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MULTIDISCIPLINARY APPROACH TOWARDS DECIPHERMENT OF SUBSURFACE FEATURES OF YUSUF MAITAMA SULE UNIVERSITY MAIN CAMPUS KANO, NIGERIA

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ABSTRACT

The need to overcome the scarcity of water at premises of Yusuf Maitama Sule University Kano Nigeria is highly needed. Induced Polarization (IP) and Spontaneous Potential (SP) methods using Vertical Electrical Soundings (VES) technique were employed. Six soil and Seven water samples were analysed using Atomic Absorption Spectroscopy (AAS). The area identified with features of groundwater accumulation were at lat. 12.002^0 N to 12.008^0 N & Long. 8.465^0 E to 8.4675^0 E, lat. 12.00^0 N, to 12.005^0 N & long. 8.47^0 E, 8.4725^0 E, lat. 12.005^0 N to 12.01^0 N.& long. 8.482^0 E to 8.49^0 E and lat. 12.01^0 N to 12.015^0 N and long. 8.460^0 E to 8.47^0 E with corresponding depths of 50 m, 48 m, 52 m and 45 m respectively. Level of contamination of underground water and soils in the study area were majorly below permissible level.

1. INTRODUCTION

Water resources are of great concern in Kano State, especially at the Main Campus of Yusuf Maitama Sule University. The campus relies on a combination of small streams, springs, and the Chalawa dams for its water supply. During the peak summer months, groundwater becomes particularly essential as the demand for water significantly increases. Over the years, the reliance on groundwater has intensified due to the growing population and expanding commercial activities.

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Geoelectrical resistivity techniques in various studies. This integration enhances the understanding of complex hydrogeological aspects related to aquifers and bedrock fractures and aids in studying fracture networks and their patterns, which are crucial for groundwater exploration [2];

Geoelectrical resistivity techniques are widely recognized for their cost-effectiveness and versatility in assessing groundwater potential and identifying problematic zones for sustainable exploration, development, and management [2],[3], [9], [8], [2]. Methods such as Electrical Resistivity Tomography (ERT) and Vertical Electrical Sounding (VES) are well-established tools for surface geoelectrical surveys [9], [4], [5]. However, these methods can encounter limitations in heterogeneous ground conditions, influenced by factors like porosity, water content, subsurface lithology, and anisotropy [11],[12], which vary significantly in complex geological formations such as those found in Kano South [1].

The primary aim of this study is to decipher the subsurface features of Yusuf Maitama Sule University's main campus. The research objectives include identifying the structural pattern of subsurface features, evaluating groundwater quality, assessing groundwater distribution, and examining groundwater recharge and discharge channels. The study involves conducting vertical electrical soundings using resistivity, IP, and SP methods at forty-five points. The collected data were processed and interpreted using IP2WIN software, and strategic water and soil samples underwent physicochemical analysis. The integration of these methods will give comprehensive model of the region.

2 THEORETICAL FRAMEWORKS

The research utilizes the theory of Resistivity, IP and SP to understand subsurface electrical properties, linking these principles to geological interpretations.

2.1 Electrical Direct Current Method

For the application of electrical direct current resistivity method [12] shown that a region of injected current density J is given by:

$$J = \frac{E}{\rho} \tag{1}$$

where J = current density, E = electric field and ρ = resistivity of the medium.

Moreover, [2] shown that resistivity of the region measured for a spread current and potential electrodes is express as;

$$\rho = \frac{\Delta V}{\mathrm{I}} K \tag{2}$$

where ΔV = measured potential difference, K = geometrical factor and I = injected current.

Various literatures [12], [7] etc have given sufficient discussion on the different field procedures and have revealed the superiority of Schlumberger array for strategic studies and hence adopted as the VES array in this research.

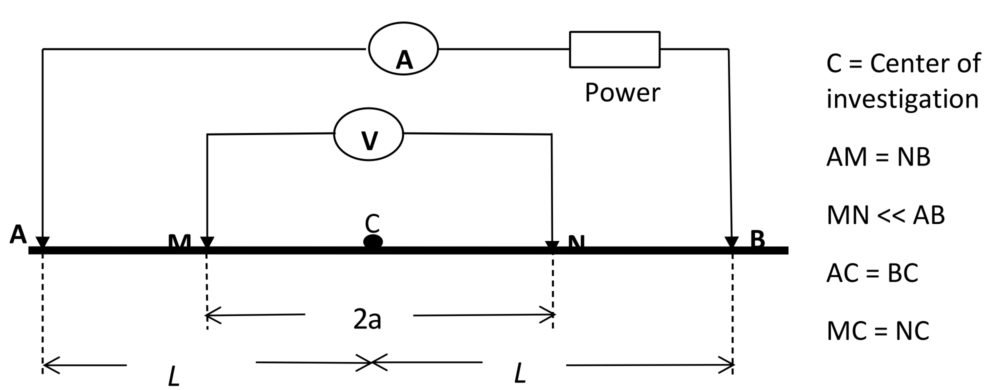


Figure 1: Schlumberger array configuration (Parasnis, 1997)

$$K = \frac{\pi}{2}\left(\frac{AB^2 - MN^2}{MN}\right) \quad (3)$$

where K is the geometric factor, AB and MN are the respective current and potential electrodes spacing.

Other methods used are IP and SP.

