THE UNDERGROUND WATER INVESTIGATIONS USING SELF-POTENTIAL GEOPHYSICAL SURVEY A CASE STUDY OF BUK OLD CAMPUS BY THE APPLICATION OF COMPUTER MODELING SOFWARE (MATLAB) KANO, NIGERIA.

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ABSTRACT

The project presents the application of self- potential method, as an aspect of geophysical methods. In the paper insight into other geophysical methods was given and ended with depth discussion on self-potential method. Details pertaining to production, utilization, equipment involved, method of investigations, success recorded in field applications of the method are presented. One of the most important feature of self-potential that made it to stand out of other geophysical methods is detection of fluid flow, as presented in various literatures and case histories of field application of the method, thereby making it a complimentary technique in field applications involving fluid flow, fracture leakage detection and pollutant migration e.t.c. It has the simplest equipment requirement that is only a potential measuring device is used. The study was carried out with the aims of investigating the underground water around the study area. The data obtained were interpreted using a computer modeling software (MATLAB). The result of the interpretation was used to determine the approximate depth of the underground water around the study area. The study showed various levels of possible flow at various points. Based on these data analysis, the levels of appreciable flow pattern started from 60.0m and extended to a maximum depth of about 100.0m, at investigation point 3.

I. INTRODUCTION

The study of geophysics is basically fundamental to surface and subsurface geophysics exploration. As name implies, geophysics involved the application of physics theory and measurement to discover properties of the earth. Before the age of reason, most of the natural catastrophic events (e.g. earthquake)are attributed to superstitious beliefs, but today there

are number of geophysics reasons for such events, the study of geophysics is categorized into two: exploration geophysics and theoretical geophysics. While the objective of exploration geophysics is for economic exploration, the theoretical geophysics bent on applying the physics theories to study and discover the properties of the earth (1). The main purpose of this study is to learn about the application of self-potential geophysical technique for groundwater investigation. The basic background of this technique is similar to the classical correction process use in magnetic prospection. The self-potential data are collected on a square grid in archaeological prospection. In this case, the desired anomaly is affected by many undesired polarization problems due to the shift of non-polarizing electrodes along the survey line. Thus, the known correction techniques are not sufficient to eliminate these undesired effects. In this study we propose a new correction system eliminating these undesired effects (inner voltage different between the non-polarizing electrodes, drift polarization, soil contact effect etc) from the anomaly.

1.1 Basic Concept of Self Potential Geophysical Survey

Self-potential methods measure naturally occurring electrical potentials in the earth. One source of these self-potentials is the "streaming potential" (or electro kinetic potential) which arises from the flow of fluid (e.g. groundwater) through a porous medium.For this reason self-potential is used in groundwater investigations and in geotechnical engineering application for seepage studies.

Self-potential surveys are conducted by measuring electrical potential differences between pairs of electrodes that contact the surface of the earth (or water, in water covered area) at a number of survey stations in the area of interest. These stations may be along profiles or spaced so as to obtain a real coverage. One station is selected as a base station and all potentials are referenced to that point. The base station should be located at a point removed from expected anomalous activity. Potential (voltage) measurements are made by contacting the earth with non-polarizing electrodes. These electrodes, often called "porous pots," are designed so as not to create any spurious chemical potential upon contact with the ground. Measurements are made by connecting a high impedance voltmeter between two electrodes, usually the base station and a roving electrode.

Self potential interpretation can range from a simple a qualitative inspection of the plotted self potential profiles to complex computer modeling involving subtle interactions between temperature electrochemical reactions and earth geometry. For most groundwater investigations a simple qualitative analysis will provide the desired information about groundwater flow paths. Data are plotted as profiles (observed potential versus distance along the profile) or, if the data provides sufficient areal coverage, as contour plots. All else being equal, the anomaly location corresponds to the maximum groundwater flow. For "point sources," some estimate of the depth of the source may be obtained from the width of the anomaly.

There are several other sources of self potential variations which may act as noise or interference when mapping streaming potentials for groundwater investigations. These include: buried metal, temperature variations, soil property variation, electrochemical variations topographic effects and telluric (naturally occurring time varying electric potentials caused by distant thunder storms and ionospheric disturbance. NGA's geophysical team has the expertise to deal with these interference and create sound geophysics create sound geophysical interpretations.

