GROUNDWATER INVESTIGATION USING GEOPHYSICAL METHODS- A CASE STUDY OF PYDIBHIMAVARAM INDUSTRIAL AREA

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Abstract

A geophysical investigation involving the vertical electrical sounding (VES) electrical resistivity methods was carried out around Pydibhimavaram Industrial area Srikakulam district Andhra Pradesh. Vertical Electrical Sounding (VES) using Schlumberger array was conducted at thirteen (13) VES stations. The study was carried out with a view to determine the subsurface layer parameters (resistivity's and thicknesses) and use same to categorize the ground-water potential of the study area. The field data obtained have been analyzed using computer software (IPI2win) which gives an automatic interpretation of the apparent resistivity. The interpretation of results showed that major portion of the study area was three layer formations. A vast range of resistivities and their corresponding thicknesses were obtained. Pseudo sections and Geo-electric Sections were generated using Surfer software. The pseudo-sections revealed that the North West (NW) and South West (SW) regions are comparatively more weathered than the other parts.

Key words: *Vertical Electrical Sounding (VES), Industrial area, resistivity, Soil layers & Geo- electric sections*

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INTRODUCTION

Groundwater is a mysterious nature's hidden treasure. Its exploitation has continued to remain an important issue due to its unalloyed needs. Though there are other sources of water; streams, rivers ponds, etc., none is as hygienic as groundwater because groundwater has an excellent natural microbiological quality and generally adequate chemical quality for most uses [1]. The use of geophysics for both groundwater resource mapping and for water quality evaluations has increased dramatically over the years. The Vertical Electrical Soundings (VES) has proved very popular with groundwater studies due to simplicity of the technique. Groundwater has become immensely important for human water supply in urban and rural areas in developed and[2] Exploration of groundwater in hard rock terrain is a very challenging and difficult task when the promising groundwater zones are associated with fractured and fissured media. In this environment, the groundwater potentiality depends mainly on the thickness of the weathered/fractured layer overlying the basement [3]. The use of geophysics for engineering studies and water groundwater exploration has increased over the last few years due to the rapid advances in computer software's and associated numerical modeling solutions. The Vertical Electrical Sounding (VES) has proved very popular with groundwater prospecting and engineering investigations due to simplicity of the techniques. The electrical geophysical survey method is the detection of the surface effects produced by the flow of electric current inside the earth. The electrical techniques have been used in a wide range of geophysical investigations such as mineral exploration, engineering studies, geothermal exploration, archeological investigations, permafrost mapping and geological mapping[4]. Using this method, depth and thickness of various subsurface layers and their water yielding capabilities can be inferred. Therefore, evaluation of groundwater potential at Pydibhimavaram Industrial area was done in order to know the groundwater yielding capabilities or groundwater conditions of the study area.

LOCATION AND GEOLOGY OF THE STUDY AREA

Location

The present study involves delineation of depth of water table and groundwater potential at Pydibheemavaram, a village in Ranastalam mandal in Srikakulam district. It is 28km far from district head quarters Srikakulam. It is situated between 18.145N 83.627E and 18.099N 83.674E Latitudes and Longitude as shown in figure1.The total geographical study area is nearly 20sq.km. The total population is around 2425. The average rainfall is 1281.2mm.

GEOLOGY

About 18.78 percent of the area in the Mandal is underlain by soft rocks comprising sandstones of Gondwana systems and occupied about 4089 Km. in the central part of the Mandal. Ground water occurs in these formations under semi-confined and confined conditions [5]. In general these formations have resulted to moderate to low productive aquifers. The ground water department has constructed 5 tube wells and irrigation Development Corporation has constructed a number of log tube wells in the area.

BOUNDARIES OF STUDY AREA:

North side: ridge pint/ hills, South side : Kandivalasa River East side : Coastal belt and West side: stream