The induced polarisation (IP) depends on a small amount charge being stored in a region when a current passed through it to be released and measured when the current is switched off as expressed according to [8];

$$MP = \frac{1}{V_0}\int_{t1}^{t2} V\,p(t)\,dt \quad (4)$$

where $V_{p(t)}$ = is the decay voltage measured over time after the current is turn off, t_1 and t_2 are the start and end times for measuring the decay voltage, and M is (IP)

The spontaneous (self) potential (SP) is an inherent electrical potential or voltage that occurs naturally. [2] gave detail the mechanisms behind SP generation, including streaming, Nerst, diffusion, and mineralization potentials. This phenomenon arises without external current injection, manifesting as potential readings on the electrode.

2.2 Dar-Zarrouk Parameters and Protection Capacity

The Dar-Zarrouk parameters according to [18] are seven in number, namely, longitudinal conductance (S) and transverse resistance (T), apparent resistivity (ρ_a), Layer Resistivity (ρ_i), layer thickness (h_i), reflection coefficient (R) and anisotropy (λ). But S and T were used as they play a crucial role in evaluating the protective capacity of subsurface layers, particularly in hydrological studies focused on groundwater vulnerability and aquifer protection. [18] demonstrated the use of S in evaluating the protective capacity of surface rocks. This parameter is a measure of the cumulative ability of overlying layers to protect underlying aquifers from potential contaminants. It is calculated as the sum of the ratio of thickness to resistivity of each layer. According to [18] it expressed as;

$$S = \sum \frac{h_i}{\rho_i} \quad (5)$$

A higher longitudinal conductance indicates better protective capacity. [2] and [10] gave the ranges of protective capacities (in mho) of rocks layers as poor protection ($S < 0.1$), weak protection ($0.1 \leq S < 0.2$), moderate ($0.2 \leq S < 0.3$) and good protection ($S \geq 0.3$).

Transverse Resistance

Transverse resistance is used to assess the resistive nature of the subsurface layers [10], and is calculated as;

$$T = \sum hi.\rho i$$

(6)

3 MATERIALS AND METHODS

The materials used includes: ABEM SAS 1000 Terametre, electrodes, solar panel, hammers and battery.

3.1 Data Acquisition

The data acquisition was conducted between (16th February, 2024 to 3rd March, 2024 and coincided with peak of the dry season. Forty-five VES were conducted within and around the University Campus. The ABEM SAS 1000 terametre and its accessories were used in taking resistivity, IP ad SP values. Schlumberger array was used with current electrodes and potential electrodes spacings ranging from 3.0 m to mostly 1060 m and 1.0 m to 20.0 m respectively (Table 1).

Six soil and seven water samples collected from selected locations and then taken to Bayero University Central Laboratory for physicochemical analysis. Geographic coordinates of the data acquisition and sample collection locations were taken using handheld global positioning

Table1: Field Data for VES 1

Lat: 12.35^{0}N Long: 8.474^{0}E Date: 16/02/2024

AB/2 (m)	MN/2 (m)	Resistivity (Ωm)	IP (mS)	SP (mV)
1.5	0.5	221.97	0.80	38.44
2.0	0.5	195.23	0.30	28.86
3.0	0.5	198.53	0.47	26.84
5.0	0.5	199.55	1.35	24.32
7.0	0.5	227.35	21.60	23.38
10.0	0.5	277.82	89.00	22.02
10.0	2.0	227.65	12.50	0.10
15.0	2.0	234.51	26.40	90.79
20.0	2.0	242.83	24.50	83.59
30.0	2.0	142.55	5.18	76.06
50.0	2.0	130.06	280.00	67.14
70.0	2.0	1111.40	316.00	64.06
80.0	2.0	6840.94	151.00	60.36
100.0	2.0	62.38	105.08	57.04
100.0	5.0	139.32	254.00	32.40
130.0	5.0	1162.00	177.00	47.25
150.0	5.0	5888.00	165.00	50.08
170.0	5.0	3097.30	164.00	52.05
200.0	5.0	209.59	498.00	54.08
230.0	5.0	3722.00	686.00	22.81
270.0	5.0	119888.00	130.00	58.19
300.0	5.0	5990.40	114.00	58.99
300.0	10.0	2376.90	106.00	49.04
330.0	10.0	1267.40	16.30	50.92
370.0	10.0	708.57	36.10	58.98
400.0	10.0	2703.20	83.50	33.28
430.0	10.0	26420.00	157.00	61.10
470.0	10.0	632.28	344.00	63.56
500.0	10.0	304.25	191.00	63.55
530.0	10.0	315.42	48.90	63.66