1.2 Role of Geophysics In Ground Water Prospecting And Hydrogeology

The demand of groundwater is increasing very fast with the rapid urbanization and industrialization programs of the developing and developed countries and the urgency to increase food production. Finding potential sources of groundwater by wildcat drilling is proving to be very expensive when the cost benefit ratio is taken into account.

Many geophysical methods (i.e. magnetic gravity seism and electrical methods) have been used to locate and delineate subsurface water resources. They are inexpensive and can rapidly provide information about the geological structure and lithologies of a large region under investigation compared to an extensive drilling program.

The most important objective of a any geophysical survey for groundwater prospecting is to translate the result of geophysical interpretation in terms of the subsurface hydrology. For this purpose, a fence diagram, a water table map, longitudinal conductive map. Geological cross-section, geophysical correction is prepared. Petroleum, mineral exploration, and geotechnical and groundwater geophysicists have routinely use geophysical reconnaissance surveys. Further detailed geophysical surveys can, in many cases, accurately identify geophysical structures or environments suitable for practical targets of interest. In this way the geophysical survey results are used to determine the locations of the minimum number of exploratory boreholes required for both selecting potential sites of groundwater aquifers.

Exploration geophysics is primarily concern with mineral and petroleum exploration. Its importance in geotechnical engineering and groundwater exploration was importance in geotechnical engineering and storage coefficient. The values of the parameters determine from the geophysical methods can be considered fairly accurate in many cases. When measurement is made between pump sites, geophysical methods also play an important role in protection the groundwater resources from being contaminated by toxic and other hazardous wastes.

Geophysical investigations are essential to determine the following:

1. Subsurface layering i.e. depths, thickness and fluid saturation.
2. Structural complications such as faults, voids feature.
3. Presence of subsurface water, as a potential water sources and potential sources of contamination.

Application of geophysical method in the field of groundwater prospecting is discussed in this section The magnetic method is Rarely used in this filed, but may be occasionally used to locate faults and shear zones, which could affect the pattern of groundwater flow. The gravity method is widely used in regional reconnaissance surveys to delineate the form and extent of porous sedimentary deposits such as buried valley-fills sedimentary basins deep weathered zones and large fracture zones and can provide estimates on the total water storage capacity of prospective basins (9). The techniques, however, suffers from the weakness that small geological changes are difficult to detect, so the method is less useful in the solution of detailed hydro geological problems, but recently microgravity has been successfully used to solve these problems (6).

Seismic methods are potentially very useful in hydrological investigations. The reflection technique would certainly provide more than adequate structural information. Seismic refraction methods are also widely used. They provide direct information on the level of the water table since an increase in water content causes a significant increase of seismic velocity in an otherwise homogeneous litho logy. The technique of fan shooting may be adapted to the location of buried channels and gravel filled valleys which are often important sources of groundwater in region of largely impermeable bedrock. Seismic refraction surveys also provide important controls on the interpretation of the gravity anomalies associated with certain aquifers (5).

The use of the gravity and seismic techniques for hydro geological investigation of an area near tattalm Chile is done. The study indicates that the gravity method can provided a rapid and inexpensive means to determine the configuration for the bedrock surface over an area of recent sediment cover, while the refraction method reveals more precise, but over a smaller area, details of bedrock surface relief and depth to the water table. When used together, the two techniques represent a powerful means of investigating the form and the potential for certain types of aquifer (5).

The electrical, seismic and gravity method for groundwater exploration in Sudan is applied. The gravity method provided useful information at low coast on the depth to bedrock in the area. He used seismic refraction as a supplement to resistivity in situations where litho logical borehole is flat. The presence and the flow of groundwater are controlled by deep bedrock structure (10).

The gravity method to groundwater search in the bra basin, Sudan is successfully applied. Although the Bara basin is not fully developed, the gravity interpretation together with the laboratory measurements or samples and numerical simulation, have allowed the hydro geological characteristics of the basin to be evaluated. They defined the boundaries of the basin and the sediment thickness.

