ORIGINAL RESEARCH ARTICLE

Aquifer characterization using geophysical and pumping test data in Kericho, Kenya

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Abstract

The exploration of groundwater resources has considerable potential for boosting water supplies in Kericho County, Kenya. However, it is underused due to limited knowledge caused by lack of adequate research in this field. As a way to fill this gap, this study aimed to characterize hydraulic and hydrogeological parameters controlling groundwater occurrence in the Kericho aquifer in Kericho County, Kenya. To achieve this objective, the study utilized a combination of geophysical and pumping test data. Consequently, fifty Vertical Electric Soundings (VES) were carried out to determine the aquifer properties of the study area. Further, seven out of fifty surveyed sites were drilled to depths ranging between 30m and 230m, and test pumping was done for 24 hours. Geophysical results show that the average hydraulic conductivity in the study area varies from 1.96 m day^{-1} to 6.2 m day^{-1}. The transmissivity ranged from 35.83 m^2 day^{-1} to 5166.4 m^2 day^{-1}, while the yield ranged between 0.7 and 9.7 M^3/hr. The aquifer hydraulic parameters determined from geophysical and pumping test data were analysed using one-way analysis of variance (ANOVA). The results show no significant difference ($p = 0.948151 > 0.05$) on hydraulic conductivity between geophysical and pumping test methods. Therefore, this study confirmed the reliability of both methodologies for groundwater assessment. Identifying prospective groundwater zones in the research area demonstrates that the combination of these methods is efficient and suited for groundwater exploration. It is suggested that observation wells be added in future studies to allow for the computation of storativity.

Key words: Geophysical, Hydraulic parameters, Kericho, pumping test.

1.0 Introduction

Groundwater is an essential source of water supply. It is one of the sources of fresh water, and its importance for every form of life in the ecosystem is inevitable (Holland et al., 2015). Over-exploitation and over-consumption are the two most serious threats to freshwater supplies. Water scarcity is widespread around the world, and groundwater extraction is emerging as a viable option for meeting rising water demands (Shaban et al., 2018). Fresh water accounts for around 3% of total water on Earth, with groundwater accounting for approximately 95%, surface water accounting for 3.5%, and soil moisture accounting for 1.5%. Furthermore, only 0.36 percent of the world's fresh water is readily available (Pervez & Henebry, 2015; Ei, 2019).

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These estimates force government entities to take steps to maintain available water resources, ensuring their continued and appropriate availability for all living creatures. Kenya is dependent on surface water resources such as groundwater, rivers, dams, and lakes. Groundwater dependence is greatest in rural and coastal regions, while some urban areas rely on it as well. However, according to a Joint Monitoring Program (2015) report, access to improved water supply in rural regions remains limited.

Previous research (Olorunfemi & Oni, 2019; Muchingami et al., 2021) has demonstrated the efficacy of integrating aquifer characteristics computed from existing drill locations and subsurface resistivity readings. This is due to the fact that the relationship between an aquifer's electrical and hydraulic properties is viable, as both qualities are related to pore space structure and heterogeneity (Niwas et al., 2006). In addition, a variety of inquiry approaches are often used to estimate the distribution of hydraulic characteristics such as transmissivity, storage coefficients, and hydraulic conductivity.

Kuria (2013) evaluated Kenya's groundwater distribution and aquifer characteristics. Results from the study show that there is no single identified aquifer with a significant amount of groundwater in areas covered by basement rock. Boucher (2009) used magnetic resonance to calculate specific yield and transmissivity in an unconfined sandstone aquifer in Niger. According to Cirpka and Valocchi (2016), full knowledge of the distribution of hydraulic parameters in the subsurface is required for solving problems in hydrogeology and related domains. Peterson and Fulton (2019) evaluated the unconfined aquifer's hydraulic characteristics using data from recovery tests. The authors employed the inverse approach to calculate the hydraulic characteristics of an unconfined aquifer using residual drawdown. Using ArcGIS, the spatial distribution of hydrogeological properties in deep and shallow aquifers was mapped. According to Pandey and Kazama (2011), maps are essential in delineating viable locations for groundwater occurrence and simulating water movement in the aquifer system.

Kenya's fresh water supply is under increasing strain due to long-term population increase and economic development (Knüppe, 2011). As a result, fifty vertical electrical sounding surveys were performed in Kericho utilizing the Schlumberger array configuration for groundwater investigation. Vertical electrical soundings produce smooth variation as a representation of subsurface changes with depth, which is inverted to obtain the subsurface representative model (Choudhury et al., 2017). The specific objectives of this study were to 1) determine hydraulic parameters from geoelectric and pumping test methods and 2) compare the significant differences in hydraulic parameters obtained from different methods.

2.0 Material and methods

2.1 Study Area

Kericho County is one of the 47 counties in Kenya. It is in the south of the Great Rift Valley, between longitudes 35 02' and 3540', and between the Equator and latitude 023'S. Also, Kericho County lies within the Lake Victoria Basin, and it covers an area of approximately 2,454 km^2. Its geology includes volcanic, igneous, and metamorphic complexes (County Integrated Development Plan, 2018). Intermediate igneous rocks and tertiary lavas (phonolites) dominate the county's subsurface. In addition, granites, volcanic ash mixing, and other abundant materials dominate a tiny portion of the county (Barounis & Karadima, 2011). The county has

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a unique environment characterized by relief rains, moderate temperatures (17^{0}C), and low evaporation rates. Fig. 1 shows the map of the study area.