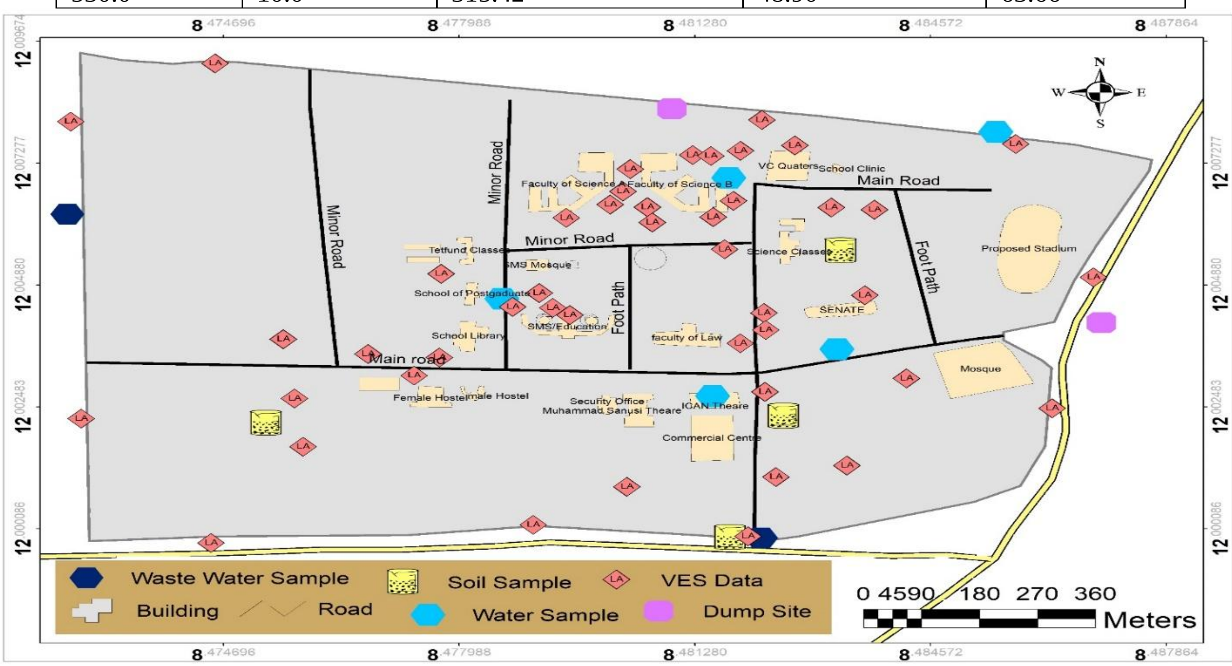


Figure 2: Cartographic map of Yusuf Maitama Sule University

3.2 Data Analysis

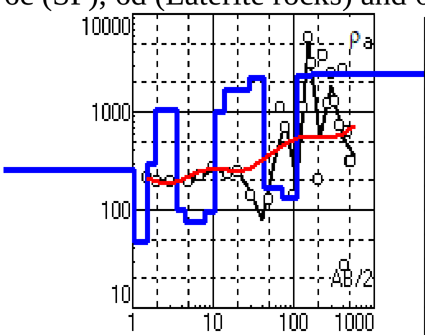
Electrical and physicochemical methods were used in collaboration with geologic and well-log of nearby area. The data from the electrical methods were subjected to IP2WIN (Version 3.0.1, 10-Jan-2003) the result were compared to the nearest borehole log and gridded with surfer golden software version 8.0, and the result from physicochemical analysis were compared with other standard as presented in table 3.

3.2.1 Electrical method

The direct electrical resistivity was plotted in IP2WIN (x86) version by Geoscan- M Ltd. Typical result of the software was given for VES1 (Figure 3). The modelled parameter table was compared with Table 2 and geoelectrical layering were deduced about the study area. Table 2 shows the standard geological layering of kano state obtained from Rural Water Resources Agency (RUWASA) and were used as reference for characterizing our geological layers within the study area.

However, the IP and SP data were plotted as graphs of respective physical field values versus depth in Microsoft Excel and the locations for possible groundwater flow were interpolated as typified in Figures 4 and 5 respectively.

The Fresh Basement Complex rocks (deduced from resistivity method) and groundwater flow depth (obtained from IP and SP methods) topographies were interpolated, gridded and plotted in Surfer Golden Software Version 11. Figures 6a (Basement Complex rocks topography), 6b (IP), 6c (SP), 6d (Laterite rocks) and 6e (Top soil) were obtained.

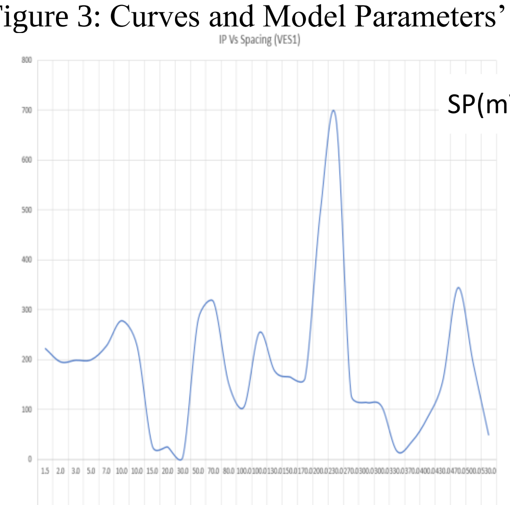


N	ρ	h	d	Alt
2	46.6	0.488	1.53	-1.529
3	298	0.383	1.91	-1.913
4	1049	1.66	3.57	-3.569
5	100	0.904	4.47	-4.473
6	75.4	3.57	8.05	-8.047
7	95.3	2.42	10.5	-10.46
8	1000	3.15	13.6	-13.62
9	1677	15.1	28.7	-28.68
10	2185	13.5	42.2	-42.17
11	171	29.2	71.4	-71.36
12	133	39.1	111	-110.5
13	2330	60.6	171	-171.1
14	2442			