Because well logging offers the advantage of continuous recording of variations in physical logging techniques is used to derive the hydro geological characteristics of the Lincolnshire limestone, England. To achieve this he investigated the internal lithostratigraphical subdivisions, the development of fissures and its association with various lithostratigraphical units, the porosity and permeability of the various units and the variation in groundwater quality within the limestone aquifer.

Reflection seismology in groundwater studies at two locations in southern Australia was employed. The first, in the revering plains of northern Victoria, he defined the location and form of a buried river valley in a region in which subsurface topography governed the distribution of permeable sediments but had no surface expression. In the second he determined the suitability of the area for a proposed water supply augmentation program involving surface recharge of aquifers outcropping in the southwest of the state (6).

Geophysical investigations are essential to determine structural investigation is essential to determine structural complications. Olesen et al. (6) use detailed geophysical investigations accompanied by drilling to investigate stuoragurra postglacial fault (SF), Norway. The one meter thick layer of fault gouge detected in the drill holes is thought to represent the actual faults surface. Resistivity measurements reveal low-resistivity zones in the hanging-wall block as well as in footwall block of the stuoragurra fault.

II. MATERIAL AND METHODOLOGY

2.1 Study Area

The study area is Bayero University, Kano; Bayero University (B.U.K) is located on latitude 110 58'N and longitude 8030'E of the Greenwich meridian, it is surrounded by DalaUngoggo, Kano Municipal and Kumbotso Local Government areas. It has an area of 18 km2 and a population of 362,059 at 2006 census. Gwale local government headquarters is in the suburb of Gwale which is strategically located on ancient city Kano. The geology of Gwale local government falls within the wider Kano region geology as consisting of igneous and sedimentary structures. Specifically, the geology of the area falls within the basement complex rock, consisting of non intrusive rocks formed during the Precambrian period. These rocks are having subjected to metamorphism a lot of the presence of literates or some part of the surface which the result of the intense process of laterisation due to the subjection of the rocks to deep chemical weathering. The pre-existing land forms are believed to be covered by windblown materials commonly referred to as wind drift.

2.2 Methodology

The self-potential geophysical method is simple, a high quality non-polarizing electrodes combined with a precision millivolmeter is used to record the voltages, resulting from natural electrical current flow in the earth, at the earth surface. We will first map the 2D distribution of SP across the landfill and into keegan marsh within the vicinity of the landfill. The self-potential measurements on the keegan landfill will be made in a conventional manner by implanting the electrode into soil surface. The geophysical measurements are obtained "in survey" from a shallow-draft paddleboat and spatially geo-referenced with precision global positioning satellite (GPS).

2.2.1 Fields Equipments of Self Potential Geophysical Survey

The self potential method goes back to 1830, when Robert fox used copper plate electrodes and a spring galvanometer as a detector in attempt to final extension of underground copper deposits in common wall. Since 1920 it has been employed in base metal search, usually as a second method. The equipment required is electrodes connected by a wire to mill volt meter. There are however two restrictions on the electrodes and detector that are most important.

If one were to use metal strokes driven into the ground as self potential electrode, the result, electrochemical action at the ground contacts would create spurious potential are erratic in different ground and at different time, so it would be possible to make a fixed correction consequently time, so it would not be possible to make a fixes correction consequently non polarizing electrodes are essential. A simple SP survey consists of a base electrode position and a roving electrode to determine potential differences on a gridded survey or along profile lines. The required equipment merely includes electrodes, wire and a precise millivolt meter.

The electrodes in contact with the ground surface should be the non polarizing type, also called porous pots (figure 3.1) porous pots are metal electrodes suspended in a supersaturated solution of their own salts (such as a copper electrode suspended in copper) within a porous container. These pots produce very low electrolytic contact potential, such that the background voltage is as small as possible. Tinker and razor manufacture models of porcelain non-polarizing electrodes that are reliable and sealed to avoid evaporation of the salt solution. Sealed pots can keep their supersaturated solutions for more than a week, even in arid locales (8). Multiple pots are purchased such that breakage and cleaning may be accomplished readily in the field. Only one set of a base and mobile electrode are used at any one measurement loop/grid. Base station pots are usually larger in size to assure constant electrical contact through the time of use of that station. Mobile or traveling pots are often smaller in volume of salt solution and size. Copper clad steel electrodes are used in a variety of electrical surveys. Steel electrodes should be avoided in SP investigations. Contact potential of these electrodes is quite high and variable in the soil at various stations of the survey.

