Application of Electrical Resistivity Method (ERM) for Groundwater Exploration (A Literature Study)

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Abstract - **The electrical resistivity method (ERM) has long been utilized in groundwater exploration and it is a largely used geophysical technique in various parts of the world. The electrical resistivity method is based on the principle that the electrical resistivity of a material is a function of water content. The electrical resistivity method was used to determine the depth to the water table, saturated thickness of the aquifer, and hydraulic conductivity of the aquifer. The ERM is a helpful tool for groundwater exploration because it can non-invasively measure the resistivity of subsurface materials. The electrical resistivity method has been used to map the subsurface structure of aquifers, locate groundwater resources, and monitor changes in groundwater systems.**

keywords **- ERM, Groundwater Exploration, Resistivity method & Potential zones**

I. INTRODUCTION (HEADING 1)

The electrical resistivity method is an active geophysical technique. It employs an artificial source introduced into the ground through a pair of electrodes. The procedure involved measuring the potential difference between the other two electrodes in the vicinity of the current flow. The apparent resistivity was calculated using the potential difference for the interpretation. The electrodes by which current is introduced into the ground are called Current electrodes and electrodes between which the potential difference is measured are called Potential electrodes. ERM is one of the most common and widely used geophysical survey methods. Unlike other more expensive and sophisticated methods, ERM is relatively easy to learn and use. The process begins with the acquisition of resistivity data from a subsurface formation. After the resistivity data has been acquired, it can be used to create a map or model of the subsurface. In this paper we have reviewed the ERM methods of VES and ERT.

Abbreviations and Acronyms: ERM - Electrical Resistivity Method, VES – Vertical Electrical Sounding & ERT - Electrical Resistivity Tomography

II. REVIEW OF LITERATURE

Electrical Resistivity Tomography (ERT)

2-D electrical resistivity tomography (ERT) has been extensively used for many years for groundwater exploration. The technique is employed together with drilling for determination of resistivity value of alluvium and the effect of groundwater.

The study was conducted conducted by Rosli Saad, Nawawi and Mohamad (2012) in areas which have a geology record of thick alluvium. The result show that groundwater will lower the resistivity value and silt also will bring down the resistivity value lower then groundwater effect. Groundwater reservoirs are found in saturated sand, saturated sandy clay and saturated silt, clay and sand. 2-D electrical resistivity tomography (ERT) is now mainly carried out with a multi-electrode resistivity meter system. Such surveys use a number (usually 25 to 100) of electrodes laid out in a straight line with a constant spacing. A computer-controlled system is then used to automatically select the active electrodes for each measure. The resistivity method basically measures the resistivity distribution of the subsurface materials. The resistivity value of sand is 81-257 Ωm, saturated sand is 45-75 Ωm, and silty sand is 29- 57 Ωm. Meanwhile clay resistivity value is 37-88 Ωm, silty clay is 20-69 Ωm, sandy clay is 57- 109 Ωm, and saturated sandy clay is 37-39 Ωm. Silty clay with sand shows resistivity value of 20-97 Ωm, while saturated silty clay with sand is 31-45 Ωm. Groundwater will lower the resistivity value and silt also will bring down the resistivity value lower then groundwater effect.

Groundwater investigation in a crystalline rock is a crucial task. A study was carried out by Kumar, Dewashish, et al (2016) at Choutuppal Telangana, India, under the pivotal research project of societal relevance. High-resolution electrical resistivity tomography (ERT) and time-domain-induced polarization (TDIP) dataset were collected in a granitic terrain to solve the groundwater problem as people are facing acute shortage of drinking water in the study area. The interpreted results derived from two-dimensional (2D) inverted resistivity models revealed substantial resistivity contrast between the weathered and massive granite and delineated three groundwater prospects zones, where the degree of weathering of fractured granite decreases with depth. On the other hand, the induced polarization (IP) results reflect marginal chargeability contrast, which indicates groundwater prospect zone. The basement of the hard rock aquifer system is clearly delineated showing very high resistivity with a range from 5000 to $\sim 4 \times 10^5$ Ohm.m, which is confirmed by drilling at two places. Both the wells are drilled during the month of April and June, 2013, which are productive with a yield varying from 82.14 to 105 l/min. This study may help in future planning for groundwater exploration strategy and development for groundwater resources.