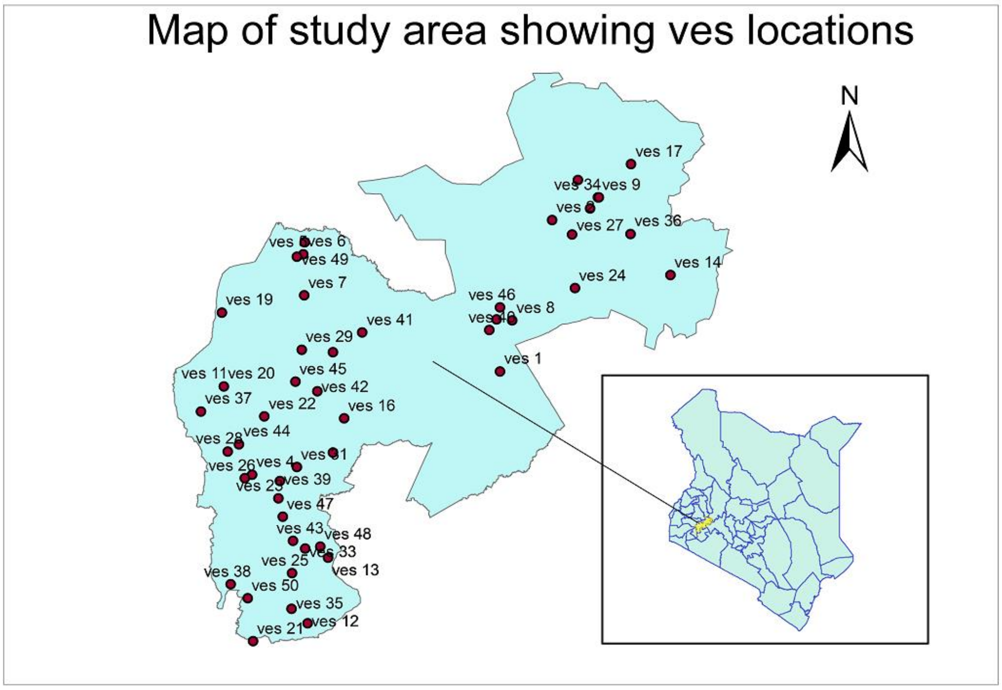

Fig. 1: Map of Study Area Showing VES Locations

2.2 Vertical electrical sounding (VES)

Fifty vertical electrical soundings (VES) were carried out to evaluate the characteristics of the aquifer in the study area using the principle of resistivity. The VES was done by employing the Schlumberger electrode configuration using an ABEM Terameter Ls2 series. To obtain detailed information about the subsurface, the electrode arrays' center point stayed constant while the electrode spacing was raised. As the sound advanced, the electrode was adjusted. The potential electrodes, on the other hand, were positioned at a spot, and the potential difference between them was measured. However, there came a time when the measured potential difference (Pd) was so small that the electrode spacing had to be increased (Ashraf et al., 2018). As a result, multiple arrays were used in the resistivity survey, and their geometric factors were based on the change in spacing. The site Schlumberger electrode configuration arrangement is shown in Fig. 2 (Ashraf et al., 2018).

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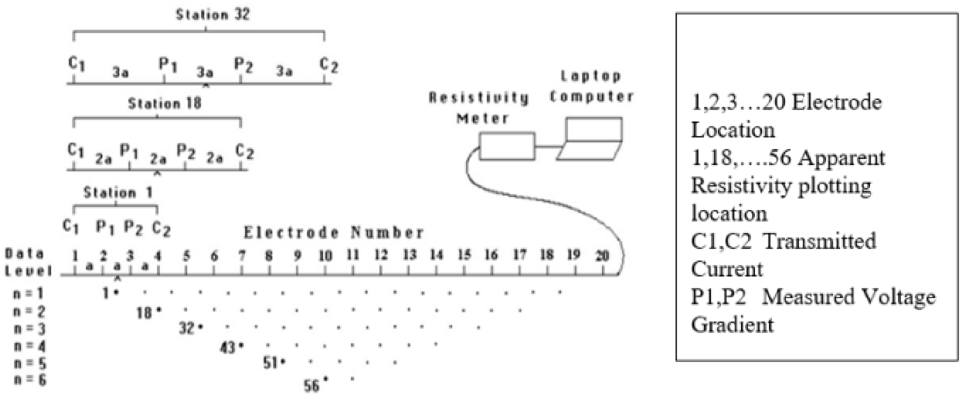

Fig. 2: Arrangement of Electrodes

The physical attribute describes the difficulty of conducting an electric current through a volume of materials of a certain length and cross-sectional area. As described in Equation (1), the resistivity of a given volume of material was computed by multiplying the electrical resistance by the cross-sectional area and dividing by the length (Zacharia, 2013).

$$\rho = R(A / L) \qquad (1)$$

Where:
ρ = Electrical resistivity (Ωm),
R = Electrical resistance (Ω),
A = Cross-sectional area (m^2), and
L= Length (m),

The measured resistivity values of homogenous ground are apparent resistivities. The data obtained in this study was interpreted using the quantitative approach to determine the geoelectric layers' depth, thickness, and resistivity. The actual subsurface resistivity values were determined by inverting apparent resistivity values using IP2 Win inversion software to determine the subsurface structure (Alva, 2009).

The hydraulic conductivity was estimated using Equation (2) (Andreia et al., 2021):

$$K = 386.40 R_{rw}^{-0.93283} \qquad (2)$$

Where,
K is the hydraulic conductivity and
Rrw is the aquifer resistivity

The transmissivity values were calculated using Equation (3).

$$T = Kh \qquad (3)$$

Where,

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T is transmissivity,
K is hydraulic conductivity and
h is aquifer thickness.

2.3 Pumping test

Among the fifty geoelectric points that were surveyed, only seven boreholes were drilled, and test pumping was done for 24 hours to determine the yield. The step drawdown-pumping test technique was used (Cooper & Jacob, 1946). The following hydraulic parameters were determined using data gathered during (drawdown) and after the pumping test (recovery): hydraulic conductivity, transmissivity, specific capacity, and storasivity. Because no observation well was available, all of these sites used single-hole pumping tests. The obtained data was then utilized to calculate the aquifer's transmissivity.