Survey wire**:** the wire used in SP surveys must be strong, hardy and of low resistance. Wire needs to have sufficient tensile strength to be able to withstand long-term pulls of survey work for multiple sites. For some field use, heavy twine or light rope may need to be twisted and knotted to long lengths of wire to add strength. Survey wire must have abrasion resistant insulator wrapping. Pulling the wire over roadway surfaces can expose bare wire. Usually random bare wire positions will not fully ground to the soil, and the effects will not fully ground to the soil, and the effects will be variable as differing lengths of wire are unreeled and occupy differing

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positions for the survey. This error will only modify the signal by a few to tens of millivolts (mv). Twisted two conductor, 18 gauge, and not solid conductor copper wire has been found to be strong and abrasion resistant (7). Resistance will be constant for survey wire between stations if the wire for a reading set is not permanently stretched in length, does not develop insulator leaks, and is not repaired. Repairs to wire should be made when needed because of bare wire or severe plastic stretching of the wire. Repairs and addition of wire to lengthen the survey use should only be made between measurement loop or grid of reads. No changes to the wire may be made during a loop or grid of readings without reoccupation of those positions. Wire accidentally severed requires a re-measurement of that complete set of circuit stations.

Millivoltemeter: An inexpensive, high input impedance voltmeter is used to read the potential in the millivolt ravage. Actual field voltage will be in error when the source potential is within an order of magnitude of the input impedance of the meter. The input impedance should exceed 50 m. higher input impedance is desirable due to the impedance reduction of air’s moisture. The resolution of the meter should be 0.1 or 1.0 mv. Several useful options on meters are available. Digital voltmeters are more easily read. Water-resistant or sealed meters are extremely beneficial in field use.

2.2.2 Field Procedures Of Self-Potential Geophysical Survey

Background potentials for these surveys may be at a level of a few tens of millivolts. Self-potential must exceed the background to be apparent. Potentials exceeding 1.0v have occurred for shallow or down hole measurements of large sources.

Measurements with the electrodes may require a system of reversing the electrode position to resolve contact potentials at the electrodes. Previously measured locations may need to be premeasured on a systematic or periodic basis. Reoccupation if s necessary when very accurate surveys are being conducted and for sites with temporal potential changes or spatial variations of electrode potential. Changes temporally in the electrodes or due to the self potential of the field require the survey to be conducted in a gridded or loop array. Loops should have closure voltages of zero or only a few millivolts. High closure potential requires re measuring several to all of the loop station. Station reoccupation should be in the same exact position of the earlier reading (s). in -closed lines should be avoided. Reoccupation of particular station intervals should be made when closed loops are not possible. The traveling electrode should periodically re-measure the base location to observe contact potential, dirty electrodes, or other system changes. Reversing the survey electrodes or changing the wire polarity should only change the voltage polarity.

Electrodes may have contact differences due to varying soil types, chemical variations, or soil moisture. Temporal and temperature variations are also possible, which may require the reoccupation of some of the survey positions on some arranged loop configuration. Electrode potentials have minor shifts with temperature change (8). Variations in the flow, or change of surface elevation where measurements are obtained are sources of variation of streaming potential. Self potentials may have temporal or spatial changes due to thunderstorm cloud passage, dissention of mineralization or electrolytic concentration, and in the groundwater flow conduits and location. High telluric potential variations may require the SP survey to be delayed for a day.

Some simple procedures are required to perform accurate and precise SP surveys. Good maintenance of porous pots, wires, and voltmeters must be observed through the survey. The traveling pot needs to be kept clean of soil with each position. Contact with moist oil, or more elaborate measures for good electrical contact with roadways or tock, must be assured. A water vessel may be varied to moisten the soil hole and clean the porcelain surface. Wire reels speed the pulling of cable and wire recovery for changing loops, and lessen wear on the cable. Reversing the wire polarity for some measurements and reoccupation of adjacent stations assures the cable has not been grounded or stripped. Repair and checking of the wire must be made between loops and is easily done when rewinding the cable reel.

