is located in Uasin Gishu plateau. The hydrogeology of this area is characterized by upper Uasin Gishu Phonolites, Lower Uasin Gishu Phonolites and the basement system. Recharge in this region is mainly through percolation of surface water.

The nature of the terrain and soil system allows sipping to recharge the aquifers. Analysis of the 20 VES conducted in four stations of the study area reveals that the subsurface of UoE is heterogeneous multilayered comprising of different rock types which possess different resistivities and thickness. They possess 3-4 interpretable geo electric layers defined by the different curve types from analysis of the raw data.

The aquifer characteristics of the area was determined through their thickness, depth and fractured zones which are essential in identification of groundwater potential zones.From the data, it is possible to delineate water bearing formations and the rocks underlying them. UoE areas has potential of rich aquifers.

The analysis in general shows a deeper aquifer from the depth of about 206 metres to 251 metres. There also exists shallow aquifers though presents different depths from point to point, indicating a possible undulation in the subsurface which can be explained by possible existence of old land surfaces.

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