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The Response of Electrical Resistivity Sounding Near Lignite Mine Area of Vadakuthu Village, Cuddalore District, Tamil Nadu, India

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Abstract

Four vertical electrical sounding (VES) survey was carried outin Vadakuthu area near Neyveli Lignite mine-IA, Neyveli, Cuddalore District. The main objectives of the study were to identify the electrical resistivity properties for the lignite formation, and to find out the subsurface layers and their corresponding thickness. In this study, the Schlumberger electrode configuration was used for the acquisition of VES data in the field. A total number of 4 VES stations were occupied within the tertiary of Cuddalore formation. Resistivity curve types ranging from simple H until HA and QHA curve types were identified to reflect the facies or lithological variations in the area. The outcome revealed that the resistivity value varies from 7.42 to 2630 Ohm meters and subsurface layer thicknesses varies between 1m and 56.7 m. High resistivity value observed in VES-2 and VES-3 could be attributed to the presence of lignite and the presence of laterite. Low resistivity value could be attributed to sand and sandy clay formation.

Keywords: Vertical resistivity sounding, lignite, lithology, thickness, Schlumberger configuration.

Introduction

The vertical electrical sounding technique is a resistivity method extensively used for investigation of shallow earth properties, and in the delineation of groundwater potential zone. By using this method, the subsurface characterization is determined based on the vertical change of resistivity values[1]. Geophysical methods are also found useful in assessment and monitoring of geotechnical characterization[2].

The principles of physics are applied in the science of geophysics to study the interior of the Earth. The study is done by carefully measurements at or near the outermost level of the land or sea that are governed by the internal dissemination of physical properties. Analysis of these quantities can reveal vertical and lateral variation of the physical properties of the Earth's interior[3]. The sensitivity of resistivity techniques to the variation of earth materials resistivity, it is helped in mapping of lithological units[4].

In the dry environmental condition, the resistivity of the geological materialization is very high and gradually decreased in clay materials. The presence of water containing salt in geological formation even in negligible proportional makes them reasonably conductive and once the moisture rise up, the resistivity fall considerably. The resistivity of the geological formation is inversely proportional to the increase of salinity of water[5].

The resistivities of the rock formations are influenced by the nature of material and their physical properties such as density, porosity, void space and geometry, water content and quality, and temperature[6]. The vertical electrical sounding technique is one of the most practical and easiest methods to acquire resistivity data in the field[7]. The area under study is composed of different geological formations namely recent alluvium, Cuddalore sandstone of Mio-Pliocene age and Sandstones of Eocene age[8]. The Alluvium formation consists of soils, sands, laterites and recent alluvium and is under lined by the Cuddalore sandstone of Mio-Pliocene age. The Cuddalore sandstone comprises of ferruginous sandstone, pebble bearing sandstone, and other sedimentary rocks[9].

Material and Methods

During our research work, a total number of four (4) VES stations had been established across the study area. The resistivity measurements were recorded using resistivity meter of SSR-MP-AT-ME model working under the Schlumberger electrode configuration of 400 m as maximum current electrode separation and 200 as maximum depth of resistivity information. The stored data had been transferred from the equipment into the laptop by using an USB cable, then, the data were analyzed using IPI2 WIN software. The master curves were used to interpret the field curves[11].

Results and Discussion

In the figure-1 and 2, the details about the study area and the sampling locations are illustrated whereas table-1 displays the electrical properties of the study area. The curve types obtained are H, QHA and HA. It is observed that the curve matching

technique shows three to five layer strata where the AB/2 moved up to 200m. The maximum error percentage of 9.66% was recognized in the VES-1 location. The resistivity of the study area varies from 7.42 Ohm meter to 2630 Ohm meter and layer thickness varies from 1m to 56.7m.