Quality assurance in the field is conducted by reoccupation of loop closure points with the same base position. Repeated and reversed readings of particular loop end stations and checking base locations provide statistics for the assessment of measurement quality.

Grid surveys offer some advantages in planning SP surveys. Changes in elevation (changing the distance to the potential source) and cognizance of cultural effects can be minimized with planning survey grids or loops. AC power lines, metal fences and underground utilities are cultural features that affect the potential field extraneous to the normal sources of interest.

III. RESULT ANALYSIS AND DISCUSSION

Table 4.1, 4.2 and 4.3 shows the observed potentials and investigation depth obtained from the investigation points 1,2 and 3 respectively.

Table 4.1 Data Collected In Investigation Point 1

s/n	Electrode spacing (M)	Observed potential (mV)
1.	1.5	59.10
2.	2.0	-30.97
3.	2.0	-19.53
4.	2.0	32.41
5.	2.0	45.80
6.	2.0	-64.65
7.	2.0	-142.00
8.	2.0	95.73
9.	2.0	22.30
10.	2.0	-190.00
11.	2.0	-227.00
12.	2.0	-59.61
13.	2.0	-118.00
14.	2.0	96.54
15.	2.0	10.46

16.	2.0	-54.35
17.	2.0	22.59
18.	2.0	-118.00
19.	2.0	43.46
20.	2.0	156.00
21.	2.0	-131.00

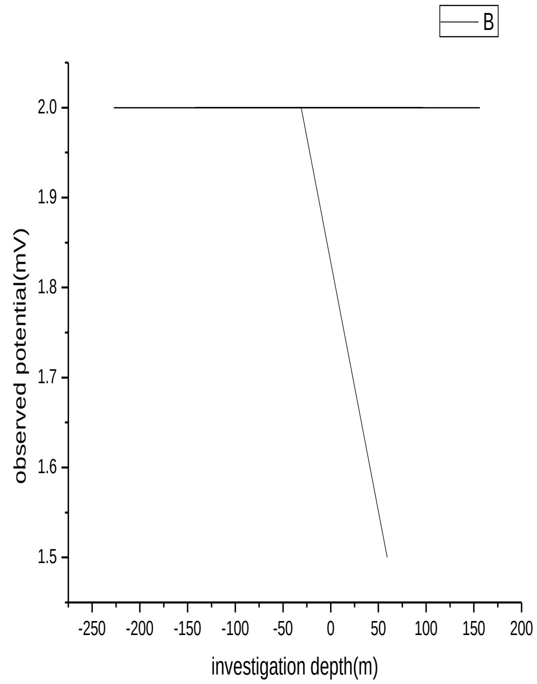

Figure 4.1 Graph of Investigation 1

Point A is the point of maximum underground water flows and point B is the approximate depth of the underground water sites, which is 45m

Table 4.1 Data Collected In Investigation Point 2

s/n	Electrode spacing (M)	Observed potential (mV)
1.	1.5	-188.0000
2.	2.0	-20.0000
3.	3.0	-66.2800
4.	4.0	-97.6000
5.	6.0	-182.0000
6.	7.0	-26.2100
7.	8.0	-47.5700
8.	10.0	-247.0000
9.	10.0	393.0000
10.	12.0	0.0827
11.	14.0	188.0000
12.	15.0	3.0870
13.	17.0	378.0000
14.	20.0	84.7200
15.	25.0	446.0000
16.	30.0	-124.0000
17.	35.0	174.0000
18.	40.0	183.0000
19.	45.0	4.5530
20.	60.0	244.0000
21.	70.0	294.0000
22.	100.0	94.8800
23.	180.0	288.0000
24.	200.0	689.0000
25.		237.0000