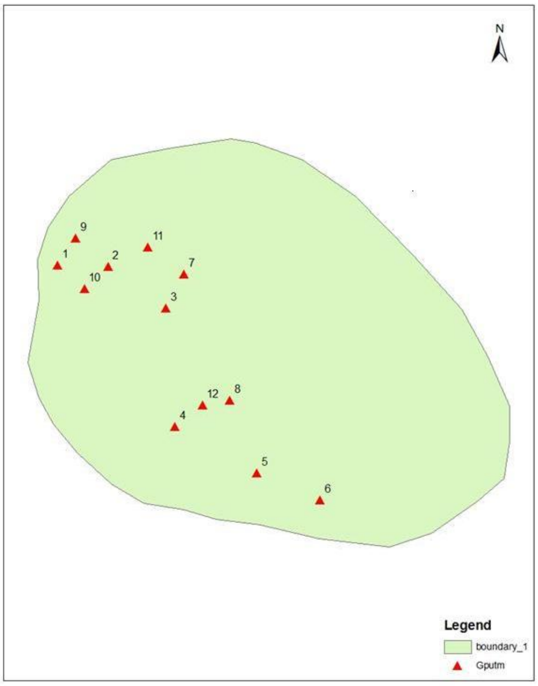

Fig.1 Study area of Pydibhimavaram

THEORY AND PRINCIPLE OF ELECTRICAL RESISTIVITY SOUNDING

Electrical resistivity techniques are based on the response of the earth to the flow of electric current. With an electrical current passed into the ground and two potential electrodes to record the resultant potential difference between them, we can obtain a direct measure of electrical impedance of the subsurface material. The resistivity of the subsurface material observed is a function of the magnitude of the current, the recorded potential difference and the geometry of the electrode array used. Measurement of resistivity is, in general, a measure of water saturation and pore space connectivity. Resistivity measurements are associated with varying depths relative to the distance between the current and potential electrodes in the survey, and can be interpreted qualitatively and quantitatively in terms of a litho logic and/or geohydrologic model of the subsurface [6].Electrical resistivity method involves the supply of direct current or low-frequency alternating current into the ground through a pair of current electrodes and the measurement of the resulting potential through another pair of electrode called potential electrodes. Rock resistivity depends on a number of factors such as the amount of water present in fractures and features, porosity and the degree of saturation. Table 1 shows the approximate resistivity ranges of some common rocks and water types in the basement complex area.

Table 1: Approximate resistivity ranges for various rock and water types in the Basement Complex area [7]

Rock type	Resistivity (Ωm)
Clay and marl	1 – 67
Topsoil	67 – 100
Clayey soil	100 – 133
Sandy Soil	670 – 1330
Limestone	67 – 1000
Sandstone	33 – 6700
Sand and gravels	100 – 180
Schist	10 – 1000
Granite	25 – 1500
Surface water (in igneous rock)	30 – 500
Groundwater (in igneous rock)	30 – 150
Weathered laterite	200 – 500
Fresh Laterite	500 – 600
Weathered/fractured basement	100 – 500
Fresh basement	>1000

RESULTS

(i) GEO-ELECTRIC SECTIONS

A visual inspection of all the geo-electric sections shows that three distinct litho logical units could be identified by the field mapping. A brief description of the two geo-electric sections obtained is as follows:

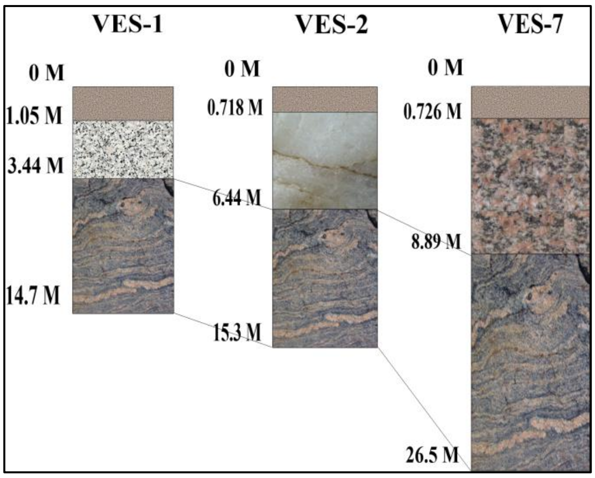

Fig 2 Geo-electric Section normal to coast

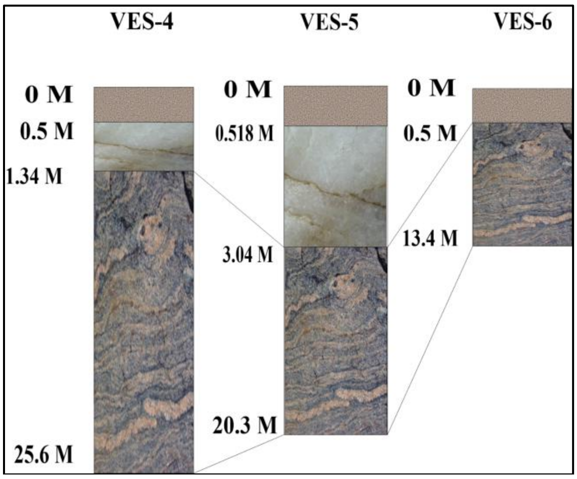

Fig.3 Geo-electric Section Parallel to River

GEO-ELECTRIC SECTION PERPENDICULARS TO COASTAL BELT

This consists of VESs 1,2&7 as shown in Figure 3. It is acquired Perpendiculars to coast direction (see Figure 1) and consists of three geo-electric layers. The first layer, the topsoil is characterized by layer with resistivity values from 13.7 to 34.9 Ohm.m and its thickness is between 0.718 to 1.05m. The second layer underneath VESs 1 is suggestive of weathered granite and the remaining two VES 2&6 are Weathered or fractured Khondolite with resistivities ranging from 12.2 to 10.4 Ohm.m. The thicknesses vary from 6.44 to 8.16m. The third layer for all the VESs is Hard rock or electrical basement [8]. The resistivity ranging from 6.49 to 7.85 Ohm.m. The thicknesses vary from 6.44 to 17.7m