2.4 Transmissivity (T)

Hefferan and O'Brien (2010) defined transmissivity as "the rate at which water passes through a unit width of a saturated thickness of an aquifer under a unit hydraulic gradient." Hydraulic conductivity (K) and Transmissivity (T) were calculated using Equation (4).

$$T = Kb \quad (4)$$

Where,
T = transmissivity (m^2/day)
K = hydraulic or aquifer conductivity (m/day)
b = thickness of the aquifer (m)

Equation (5) gives the drawdown (s), for pumping well after [21].

$$s = 2.3Q / 4\pi T \log 2.25Tt_0 / r^2 \quad (5)$$

2.5 Application of Cooper and Jacob method

The pumping test results from the wells were plotted on semi-logarithmic paper, as shown in Fig. 3, for the Kaptaragon borehole as a sample.

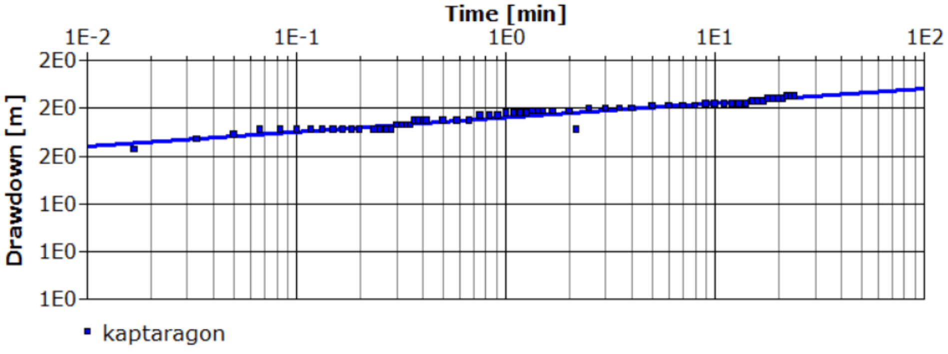

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Fig. 3: Kaptaragon Borehole Time Drawdown Plot

Transmissibility and storativity were calculated using Equation (6) (Kaptaragon borehole).
Pumping rate, Q = 9.7 m^3/hr.
Well radius, r_w = 0.075m
Change in drawdown per log cycle of time, Δs = 0.185m

$$T = \frac{2.3Q}{4\pi \Delta s} = \frac{2.3(9.7)}{4 \times 3.14 \times 0.185} = 9.602 \text{ M}^2/\text{hr.}$$
(6)

T = 9.602*24 = 230.4 M^2/day

2.6 Storativity (S)

According to Andreia et al. (2021), "storativity or storage coefficient (S) is the volume of water an aquifer releases from or takes into storage per unit surface area per unit change in head." The non-equilibrium is as shown in Equation (7):

$$S = 2.25T\frac{t_0}{r^2} \qquad (7)$$

Where,
t_o is the time at zero drawdown (s),
S is the storativity of the aquifer, and
r is the distance from the pumping well to an observation well (m).

To evaluate S, the distance to the observation site (r) is required. Therefore, S could not be calculated since no observation wells were used. Table 1 shows the transmissivity, hydraulic conductivity, and specific yield of the Kericho aquifer.

Table 1: Transmissivity, Hydraulic Conductivity, and Specific Yield of the Aquifer in the Kericho Area

Borehole Name	Yield (M^3/hr)	T(m^2/d)	T Range (m^2/d)	Class type	K (m/d)	Specific capacity (m^3 /d/m)
Kapcheluch	6.0	506.6	100 - 1000	High	2.895	11.842
Kaptaragon	9.7	230.2	100 - 1000	High	0.959	125.838
Katet	7.0	1536.8	>1000	Very High	7.881	40.000
Kibugat	3.1	4.7	1 to 10	Low	0.105	1.689
Lemotit	0.7	61.5	10 -100	Intermediate	1.397	2.714
Motero	6.0	76.8	10-100	Intermediate	1.348	10.835
Seretet/Cheptororiet	1.9	417.1	100-1000	High	1.629	0.573
Average	4.9	404.8			2.3	27.6

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Specific Capacity (Sc): Specific capacity is defined as the discharge rate per drawdown. Mathematically, Sc is expressed as shown in equation (8);

$$Sc = Q/s \tag{8}$$

Where;

Q is the discharge rate in m^3/d.

s = drawdown in m

Furthermore, a well's productivity is frequently stated in terms of its specific capacity (Freeze & Cherry, 1979). Accordingly, the calculated specific capacities of wells ranged from 0.573 to 125.838 $m^3/d/m$, with a mean of 27.6 $m^3/d/m$.

2.7 Hydraulic conductivity (K)

Permeability is defined as the ease with which water can travel through a unit thickness of an aquifer. Equation (9) was used to calculate the hydraulic conductivity:

$$T=Kb \tag{9}$$

Therefore, $K = T/b$

Where

b = saturated thickness of the aquifer (m)

2.8 Groundwater Flow Direction

A field survey was done to determine the location of each borehole in the research region. The global positioning system (GPS), Garmin 64s, was utilized to record the surface elevations, latitudes, and longitudes of selected borehole locations within the study region. In addition, the static water level (SWL) or depth of the water level in the boreholes was measured and recorded using a dipper meter. The hydraulic head of each drilling location was calculated by subtracting the depth to the water table in the boreholes from the ground elevation relative to sea level, as indicated in equation (10).

$$HH = GE - SWL \tag{10}$$

Where,

HH= Hydraulic head, m

GE=Ground Elevation, m

SWL=Static Water Level, m

The computer-aided method was adopted in this study to generate the study area's base contour map and flow direction. Golden Software's SURFER software suite was used for this investigation. Groundwater level data was organized as XYZ files, where X and Y are the plane coordinates of the measuring stations and Z is a function of water table elevation.