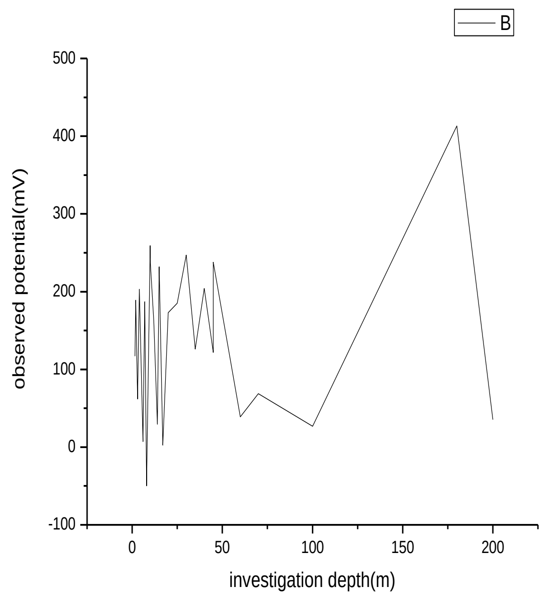

Figure 4.2 Graph of Investigation Point 2

Point a is the point of maximum underground water flows and point b is the approximate depth of the underground water sites, which is 180m

Table 4.3 Data Collected in Investigation Point 3

S/N	Electrode spacing (M)	Observed potential (mV)
1.	1.5	117.000
2.	2	189.000
3.	3	61.870
4.	4	203.000
5.	6	7.045
6.	7	187.000
7.	8	-49.820
8.	10	259.000
9.	10	241.000
10.	12	162.000
11.	14	29.360
12.	15	232.000
13.	17	2.576
14.	20	173.000
15.	25	185.000
16.	30	247.000
17.	35	126.000

18.	40	204.000
19.	45	122.000
20.	45	238.000
21.	60	38.980
22.	70	68.790
23.	100	26.860
24.	180	413.000
25.	200	35.310

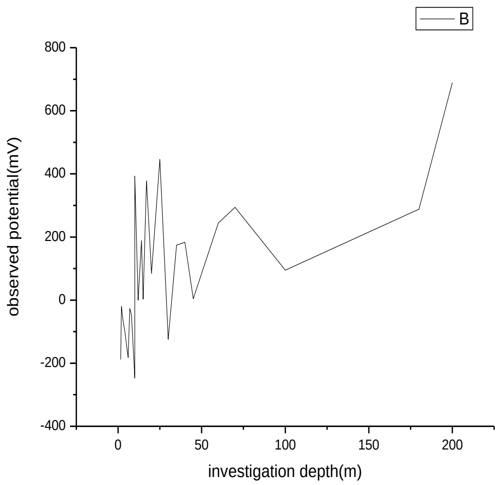

Figure 4.3 Graph of Investigation Point 3

Point a is the point of maximum underground water flows and point b is the approximate depth of the underground water sites, which is 180m

3.1 Analysis

Based on the information from the above, the first graph that is investigation point one is not good for drilling because the maximum depth of underground water sites is 45m. The second graph and third graph that is investigation point one and three because their maximum depth of underground water sites is 180m. This is because the rate of accumulations of water is highly dependent on pressure gradient and water levels to flow towards and accumulate at locations of lowest pressure gradient, consequently, more water will be found at locations two and three as they have deeper depth counting lower pressure gradient. The result showed that the borehole depth ranging from 60.0m to 70.0m depth could be recommended at location two and three.

3.2 Summary

Self-potential geophysical surveys measure the potential difference produced by small, naturally produced currents beneath the earth's surface, between any two points on the ground. The self potential method is passive, non intrusive and does not require the application of an electric current.

Self potential field's surveys are conducted by measuring electrical potential differences between pairs of electrodes that contact the surface of the earth (or water, in the water covered areas) at a number of survey stations in the area of interest.

3.3 Recommendation

Self potential method appears useful in determine the approximate depth to the water table. But, it does not lead to any information concerning the optimum well sites, so therefore, geophysicist and geoscientist should develop a means in which the method will be used to determine the optimum well sites.Furthermore, self potential method cannot detect the presences of multiple, tracked aquifers. It is only useful for the uppermost aquifer. So, geophysicist should develop a new means in which the method will be use to determine the multiple, stacked aquifers.

Self potential method requires considerable time and effort to apply using computer algorithm that is publically available. Programmers should develop software that will be used to plot and interpret self potential data effectively.

IV. CONCLUSION

Self potential method of ground water exploration is found to be very effective indicating the ground water movement or seepage along a face or over an area of investigation to collect multiple readings.

Self potential method has the advantage of measuring a property that is directly related to the ground water. That is electrical potential generated by its movement through the earth.

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