GEO-ELECTRIC SECTION PARALLEL TO KANDIVALASA RIVER

It comprises of three VES points (i.e. VES 4, 5&6) acquired approximately parallel to Kandivalasa river direction. The geo-electric section reveals three to three geo-electric layers (see Figure 4). The first layer, topsoil, is composed of Dry Sandy, Silt/Clayey having resistivity values ranging from 14.9 to 37.8 Ohm.m with thicknesses of 0.5 to 0.518m. The second layer beneath VESs 4, 5, and 6 is composed of Weathered or fractured Khondolitewith resistivity values ranging from 6.61 to 13.9 Ohm.m and layer thicknesses in the range of 1.38 to 13.3 m. The third layer for the VESs points 4&5having semi weathered gneiss and resistivity ranging from 12.5 to 17.9 Ohm.m. VESs points 6 having semi weathered gneiss overlying the hard rock, resistivity is 78.3 Ohm.m The thicknesses is infinity.

(ii) PSEUDO-SECTIONS:

Pseudo sections have been generated for the VES profiles. Points which are collinear or roughly collinear are considered for generating a Pseudo Section so as to portray the variation of resistivity across the points considered in a profile.

Profile 1: Locations 4, 5, 6 are considered for generating a pseudo-section as they are collinear. At Station-5 (L-5 in Fig.4) the low resistivity zone is partly sandwiched in between layers of high resistivity. The anomaly begins at Station-4 and extends to Station-5 which indicates the possible existence of weathered material. By augmenting the geological reference of the study area the zone can be inferred as alluvial deposit. This low resistivity anomaly extends further into the Station-6 which has a gradual increment in the resistivity values as one ascends downwards. At greater depths the resistivity value is inexplicably high indicating rock strata.