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3.0 Results and Discussion

The results for the variation of aquifer resistivity and thickness are shown in Table S1. The aquifer resistivity ranged between 10.1 and 1481.3 Ω, while the thickness ranged between 1 and 197m. A detailed description of the data is presented in Table S1. The summary of the interpreted variation in electrical resistivity survey values is presented in Table S2. The VES analysis shows that the area is characterized by 4 to 5 geoelectric subsurface layers, with 4-layer types occurring often. Table S3 shows the variation in aquifer resistivity and thickness due to lithologic composition, from which the longitudinal conductance, hydraulic conductivity, and transmissivity were calculated.

3.1 Qualitative Interpretation

It was observed that most parts of the watershed are characterized by low hydraulic conductivity (Figs. 4–7). According to Abidin et al. (2012), hydraulic conductivity regulates the rate at which water can flow into and through porous storage rocks in aquifers. Therefore, areas with high hydraulic conductivity are likely to have good aquifer recharge capability. The fluctuation in hydraulic characteristics is caused mostly by strong fracture and heterogeneity caused by the presence of phonolites. Aquifer sustainability is endangered by increasing water abstraction, threatening the availability of groundwater in the future. The hydraulic characteristics of an aquifer test are an excellent indicator of the amount of water that can be extracted from an aquifer.

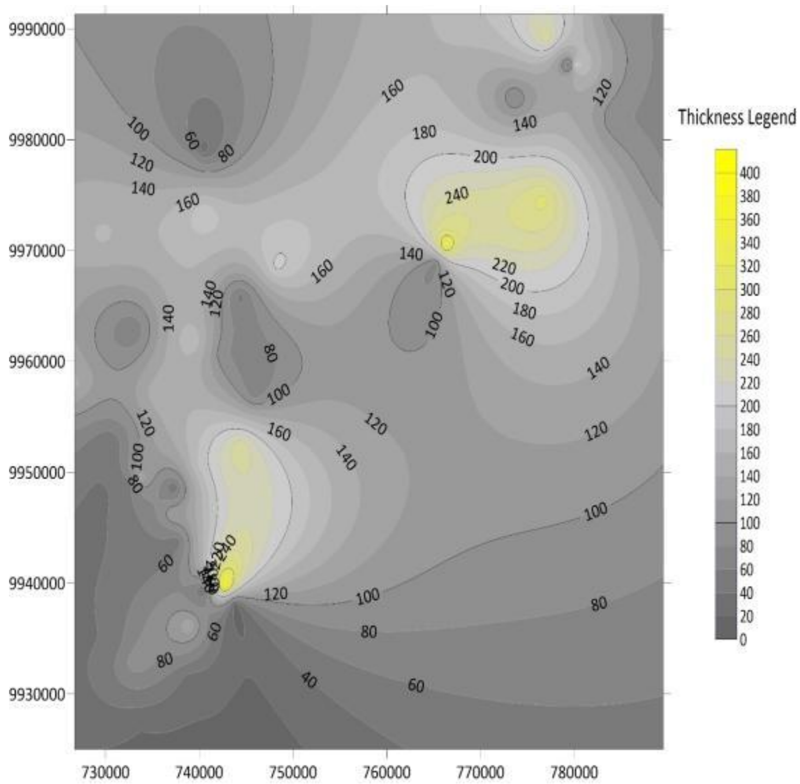

Figure 4: Spatial Distribution of Aquifer Resistivity

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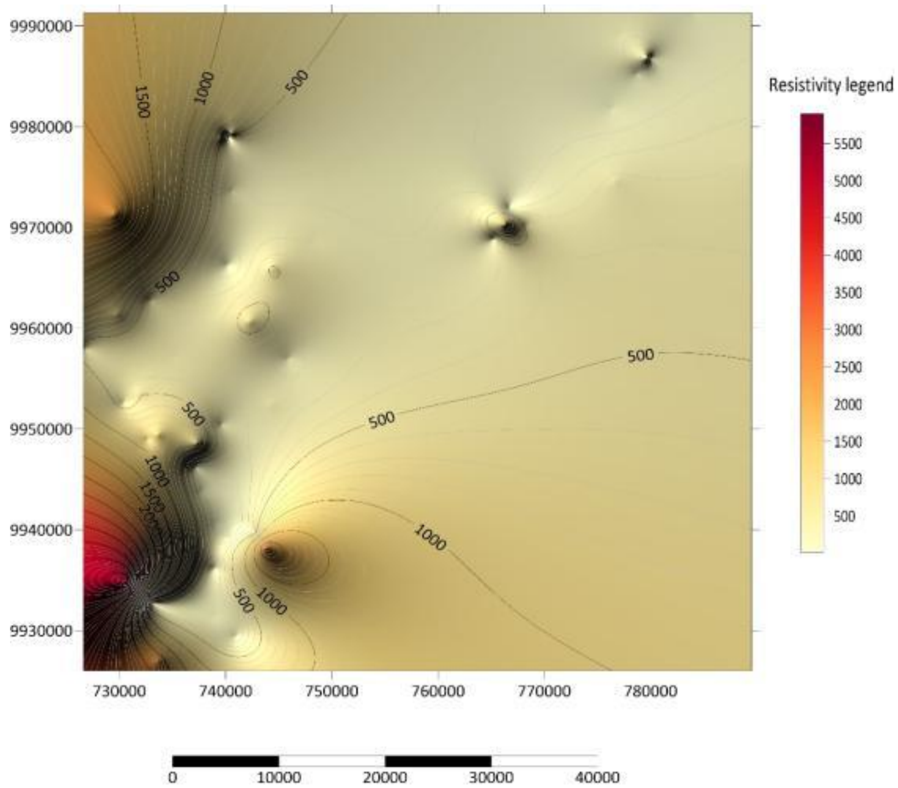