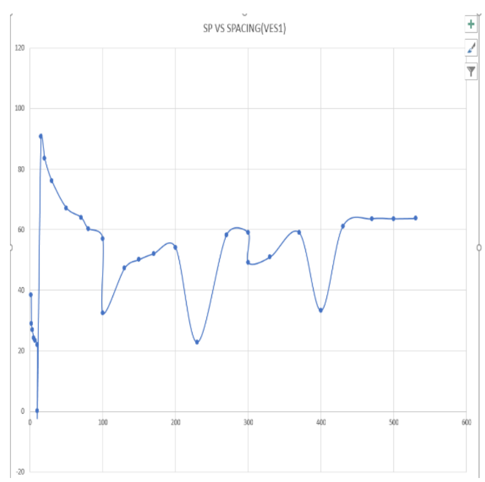
N	Number of layers
ρ	Resistivity of layers (Ωm)
h	Thickness of the layers (m)
d	Depth to bottom of layers (m)
Al	Height above ground the level (m)

Figure 3: Curves and Model Parameters' Windows for VES 1

IP(mS)



SP(mV)



Spacing (m)

Figure 4: IP against AB/2 for VES 1

Spacing (m)

Figure 5: SP against AB/2 VES 1

Table 2: Geological Layers of Kano state (RUWASA, 2022)

Geological Layers	Resistivity Values (Ωm)
Top Soil	100 – 250
Laterite	50 – 500
Completely Weathered rock	30 – 90
Slightly Weathered rock	300 – 1000
Fresh-Basement	> 1000

The protective capacity of each VES point was calculated by considering the resistivities and corresponding depths of the top layers using Equations 5 and 6. The values obtained were gridded and plotted as shown in Figure 6f. The regions were classified according to the format given by [11], as shown Figure 7.

3.2.2Physicochemical Analysis

The data obtained from the analysis is given in Table 3. The concentrations of Cr, Pb, Co, Ni, and Cd were given alongside the corresponding Ph, Total Dissolved Solute (TDS) and Electrical Conductivity of the collected samples.

RESULT AND DISCUSSION

This section presents the results of the geophysical surveys conducted in YUMSUK, using Resistivity, induced polarization (IP), spontaneous potential (SP) and Physicochemical analysis. The findings are analysed and discussed in relation to the study's goal of deciphering subsurface features.

4.1 Direct Current Resistivity Results

Locations identified with potential for groundwater accumulation were identified and variously labelled for the different electrical methods. The areas identified based on resistivity method, Basement rocks topography, are designated as D1 (lat.12.002 ^{0}N to 12.008 ^{0}N and long. 8.465 ^{0}E to 8.4675 ^{0}E), D2 (lat. 12.00 ^{0}N to 12.005 ^{0}N and long. 8.47 ^{0}E to 8.4725 ^{0}E), D3 (lat. 12.05 ^{0}N to 12.10 ^{0}N and long. 8.485 ^{0}E to 8.49 ^{0}E), D4 (lat. 12.01^{0}N to 12.015 ^{0}N and long. 8.465 ^{0}E to 8.47 ^{0}E) and D5 (lat. 12.00525 ^{0}N to lat. 12.01^{0}N and long. 8.475^{0}E to 8.4775 ^{0}E) with corresponding depths of 48 m, 47 m, 50 m, 47 m and 52 m respectively. Areas with groundwater potential, identified via resistivity and basement rock topography, were designated D1–D5 (Figure 6a).

For IP in Figure 6b as labelled by IP1 (lat. 12.0005^{0}N to 12.007^{0}E and long 8.465^{0}E to 8.75^{0}E), IP2 (lat. 12.002^0 N to 12.008^{0}N and long. 8.465^{0}E to 8.4675^{0}E), IP3 (lat. 12.00^{0}N to lat. 12.005^{0}N and long. 8.47^{0}E to 8.4725^{0}E), IP4 (lat. 12.005^{0}N to lat. 12.01^{0}N and long. 8.482^{0}E to long. 8.49^{0}E) and IP5 (lat. 12.01^{0}N to lat. 12.013^{0}N and long. 8.482^{0}E to long. 8.49^{0}E) with corresponding depth of 47 m, 48 m, 45 m, 50 m and 47 m respectively. While for SP the locations in figure 6c were indicated as SP1 at (lat. 12.002^0 N to 12.008^{0}N and long. 8.465^{0}E to 8.4675^{0}E), SP2 (lat. 12.01^{0}N to 12.015^{0}N and long. 8.465^{0}E to long. 8.47^{0}E) SP3 (lat. 12.00^{0}N to 12.005^{0}N and long. 8.47^{0}E to 8.4725^{0}E), SP4 (lat. 12.005^{0}N to 12.01^{0}N and long. 8.482^{0}E to 8.49^{0}E), SP7 (lat. 12.0005^{0}N to 12.007^{0}E and long. 8.465^{0}E to 8.75^{0}E), and SP8 (lat. 12.00525^{0}N to 12.01^{0}N and long. 8.475^{0}E to 8.4775^{0}E) at depths of 48 m, 47m, 47 m, 50 m, 45 m and 40 m respectively.