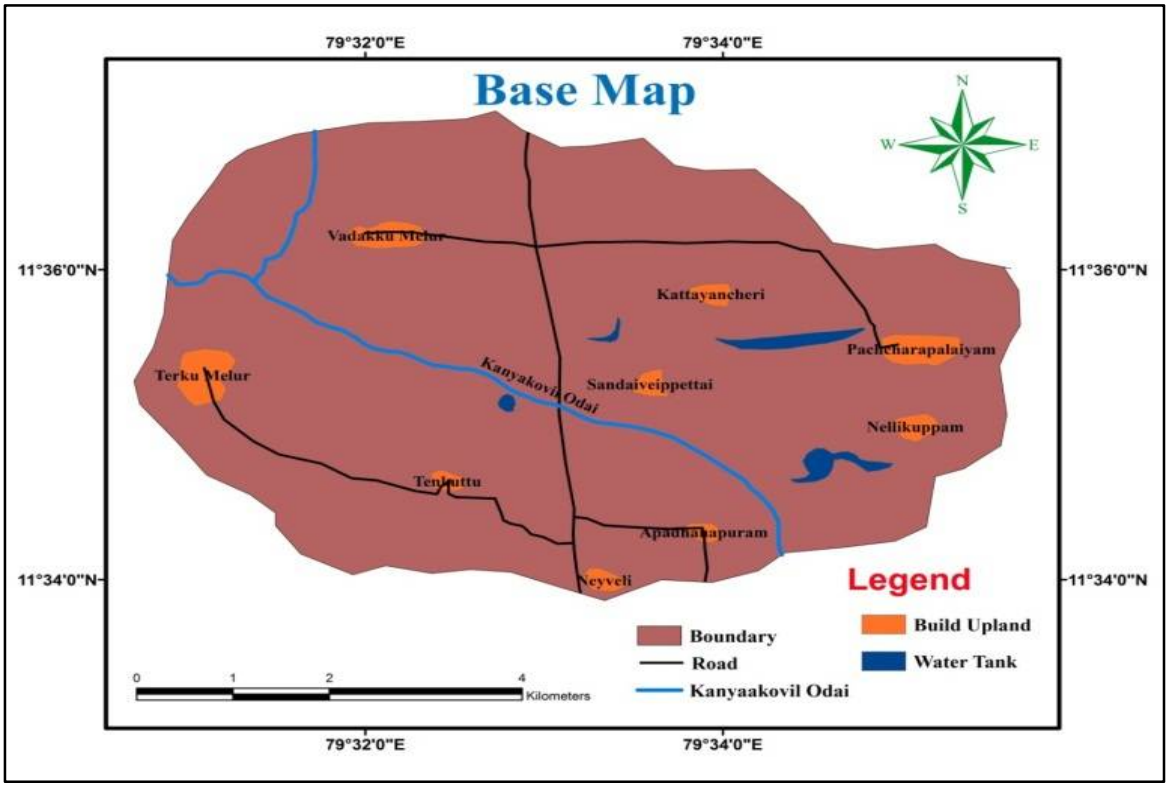


Figure-1
Base map showing the boundary of a study area

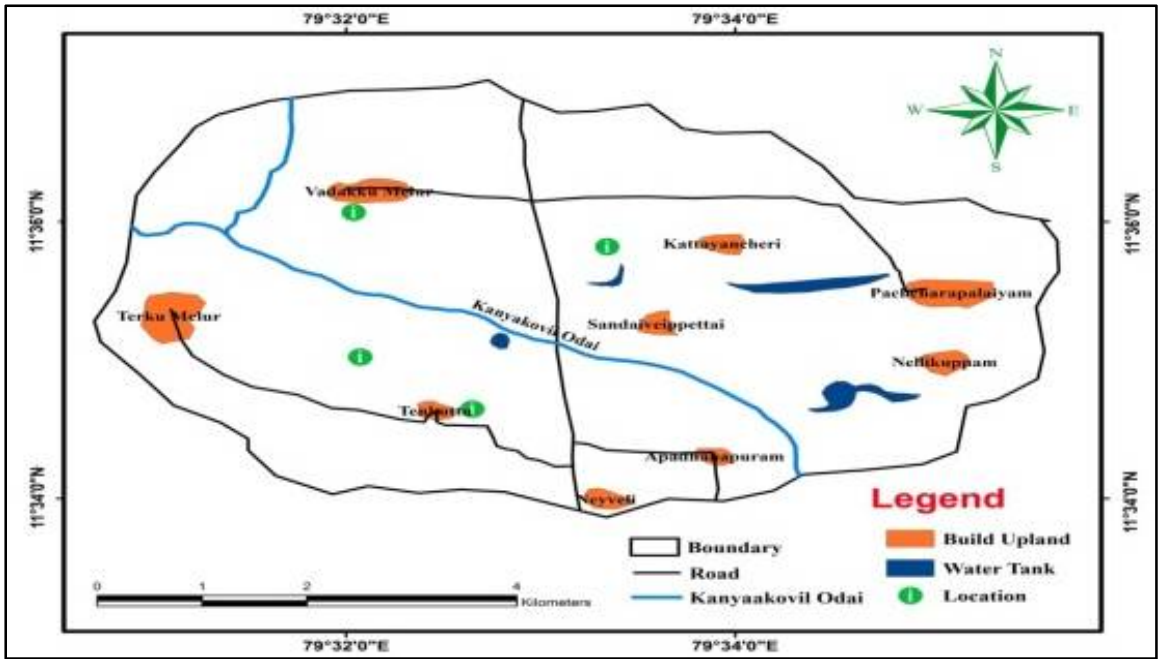


Figure-2
VES location

Table-1
Electrical resistivity and layers thickness of a study area

VES No	No. of Layers	Resistivity Value(Ohm m)	Layer thickness (m)	Error percentage	Curve Types
1	1	57.9	21.6	9.66	H
	2	11	17.3		
	2	74.9	-		
2	1	94.5	1	3.05	QHA
	2	63.8	7.42		
	3	14.6	9.44		
	4	38.3	56.7		
	5	1267	-		
3	1	54.8	3.55	2.5	HA
	2	30.9	6.01		
	3	44.6	115		
	4	3630	-		
4	1	224	4,76	2.62	H
	2	7.42	5.82		
	3	147			

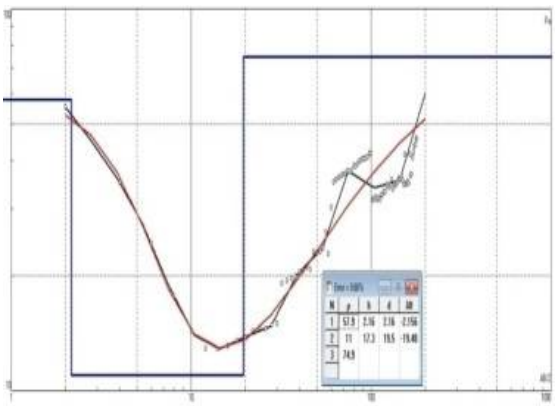
The first layer's resistivity and thickness value had been calculated as 54.8 Ohm meters to 224 Ohm meters and 1m to 21.6 m respectively. The lowest resistivity value (54.8 Ohm meters) found in first layer is seen in VES-3 and the highest resistivity value (224 Ohm meters) is found in VES-4. The smallest layer thickness had been noted in VES-2 while the highest is found in VES-1. In the first layer, the lowest and highest resistivities are due to the soil characteristics of the Cuddalore District. The presence of loamy soil in the area under study is the cause for low resistivity; the loosened dry top soil could be for high resistivity whereas in the first layer, the high resistivity is due to the presence of dry sand clay soil.