Figure 5: Spatial Distribution of Aquifer Thickness

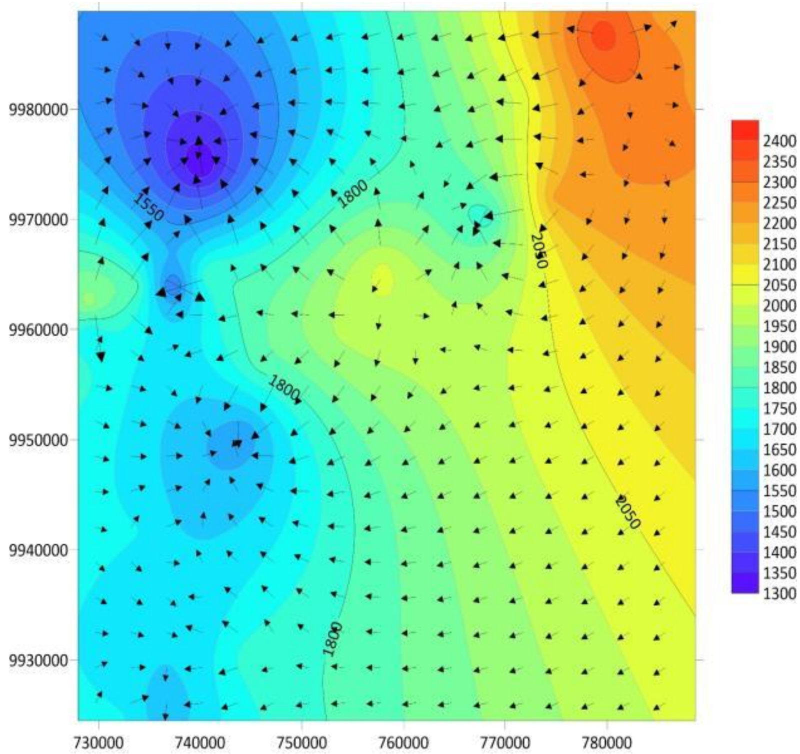

Figure 6: Spatial distribution of Hydraulic conductivity

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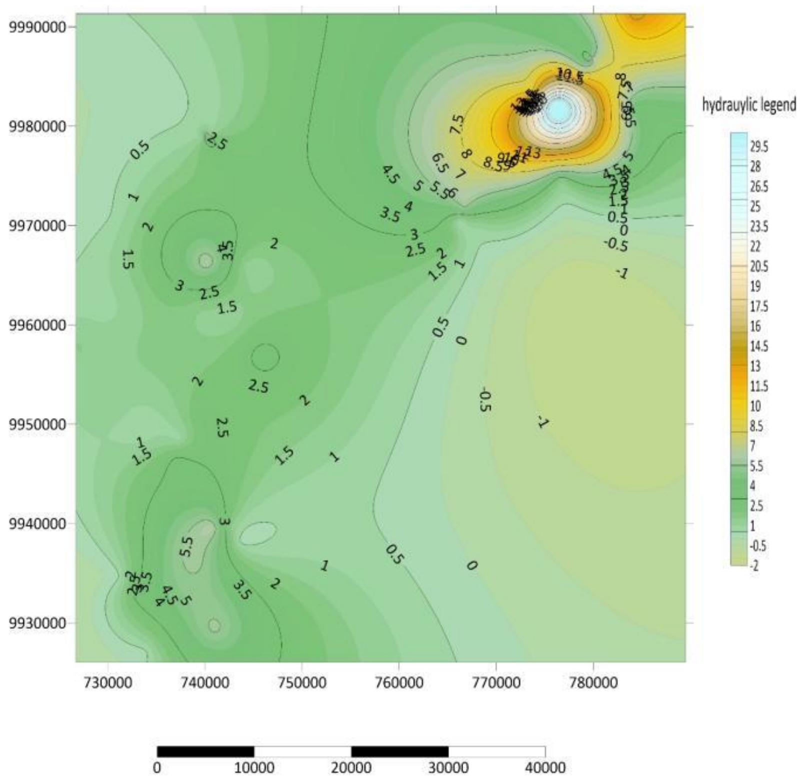

Figure 7: Groundwater Flow Direction Map in Kericho

The aquifer resistivity in the study area ranged from 12 to 5918 Ωm with an average of 610 Ωm (Table 2).

Table 2: Resistivity distribution

Zone/Resistivity(Ω)	Range	Average	SD
Belgut	155-817	399.483	260.89
Bureti	80.3-5917.5	976.901	1693.75
Kipkelion	12.4-2333.81	376.751	573.013
Soin/Sigowet	83.6-771.35	412.22	211.578

The minimum resistivity was observed in point VES 27 (Lelechwet), and a maximum resistivity was observed in point VES 38 (Kibugat). Moreover, the variation of the thickness in the study area is also shown in Table 3. Accordingly, the minimum value is observed in point VES 13/51 and a maximum value in point VES 48 with an average of 118 m. Dar-Zarrouk parameters (Longitudinal Conductance, Thickness, and Aquifer resistivity), transmissivity and hydraulic conductivity, were used to evaluate the groundwater potential of the area.

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Table 3: Geo-electric sub-surface layer

	Resistivity RangeΩ	Common Range Thickness (m)
Layer 1	9.9-61922	0.4-13.1
Layer 2	7.1-4068	1.2-68
Layer 3	3.1-1110	4.1-146.1
Layer 4	9.3-5529.3	10.6-264
Layer 5	23.7-1579	

Figure 4 shows the spatial distribution of aquifer resistivity in the study area in which the highest value is observed at the southwestern part (Bureti) with an average of 976.901 Ω and the lowest at the Northeastern part (Kipkelion) of the study area, which has an average of 376.751 Ω as shown in Table 4.