The thickness of laterite rocks varies from 1.5m to 23m in the study area, the portion LT1 in Figure 6d at Lat. 12.0025^{0}N to 12.0075^{0}N and Long. 8.4625^{0}E to 8.4675^{0}E is thicker and needs strength analysis for civil engineering construction.

Based on Figure 7 the area bounded by; lat. 12.004^{0}N to 12.01^{0}N and long 8.465^{0}E to 8.469^{0}E has high protective capacity whereas the rest of the has reduced protective capacity

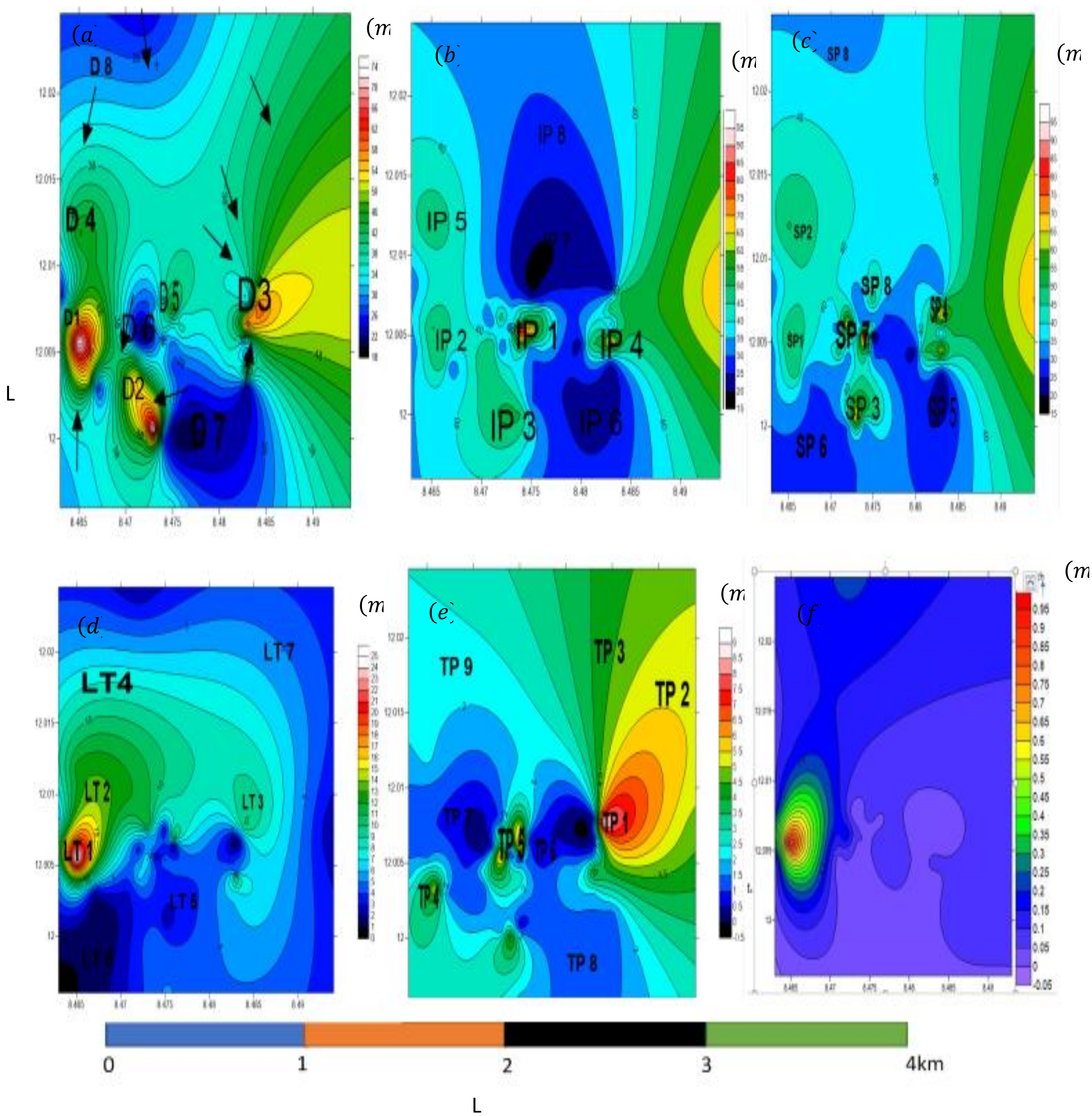


Figure 6: Geoelectrical contour map:(a) Basement topography (b) Induced Polarization (c) Spontaneous Potential (d) Laterite Rocks (e) Top Soil (f) Protective Capacity