Two main applications of electrical resistivity tomography (ERT) methods have been addressed covering characterization of leachate movement from a composting area of a Sugar Mill in Southern India. Good correlation has been obtained between ERT and groundwater quality assessments as well as from groundwater monitoring data sets. The study helped in conceptualization of hydrogeologic framework in basaltic terrain. Impacts on groundwater regime associated with urbanization and industrialization can easily be assessed through the variation of resistivity in the inverse resistivity pseudo-section model of the ERT investigations. Assessment of groundwater potential in an upcoming Urban Node, Greater Hyderabad city has been illustrated in the second example. Identification of good thickness of weathered regolith for location of water harvesting through Green Fingers evolved. The small infrastructure would help carrying of enhanced surface runoff as well as to sustain groundwater yield in the urban node and thereby ensuring sustainable groundwater resource exploitation. The above studies have illustrated immense potential of the ERT tools in the assessment of groundwater contamination as well as groundwater potential. Rao, G. Tamma, et al.(2014)

VERTICAL ELECTRICAL SOUNDING (VES)

Groundwater potential aquifers producing zones have been delineated through investigation conducted by the electrical resistivity survey. Weathered and fractured horizons have been identified in the study area underlying VES stations, and all of these constitute the aquifer zones. Good prospects therefore exist for groundwater development in the study area where the depth to basement is relatively thick and has favorable low resistivity, while those with thin depth to bedrock and high resistivity value have a lower potential for an aquifer. The productive groundwater potential zones are identified at the central eastern part, and as subordinately at the south western part of the study area. The electrical resistivity data therefore gives reasonably accurate results among other methods that can be used to understand the subsurface layers and basement configuration in groundwater prospecting. The study conducted by Joseph Olakunle and Coker (2014)

. Vertical Electrical Sounding (VES) was carried out at 40 sites in the study area coupled with pumping test which is conducted by Okoro, Egboka and Onwuemesi (2010). For the 40 VES measurements carried out for this research, only eight (8) locations had valuable information from previous pumping test of existing borehole for the accurate estimation of hydraulic parameters. The hydraulic conductivity Kc and transmissivity Tc data calculated from the interpreted VES data. The transmissivity Tc values calculated from the VES results range from 0.48 to 19.50m^2 /day while the equivalent obtained from pumping test vary from 1.07 to 33.74m^2 /day. The interpreted resistivity data were transformed into aquifer parameters (T) and (K) for VES locations with valuable pumping test data. The calculated aquifer parameters were consistent and well defined within the range of observed aquifer parameters obtained from pumping test. The calculated transmissivity (Tc) values vary between 0.48 to 19.50m^3 /h while the calculated hydraulic conductivity (Kc) values vary from 0.06 to 3.75m^2 /h.

The Schlumberger configuration was used in the survey conducted by Bahammou, Benamara, Ammar, Hrittta, Dakir and Bouikbane (2021). Study involves the resistivity technique of Vertical Electrical Sounding (VES) was carried out North of Ain Al Atti area, in Zaouia Jdida locality, with the aim of delineating zones not contaminated by the extension of the salinity and determining the potentiality of the existing aquifers. The measurements of apparent resistivity were collected using Molisana Apparecchiature Elettroniche (MAE) advanced geophysics instruments and were taken in twenty two VES points, along four profiles oriented N-S. The VES profiles were implanted using the Schlumberger configuration. The interpretation of the acquired data also shows the presence of small depressions that could be implicated in the storage of the infracenomanian groundwater. Furthermore, the resistivity results reveal the presence of electrical discontinuities interpreted as faults and fracture zones. These could be the preferential axes of the groundwater circulation.

A resistivity survey was carried out to study groundwater potential in Lagos State University (Faculty of Law open field) by Alabi, Bello, Ogungbe and Oyerinde (2010). They used to found the data such as depth, thickness, resistivity and sediment at which water can be obtained. The geo-electrical methods used in the survey are Vertical Electrical Sounding and Horizontal profiling, with the aim of determining which method is best used to determine groundwater potential. Four Vertical Electrical Soundings were conducted using the Schlumberger configuration and Horizontal spread covering the entire area. The VES data were subjected to an iteration software (WIN RESIST) which showed that the area is composed of top soil, clay, sandy clay and sand. The Horizontal Profiling data was also subjected to an iteration software (DIPPRO) which gave the imaging of the lateral variation in resistivity.

III. Conclusion

The ERM is a geophysical prospecting technique that can be used to delineate subsurface features, such as groundwater bearing zones. The method is based on the principle that the electrical resistivity of rocks and soils varies depending on their composition and water content. Geoelectrical imaging has shown good application in mapping the distribution of resistivity of the subsurface based on the content or otherwise of leachate from the dumpsite under study. Areas affected by the leachate could be inferred from the 2D inversion sections as well as the VES data (Ugbor et. Al (2021)

The joint application of Vertical Electrical Sounding (VES) and Electrical Resistivity Tomography (ERT) methods allowed the identification of saline domains and monitoring their evolution through time (Zarroca, Mario, et al.(2011).

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