Table 4: Aquifer Thickness

Zone / Aquifer Thickness(M)	Range	Average	SD
Belgut	54-256	136.6667	79.21491
Bureti	15.1-404.7	85.78154	103.5153
Kipkelion	44-289	145.1875	81.67558
Soin/Sigowet	26-208	98.64615	63.65049

Krásný (1993) reported that high resistivity readings suggest a low conductive zone, whereas low resistivity values are thought to be a highly conductive zone that indicates a water-bearing zone. In this context, stations in the Kipkelion area exhibit low aquifer resistivity readings and high conductive geomaterials, indicating good groundwater potential. Fig. 5 shows the spatial distribution of aquifer thickness across the study area. It is observed that the aquifer thickness is high in the Northeastern and southwestern parts of the study area, as summarized in Table 5.

Table 5: Hydraulic Conductivity

Zone / Hydraulic Conductivity(m^2/d)	Range	Average	SD
Belgut	0.742-3.507	1.958481	1.061211
Bureti	0.117-6.46	3.191219	2.35624
Kipkelion	0.279-36.9	6.223458	9.015386
Soin/Sigowet	0.783-6.222	2.095527	1.78585

Figure 6 shows the spatial distribution of hydraulic conductivity across the study area. It is observed that low hydraulic conductivity covers most parts, while high hydraulic conductivity covers fewer parts of the study area. Hydraulic conductivity, as defined by Abidin et al. (2012), determines the rate at which water may flow into and through porous storage rocks in aquifers. Therefore, areas with high hydraulic conductivity are likely to have good aquifer recharge capability. The variation in hydraulic characteristics is mostly owing to the extensive fracturing

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and heterogeneity caused by the dominance of phonolites in Kericho (Table 6).

Table 6: Summary of Hydraulic conductivity estimates from geophysics and pumping test

Borehole Name	K from pumping test (m/d)	K from Ves(m/d)
Kapcheluch	2.895105	2.7604
Kaptaragon	0.959275	1.3203
Katet	7.881119	6.4157
Kibugat	0.105029	0.117
Lemotit	1.397107	1.4846
Motero	1.347525	1.4031
Seretet/cheptororiet	1.629439	2.1369
Mean	2.316371	2.234

The high groundwater potential was observed at 32 VES stations because of the high values of hydraulic conductivity, transmissivity and aquifer thickness, with low aquifer resistivity. These VES points are categorized as areas of high groundwater potential, most likely to be of great regional importance. The 15 stations of intermediate groundwater potential are for local water supplies for the small communities. On the other hand, three stations with low groundwater potential (due to the high value of aquifer resistivity and low value of the aquifer thickness) provide a local water supply for private consumption.

Pumping tests of 7 boreholes in Kericho were analyzed to determine the yield and hydraulic parameters of the aquifer. From the Mean values of hydraulic parameters (T= 404.8 m^2/d, K=2.3 m/d, SC=27.6 m^3/d/m), the aquifer in Kericho County has a substantial quantity of water (Table 6). Furthermore, the interpreted results show that the Katet aquifer is more productive (SC=40 M^3/d/m, T= 1536.8m^2/d) than any other surveyed location.

To find out if there was a significant difference between hydraulic conductivities determined through VES as compared to test pumping, the data presented in Table 8 were subjected to further analysis. First, the analysis of variance (ANOVA) test was performed, and hydraulic conductivity (K) results from the pumping test and VES are 2.316 m/d and 2.234 m/d, respectively. This shows no significant difference ($p = 0.948151 > 0.05$) between hydraulic conductivities obtained from the two methods. Based on standard values by Egbai et al. (2013), the average value computed for the area can generally be classified as having high potentials for groundwater transmission and groundwater withdrawal of lesser regional importance. The results in Table 8 demonstrate that the area has a very varied and large range of hydraulic conductivity and transmissivity. Hydraulic conductivity ranges from 0.105m/d to 7.881m/d on average. The hydraulic conductivity is high in some wells and relatively low in others, indicating the heterogeneous condition of the subsurface geologic formations. The concept of groundwater movement direction is that groundwater level is normally higher in discharge areas and lowest in recharge areas (Olorunfemi & Oni, 2019). The findings indicate that land use activities such as solid waste disposal in the region will be unfavorable for communities living in the research area's western section. Hence, knowledge of groundwater flow is

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essential in siting refuse dumps.

4.0 Conclusion

The findings show that 10% of the VES stations have “very high” groundwater potential, 54% have “high” groundwater potential, while 6% are of “low” groundwater potential, while the rest have “intermediate” groundwater potential. Areas with the lowest hydraulic conductivity and lowest transmissivity have the lowest groundwater potential. The empirical relationship between hydraulic conductivity and aquifer resistivity is a good tool for categorizing groundwater potential. Therefore, the geoelectrical sounding technique is an inexpensive tool for calculating the hydraulic parameters and categorizing the aquifer potential of the study area.

5.0 Acknowledgement

5.1 Funding

None

5.2 Conflict of interest

None.

5.3 General acknowledgment

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5.4 Ethical consideration and clearance