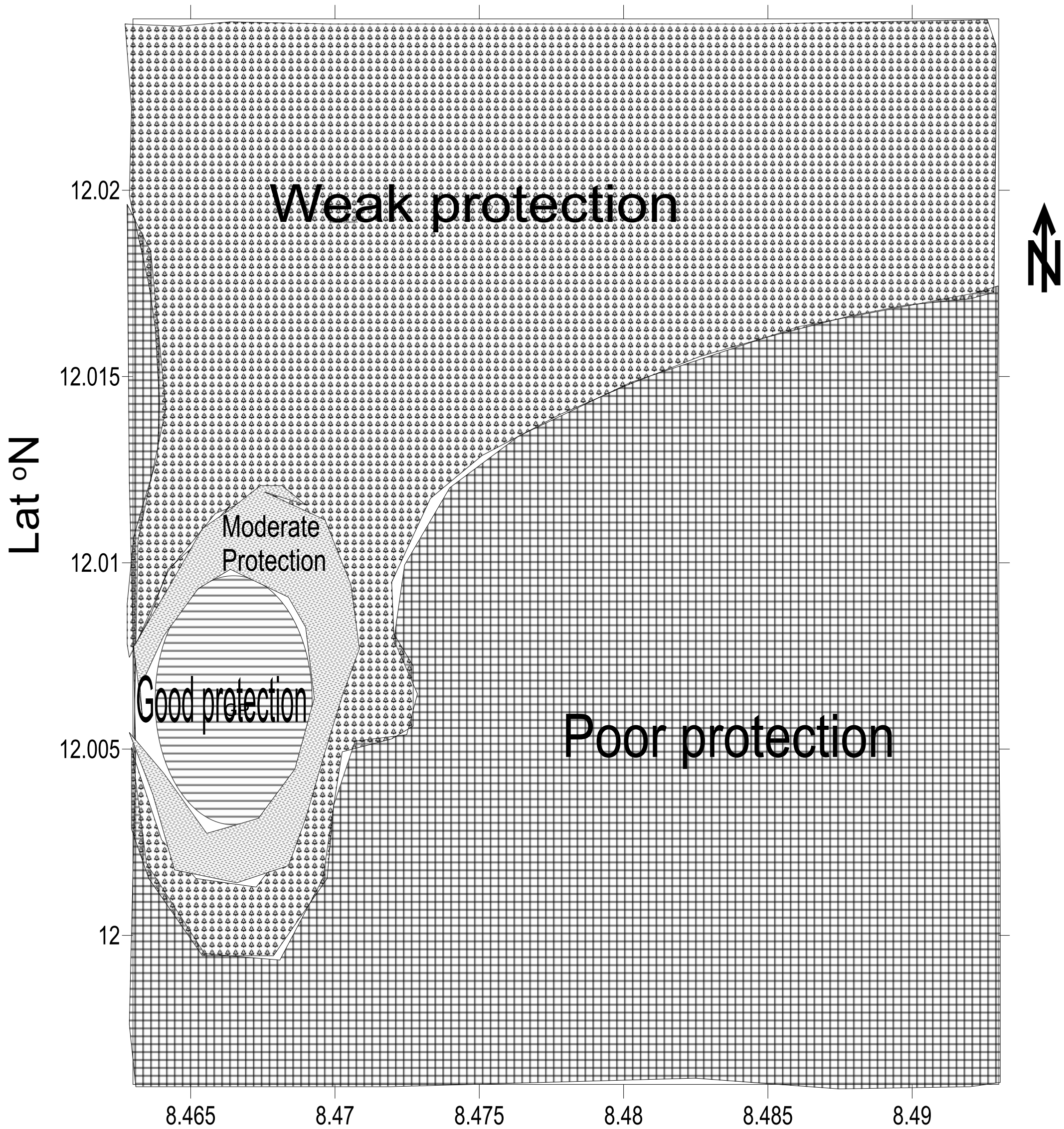


Figure 9: Transmission and Reflection Measured for Wood at 10 GHz

4.1 Physicochemical **Results**

Physicochemical analysis was conducted to complement geophysical methods in the study area. These parameters provide insights into the geochemical environment.

4.2.1 Heavy Metals Analysis

Underground water and soil samples were analysed for the presence of heavy metals at the strategic places within and outside the university and the results reported in Tables 3. The results indicate significant variations in the analyses concentrations under consideration which is attributed to the differences in activities.

Chromium (Cr) was not detected in some samples collected, while concentrations below standard limit set by WHO/FEPA (World Health Organization/Federal Environmental Protection Agency) were reported in other sampling locations for both underground water and soil samples except for WC and SA which are wastewater and soil from dumping site respectively. These samples were collected at a location near the university campus fence. Consumption of Cr can cause asthma, eye irritation, liver damage, pulmonary congestion, [9].

Lead, (Pb) which is also a heavy metal of concern was analysed in both water and soil samples, the standard value according to the WHO/FEPA is 0.01 mg/L for underground water and 85 mg/kg for soil samples. The Pb was not much detected in all the samples under consideration, except sample WF the concentration is higher than the Pb permissible limit for underground water. However, for soil samples all the samples analysed shows that the concentration is lower than the standard as indicated in Table 3. Considering sample WF and sample SK, both are collected at the nearest location, this is an indication that Pb contamination is observed which may be linked to human activities. The result from wastewater also has higher Pb concentrations, though the samples was collected outside the University premises, the health complications associated with exposure to Pb include poisoning, damage to the central nervous system among others [8], [5].

Cobalt, (Co) was analysed in the samples under consideration, and it's a heavy metal of concern. Co was detected in all the samples under investigation which are compared with the permissible limit set by WHO/FEPA of 0.04mg/L for underground water and 50 mg/kg for soil sample. The underground water sample WA in the table has Co concentrations higher than the standard permissible limit set by WHO/FEPA, in addition to all the samples in table 4. Conversely, Co was detected below the approved standard limits for the soil samples. Considering sample WA in table which was collected outside the University, the result is close in location to sample SD was obtained. This indicates that the location has higher Co concentration which may be linked to the nearby dumping site. The dumping site located close to the University fence may leach the heavy metals to the underground water overtime thereby resulting in contamination. Traces of Co in water and soil could be detrimental to human health. The health risks associated with exposure to Co include damage to lungs, liver, and heart [9].