The resistivity of the second layer is found between 7.42 Ohm meters and 30.9 Ohm meters while thickness varies from 5.82 m to 17.3 m. The low resistivity value is detected in VES-4 of second layers. The resistivity of 30.9 ohm meters is found in VES-3 which is considered as the highest resistivity in the second layers. The layer thickness of 5.82 m is seen in VES- 4, whereas in VES -1, it is 17.3 m. The resistivity is low due to the existence of sandy clay formation. The lowest value of resistivity was influenced by higher percentage of cementing clay materials**.**

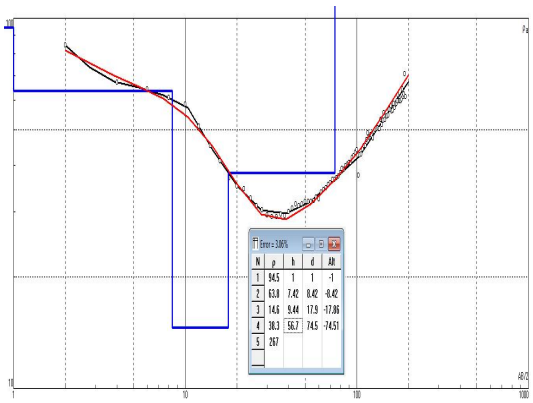
The resistivity value ranges from 14.6 Ohm meters to 147 Ohm meters is found in the third layer. The highest value is detected in VES-4 whereas the lowest is found in VES-2. The high resistivity value observed in the third layer is due to the presence of sandstone containing some fossils. The resistivity values are found low in the second layer formation in line to the occurrence of clay and the highest resistivity in the first layer is caused by the distribution of dry sand clay soil within the study area.

The fourth layer is observed only in VES-2 and VES-3. The resistivity value is found between 38.3 Ohm meter and 2630 Ohm meters. The high resistivity value observed in the fourth layer could be attributed to the presence of lignite.

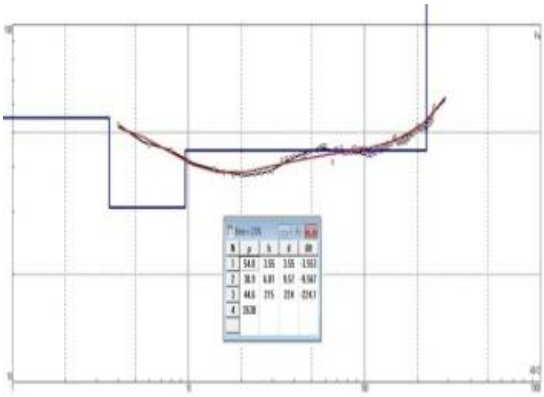
Based on knowledge of regional lithology, the sandstone formation of a study area occurs above lignite seam at a depth varying from 40 m to 140m. The lignite bed is found in between clay formations[12]. The result of VES-2 shows that the high resistivity value was observed in the fifth layer as 1267 Ohm meters. The resistivity values are found low in both third and fourth layer formations. The high resistivity value noticed in the fifth layer could be attributed to the presence of lignite. The moderate resistivity values in the remaining layers are due to sandy clay formation.



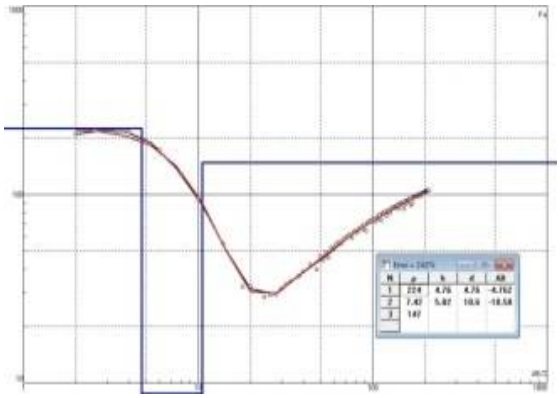
VES -1



VES-2



VES-3



VES-4

Figure-3
VES curves of a study area

Conclusion

The present study of electrical resistivity response near the lignite mine region had shown a reliable indication. The resistivity distribution obtained in the VES-2 and VES-3 match with the existing lignite seam map of the region while the values of resistivity in other VES locations did not indicate the lignite formation. Based on the knowledge of regional lithology the highest resistivity may be attributed to the lignite formation.

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