None

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7.0 Appendix

Table S1: Variation of Aquifer Resistivity and Thickness

		Layer 1		layer 2		Layer 3		Layer 4		Layer 5		Layer 6	
VES station	***Borehole Name***	***Resistivity (Ω)***	***Thickness (m)***	***Resistivity (Ω)***	***Thickness (m)***	***Resistivity (Ω)***	***Thickness (m)***	***Resistivity (Ω)***	***Thickness (m)***	***Resistivity (Ω)***	***Thickness (m)***	***Resistivity (Ω)***	***Thickness (m)***
VES 1	Motero	507.3	1.3	236.9	3.6	390.9	10	21.8	47	81.1	_	_	_
VES2	Tingatela	293.02	1	20.08	6.2	39.239	24.1	13.699	56	139.13	_	_	_
VES3	Lelaitich idp camp	13.7	3.8	221.6	18	99.6	44.1	589.8	_	_	_	_	_
VES 4	Sunshine	82	1	576	1.9	91	30	902	100	_	_	_	_
VES 5	Aic Tumaini	135.72	4.3	73.924	26	17.166	_	_	_	_	_	_	_
VES 6	Atc Kipsitet	41.8	1	33.8	10	550.8	34	10.1	_	_	_	_	_
VES 7	Asenewet	463.9	0.8	31.9	8	209.5	60.3	38.6	135	148.5	_	_	_
VES 8	Kaptaragon	134	1.3	23.3	9.5	104.9	43	335.6	197	41.9	_	_	_
VES 9	Lemotit Atletic camp	1481.3	1.2	13.993	17	33.997	44	354.46	_	_	_	_	_
VES 10	Masasita hills area	246.8	0.6	19.247	7.7	41.711	14	17.102	120	_	_	_	_
VES 11	Emdit Primary	2034.9	0.7	98.419	2.7	189.52	90	581.83	_	_	_	_	_
VES 12	Sosit	433.2	4	8.1	68	85	_	_	_	_	_	_	_
VES 13	Kusumek	323.7	2.5	26.3	9.6	153.4	15.1	2267.1	_	_	_	_	_
VES 14	Ewat	52.4	0.6	25.8	5	219.9	27	90.9	57	1579	_	_	_
VES 15	Seretet	110.3	0.6	323.5	7	157.4	43	170.6	108	154.9	148	224.2	_
VES 16	Cheptororiet	729.71	1.6	439.42	16	51.136	68.2	103.46	_	_	_	_	_
VES 17	Soget	234.5	2	14.3	10	25.6	18	10	74	259.7	_	_	_
VES 18	Sototwet	72.6	1.1	196.7	9.1	49.3	53	477.5	_	_	_	_	_
VES 19	Ngendalel	329.5	1.1	120	3.5	620.5	16.7	495.9	50	1342.01	114.3	981.3	_
VES 20	Kapsomboch	395.9	13.1	72	63.5	444.9	120	507.6	_	_	_	_	_
VES 21	Butiik	416	1.28	54	19.57	251	21.46	2000	_	_	_	_	_

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VES 22	Kapsewa	1126.7	2.1	213	17.2	131.3	37.7	186.1	113.7	1126.7	_	_	_
VES 23	Tulwet	486.8	2.2	248.1	7.2	14.7	120.8	139.9	_	_	_	_	_
VES 24	Kiprengwe	1183.4	1.1	17.813	13	304.96	57	32.4777	232	136.26	_	_	_
VES 25	Kamolok	50.702	2	68.7	9	12	33.7	77.5	101.6	37.9	_	_	_
VES 26	Koiwalelach	904.9	2	283.3	7.2	516.6	18	300.4	36	687.7	_	_	_
VES 27	Lelechwet	2704	0.9	7.1	4	3.1	140	9.3	_	_	_	_	_
VES 28	Kamaget	81.8	4.8	51.4	12.2	16	40	373.1	_	_	_	_	_
VES 29	Kaptugumo	115.2	2.1	91.9	17.2	30.7	37.7	52.9	113.7	29.9	_	_	_
VES 30	Kabloin	223	2	80.8	7.2	1109.5	85.2	80	264	489.5	_	_	_
VES 31	Kapcheluch	372.3	1.8	126.6	22.7	34.6	87.5	165.2	87.5	165.2	_	_	_
VES 32	Tingoro	1441.3	2	51.8	16.3	117	63	55	192	124	_	_	_
VES 33	Ketisyek	73.6	0.7	265.9	2.5	67.8	10	12.5	28	454.7	_	_	_
VES 34	Katet	556.1	1	12.4	18.2	58.7	77	22.2	118	366.9	_	_	_
VES 35	Kapsogeruk	165.7	0.4	49.2	1.2	87.8	5	16.2	26.1	701.5	_	_	_
VES 36	Kapkondor	207.3	1.4	48	6	11	13	122.5	70	23.7	_	_	_
VES 37	Kabatet	61922	4.7	563	14.6	103.8	146.1	269.4	_	_	_	_	_
VES 38	Kibugat	99.7	5.6	15.9	16.5	388.2	44.5	5529.3	_	_	_	_	_
VES 39	Mosore	4600.1	1	1714.2	6	695.6	41	98.4	_	_	_	_	_
VES 40	Kondamet	81.5	1.7	252.3	4.5	54.1	71.6	162.9	_	_	_	_	_
VES 41	Kisabei	86.7	2	341.8	5	71.9	83	193.7	125	587.1	_	_	_
VES 42	Sosiot Girls	915.1	0.8	202.7	3.5	474.2	88	137.7	_	_	_	_	_
VES 43	Ngororga	393.12	0.8	134.12	7	27.723	26	75.914	71	1516.2	_	_	_
VES 44	Kapkeburu	419.27	4.8	216.1	26	430.82	72.1	60.194	_	_	_	_	_
VES 45	Cheribo	891.2	0.4	4068.4	1.5	256.7	21.6	94	157.2	524.3	_	_	_
VES 46	Kipsegi	298.66	0.5	17.387	2	216.76	8.5	70.082	51	18.584	223	33.753	_
VES 47	Koituk	195.34	1.1	62.331	12	12.467	49	148.4	_	_	_	_	_

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VES 48	Chelilis	104.9	0.7	333.2	5.6	25.9	47.9	281.7	160.7	91.7	244	118.8	_
VES 49	Chebirir	9.9	6.5	70.8	38.6	41.9	71	509.4	_	_	_	_	_
VES 50	Arokyet	124.4	0.9	39.2	2	99.1	4.1	42.1	10.6	117.3	80.6	42.1	_