Nickel, (Ni) is another heavy metal of concern under investigation which was detected in all the samples under consideration. The permissible limit of Ni is 0.02 mg/L for underground water and 35 mg/kg for soil according to WHO/FEPA. The elevated Ni concentrations of 0.11 mg/L in sample WE as reported in Table 3 are alarming. Sample WE were obtained inside the campus and very close in location to sample SH in which also record a substantial amount of Ni concentration. As reported in wastewater and soil from dump site samples. all the samples are collected outside the campus, while sample WE was collected near sample SH. Therefore, the contamination may be from location where SH was collected. The consumption of Ni could lead to detrimental health effects which may include allergy, kidney diseases and lung fibroids[8], [5].

Cadmium, (Cd) was also analysed in both water and soil samples, and comparison was made to the permissible limit set by WHO/FEPA. As reported, the sample WF has value higher than the permissible limit of 0.003 mg/l, also sample SK which both the samples are from the same location indicating the higher Cd concentrations. The samples of wastewater also show higher Cd concentration. The health implications arising from the exposure of Cd includes flu-like symptoms and it can damage lungs [6].

4.2.2 Physicochemical

pH (Potential hydrogen) is a measure of acidity and alkalinity of water or any aqueous. It quantifies the concentration of hydrogen ion (H+) in the water. The pH scale ranges from 0 to 14, with 7 being considered as neutral, below 7 indicated acidity and values above 7 is alkalinity [8].

The acceptable pH range for drinking water typically falls between 6.5 and 8.5 (WHO 2004). The range of the pH found in the region falls between 6.74 to 8.42 (WHO/FEPA 2014) in Table 3, therefore pH of all the five samples considered are safe and acceptable as it all falls within the range like in all the remaining three tables.

Electrical conductivity (EC) is a key parameter in water quality assessment that measure water sample's ability to conduct an electrical current. EC is an essential indicator of water quality due to its association with the concentration of dissolved ions and salts, EC is a fundamental parameter used assess water quality and can help to identify changes in the mineral content of underground water. EC is measured in micro Siemens per centimetre (µS/cm) or milli Siemens per centimetre (mS/cm). The acceptable EC levels level is 1500 µS/cm according to the (WHO/FEPA 2014). Therefore, out of five samples and across all the Table 3 no anyone that is close to the maximum permissible limit hence no contamination.

Total dissolved solids (TDS), in water refers to the total concentration of inorganic and organic substances that are dissolved in water. TDS is an important parameter in water quality assessment and can provide valuable insights into the safety and subtlety of underground water, it comprises various dissolved substances found in water. The substances can include minerals such as calcium, magnesium and potassium and ions which include chloride, sulphate and bicarbonate. It also includes trace elements such as heavy metals like ion and arsenic. TDS is measured in parts per million (mg/l) in water sample and (mg/kg) in soil, the acceptable TDS level 100ppm according to (WHO/FEPA 2014) and the maximum value found from these five samples are 500ppm in sample WA which is below the maximum limit therefore it considered safe and acceptable. But in Table 3 it exceeds the permissible limit.

TYPES	SAMPLES	CO-ORDINATES		Cr (mg/l)	Pb (mg/l)	Co (mg/l)	Ni (mg/l)	Cd (mg/l)	Ph	EC (µS/cm)	TDS (mg/l)
		(^{0}N)	(^{0}E)								
Underground Water	WA	12.0077	8.484	ND	ND	0.041 ± 0.0024	0.016 ± 0.0052	0.0011 ± 0.001	6.74	0.72	500
	WD	12.00416	8.472	0.0016 ± 0.001	0.005 ± 0.0032	0.0044 ± 0.003	0.001 ± 0.001	0.0011 ± 0.0002	8.42	0.69	480
	WE	12.00555	8.474	ND	ND	0.003 ± 0.0033	0.116 ± 0.0051	0.0028 ± 0.0022	7.50	0.51	350
	WF	12.00444	8.483	0.0063 ± 0.0034	0.0017 ± 0.001	0.0029 ± 0.0017	0.0018 ± 0.0022	0.007 ± 0.0004	7.8	0.61	430
	WG	12.00333	8.471	ND	0.011± 0.0052	0.0036 ± 0.0022	0.0061 ± 0.0021	0.0021 ± 0.0002	7.76	0.60	410
FEPA(2007) /WHO(2004)				0.05	0.01	0.04	0.02	0.003	6.5 - 8.50	15.00	1000
Soil Sample	SE	11.996	8.475	76.75± 0.0139	6.35± 0.0088	3.25± 0.003	9.35± 0.0021	0.11± 0.0002	8.66	0.33	59
	SH	12.0052	8.472	27.50± 0.0485	3.55± 0.022	0.071± 0.23	6.85± 0.0085	0.45± 0.0006	8.35	0.26	80
	SK	12.005	8.474	7.05± 0.0139	8.45± 0.0240	6.10± 0.0025	9.55± 0.014	0.915± 0.0031	8.21	0.32	70
	SL	12.0017	8.142	6.00± 0.014	1.10± 0.0055	14.00± 0.0061	1.55± 0.0031	0.4± 0.0011	8.13	0.20	86
WHO(2015)/ FEPA(2007)				100.00	85.00	50.00	35.00	1.0	8.5	15	100
Waste Water	WB	12.004	8.472	0.047± 0.0043	0.014± 0.0129	0.055± 0.0003	0.094± 0.0009	0.009± 0.0009	8.51	1.26	86
	WC	12.005	8.465	0.179 ± 0.0035	0.081± 0.0309	0.072 ± 0.0033	0.0076 ± 0.0025	0.007 ± 0.0004	8.12	1.57	108
FEPA/WHO				0.0 5	0.01	0.04	0.02	0.003	8.5	10	100
				0.01	0.04	0.02	0.003	6.5 - 8.50	10	15.00	
Soil from Dump site	SA	12.00160	8.485	40.75± 0.0102	36.40± 0.0126	4.05± 0.0011	1.15± 0.0011	0.14± 0.0102	6.74	0.72	220
	SD	12.05	8.483	0.105 ± 0.0005	6.10± 0.0021	40.40 ± 0.0018	9.35 ± 0.0046	0.70 ± 0.0010	8.39	1.59	102
FEPA/WHO				2.00	50.00	50.00	50.00	0.01	8.5	15	100

Discussion

Based on this research, the following areas were identified as potential sites for underground water accumulation D1, IP2 and SP1(lat.12.002 ^{0}N to 12.008 ^{0}N and long. 8.465 ^{0}E to 8.4675 ^{0}E), then at D2, IP3 and SP3 (lat. 12.00 ^{0}N to 12.005 ^{0}N and long. 8.47 ^{0}E to 8.4725 ^{0}E), then D3, IP4 and SP4 (lat. 12.05 ^{0}N to 12.10 ^{0}N and long. 8.485 ^{0}E to 8.49 ^{0}E), then D4, IP5, and SP2 (lat. 12.01^{0}N to 12.015 ^{0}N and long. 8.465 ^{0}E to 8.47 ^{0}E). All these four locations indicate a consensus that there is potential for underground water in the points mentioned.

Then the other points were the agreement is between the two methods are IP1 and SP7, then D5 and SP8. These are the locations were the agreements made for groundwater accumulation. In comparison to the contamination of underground water it shows that at Latitude 12.0033^{0}N to long. 8.471^{0}E the portion has contamination of Lead (Pb), at lat. 12.004^{0}N and long. 8.472^{0}E there is mild contamination of Chromium and at lat. 12.004^{0}N to long. 8.483^{0}E the value of Cadmium partially liberated above the standard permissible limit. The location lat. 12.0033^{0}N to long. 8.471^{0}E which has the concentration of Pb above the permissible limit and it correspond to one location with high potential of underground water though the point has poor protection capacity.

For Laterite soil where the civil engineering construction is supposed to be carry out in the University Campus, after doing strength analysis the following observation was made. At latitudes 12.005^{0}N to latitudes 12.01^{0}N and long. 8.465^{0}E to 8.47^{0}E which is indicated as LT1 in laterite contour map has a good thickness of laterite depth to around 14m to 23m. then LT2, LT3 andLT4 which has less laterite thickness. Moreover, heavy metals detected in soil sample only Cd detected close to the standard limit in sample SK at coordinates of 12.005^{0}N and 8.474^{0}E. Thus, almost all samples obtained from waste water and dumping soil site were found contaminated above the permissible limit and are outside the campus fence.

CONCLUSION

This multidisciplinary investigation of subsurface features in Yusuf Maitama Sule University revealed significant insights in to the geological and hydrological characteristics of the area. Through the use of VES several features have been delineated with varying resistivity values. The finding indicates that at locations lat. 12.002^{0}N to 12.008^{0}N and long. 8.465^{0}E to 8.4675^{0}E, then at lat. 12.00^{0}N to lat. 12.005^{0}N and long. 8.47^{0}E and 8.4725^{0}E and also at lat. 1201^{0}N to 12.015^{0}N and long. 8.465^{0}E to 8.47^{0}E there is agreement between the three methods that is resistivity, IP and SP.

Moreover, there are other locations with potential underground water but the agreement is not between the three methods which are IP and resistivity at lat. 12.00525^{0}N to lat. 12.01^{0}N and long. 8.475^{0}E to 8.4775^{0}E then between IP and SP at 12005^{0}N to 12.007^{0}N and long. 8.465^{0}E to 8.75^{0}E. The IP and SP values were plotted against the spacing (AB/2) to help in providing the depth in the aquifer and was cross-correlated with the resistivity value obtained from IP2WIN then processed it using Surfer golden software. The findings show four different locations in the University Campus were all the three methods come in agreement as a water bearing zones while other two locations the coincidences are between two methods. While for physicochemical analysis the contamination discovered at lat. 12.0033^{0}N to long. 8.471^{0}E, lat. 12.004^{0}N and long. 8.472^{0}E, which is maybe from dumping site of refuse and wasted water outside the Campus, since most of the samples from waste water and soil from dumping site was found contaminated. Moreover, by using Darzarrouk Parameters shows that the area lying from Lat. 12.004^{0}N to 12.01^{0}N and long 8.465^{0}E to 8.469^{0}E had good protection capacity.

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