Table S3: Summary of VES Analysis

VES station	Borehole Name	Sub-County	Aquifer Resistivity(Ω)	Aquifer Thickness (m)	Longitudinal conductance(m/Ω)	Hydraulic Conductivity(m/d)	Transmissivity(m^2/d)	Eastings	Northings	Groundwater Potential
VES 4	Sunshine	Ainamoi	993	130	0.1309	0.6186	80.4149	73363	9949456	Intermediate
ves 30	Kabloin	Ainamoi	1190	349	0.2936	0.5227	182.5236	76625	9970345	High
ves 15	Seretet	Belgut	263	256	0.9738	2.1369	547.0460	74441	9952428	High
ves 16	Cheptororiet	Belgut	155	68	0.4411	3.5066	239.1507	745880	9956998	High
ves 26	Koiwalelach	Belgut	817	54	0.0661	0.7420	40.0703	732672	9948978	Intermeadiate
ves 31	Kapcheluch	Belgut	200	175	0.8759	2.7604	483.0707	739594	9950434	High
ves 42	Sosiot Girls	Belgut	612	88	0.1438	0.9717	85.5107	742317	9960659	Intermediate
ves 45	Cheribo	Belgut	351	179	0.5098	1.6332	292.0197	739370	9961957	High
ves 12	Sosit	Bureti	91	26	0.2857	5.7483	149.4560	740984	9929440	High
ves 13	Kusumek	Bureti	2421	15	0.0062	0.2694	4.0682	743723	9938239	Low
ves 21	Butiik	Bureti	2251	21	0.0095	0.2883	6.1869	733735	9926998	Low
ves 23	Tulwet	Bureti	155	121	0.7814	3.5065	423.5881	737153	9946223	High
ves 25	Kamolok	Bureti	90	135	1.5117	5.8387	789.9795	738919	9936149	High
ves 33	Ketisyek	Bureti	80	38	0.4732	6.4604	245.4963	740692	9939499	High
ves 35	Kapsogeruk	Bureti	104	31	0.2990	5.0756	157.8513	738881	9931365	High
ves 38	Kibugat	Bureti	5918	45	0.0075	0.1170	5.2075	730774	9934688	Low
ves 39	Mosore	Bureti	794	41	0.0516	0.7621	31.2451	737313	9948566	Intermeadiate

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ves 43	Ngororga	Bureti	104	97	0.9360	5.0922	493.9422	739042	9940494	High
ves 47	Koituk	Bureti	161	49	0.3046	3.3789	165.5673	737709	9943761	High
ves 48	Chelilis	Bureti	373	405	1.0838	1.5404	623.4031	742687	9939710	High
ves 50	Arokyet	Bureti	159	91	0.5721	3.4079	310.8027	732999	9932775	High
ves 1	Motero	Kipkelion	413	57	0.1381	1.4031	79.9778	732907	9962767	Intermediate
ves 2	Tingatela	Kipkelion	53	80	1.5131	9.5292	763.2865	773622	9983746	High
ves 8	Kaptaragon Lemotit	Kipkelion	441	240	0.5448	1.3203	316.8811	768312	9970197	High
ves 9	Atletic camp	Kipkelion	388	44	0.1133	1.4846	65.3240	779758	9986775	Intermediate
ves 10	Masaita hills area	Kipkelion	59	134	2.2784	8.6381	1157.5083	778728	9985307	Very high
ves 14	Ewat	Kipkelion	311	84	0.2703	1.8280	153.5520	789418	9976298	High
ves 17	Soget	Kipkelion	36	92	2.5843	13.7974	1269.3630	784201	9991265	Very high
ves 19	Ngendalel	Kipkelion	2334	164	0.0704	0.2787	45.7975	729583	9971285	Intermediate
ves 20	Kapsomboch	Kipkelion	953	120	0.1260	0.6431	77.1692	729847	9961334	Intermediate
ves 24	Kiprengwe	Kipkelion	337	289	0.8565	1.6930	489.2830	776692	9974564	High
ves 27	Lelechwet	Kipkelion	12	140	11.2903	36.9029	5166.4068	776329	9981806	Very high
ves 32	Tingoro	Kipkelion	172	255	1.4826	3.1745	809.4859	777079	9989145	High
ves 34	Katet	Kipkelion	81	195	2.4104	6.4157	1251.0657	779881	9986769	Very high
ves 36	Kapkondor	Kipkelion	134	83	0.6217	4.0209	333.7356	784114	9981861	High
ves 40	Kondamet	Kipkelion	217	72	0.3300	2.5557	182.9913	765247	9968900	High
ves 46	Kipsegi	Kipkelion	89	274	3.0902	5.8899	1613.8435	766713	9971970	Very high
ves 3	Lelaitich IDP camp	Soin/sigo wet	689	44	0.0640	0.8694	38.3411	740622	9980746	Intermediate
ves 5	Aic Tumaini	Soin/sigo wet	91	26	0.2854	5.7436	149.3336	740423	9979116	High
ves 6	Atc Kipsitet	Soin/sigo	561	34	0.0606	1.0539	35.8322	740451	9979147	Intermediate

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		wet								
ves 7	Asenewet	Soin/sigo wet	248	195	0.7872	2.2556	440.5140	740545	9973587	High
ves 11	Emdit Primary	Soin/sigo wet	771	90	0.1167	0.7829	70.4636	729847	9961334	Intermediate
ves 18	Sototwet	Soin/sigo wet	527	53	0.1006	1.1174	59.2216	744388	9965912	Intermediate
ves 22	Kapsewa	Soin/sigo wet	317	151	0.4770	1.7925	271.3870	735249	9957264	High
ves 28	Kamaget	Soin/sigo wet	389	40	0.1028	1.4823	59.2939	730379	9952564	Intermediate
ves 29	Kaptugumo	Soin/sigo wet	84	151	1.8110	6.2222	942.0443	740219	9966268	High
ves 37	Kabatet	Soin/sigo wet	373	146	0.3915	1.5412	225.1661	726785	9957965	High
ves 41	Kisabei	Soin/sigo wet	266	208	0.7831	2.1166	440.2585	748311	9968581	High
ves 44	Kapkeburu	Soin/sigo wet	491	72	0.1468	1.1932	86.0279	731892	9953546	Intermediate
ves 49	Chebirir	Soin/sigo wet	551	71	0.1288	1.0710	76.0408	739607	9978818	Intermediate

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