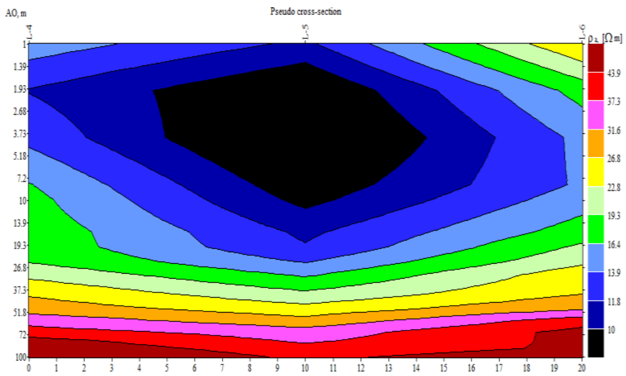

Fig.4 Profile -1 Pseudo Section of 4, 5, 6

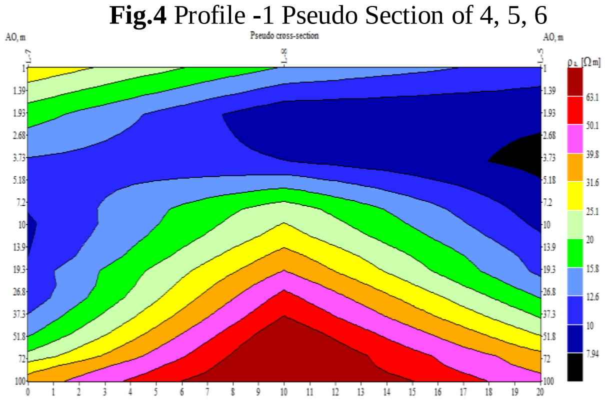

Fig.5 . Profile -2 Pseudo Section of 7, 8, 5

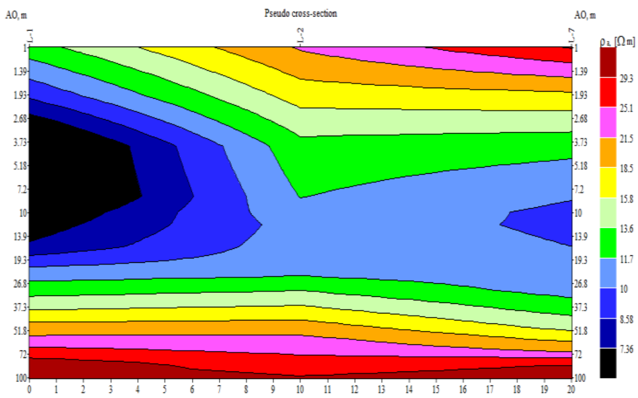

Fig.6. Profile -5 Pseudo Section of 1, 2, 7

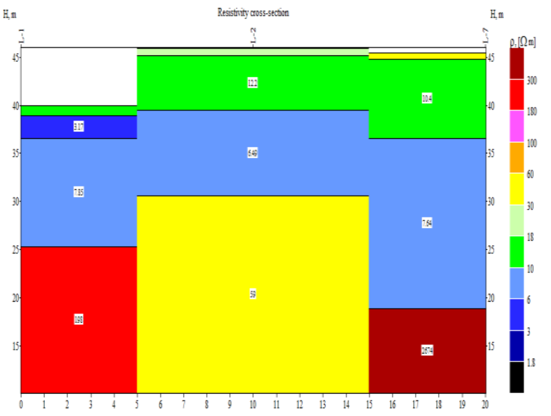

Fig.7 Profile 1, Resistivity Section of 1, 2, 7

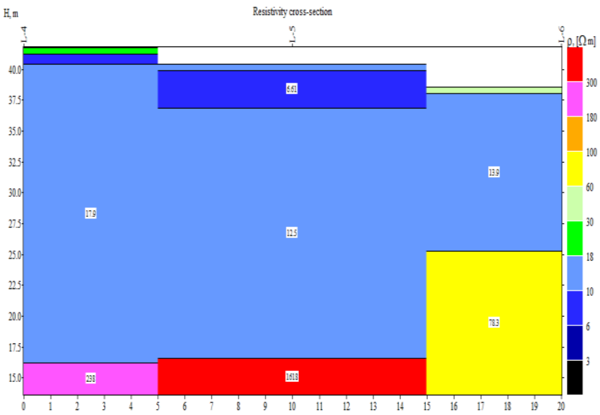

Fig.8.Profile 2 Resistivity Section of 4, 5, 6

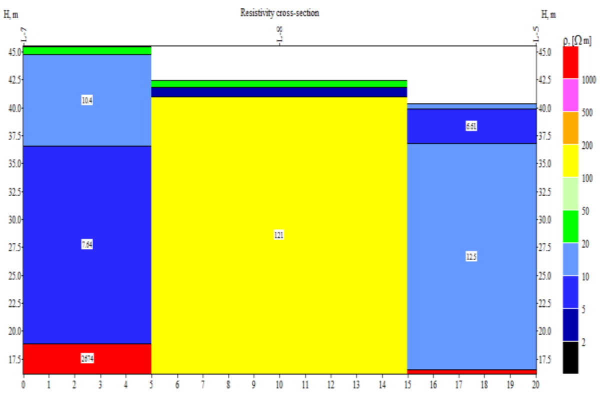

Fig.9 Profile 2Resistivity Section of 7, 8, 5

Locations 4, 5, 6 are considered for generating a pseudo-section as they are collinear. At Station-5 (L-5 in Fig.4) the low resistivity zone is partly sandwiched in between layers of high resistivity. The anomaly begins at Station-4 and extends to Station-5 which indicates the possible existence of weathered material. By augmenting the geological reference of the study area the zone can be inferred as alluvial deposit. This low resistivity anomaly extends further into the Station-6 which has a gradual increment in the resistivity values as one ascends downwards. At greater depths the resistivity value is inexplicably high indicating rock strata.

Profile 2: Locations 7, 8, 5 are considered for this pseudo - section show in fig 5. Evidently, at Station-7 (from Fig.5) the trend in resistivity is increasing at the top layers and decreases as one ascends downwards. But again at higher depths the anomaly is increasing. The resistivity values suddenly increase from a marginal range of 10 to 15 ohm-meter to a range of 20 to 25 ohm-meters at a depth of 60 meters. This indicates a sudden change in the layers leading to denser strata. Much of the portion has the same loose deposit extending greater depths and hence the low resistivity anomaly is sandwiched between two layers of high resistivity. These loose sediment depositories could preferably be Alluvium and Lacustrine deposits which can be inferred from the geology of the study area. These are possible zones of aquifer existence.

Profile 3 : Stations 1, 2, 7 are considered for the Pseudo Section as shown in fig.6. The Pseudo-Section for the points 1, 2 and 7 has a different trend than that of the others. Exactly under Station-1 (fig.6) the resistivity values are haphazard in variation. Prominently the low resistivity zones lie in the range of 1metre to 25metres.Wherin the case of Station points 2 and 7 the resistivity profiles can be juxtaposed in comparison. There's a mild visible difference and the low resistivity anomaly continues from Station point 1 to Station point 7 throughout in a similar fashion.

The southernmost region of the profile has highly resistive material which could be composed of hard rock formations. The highly weathered low resistivity zone is sandwiched in between the high resistive layers.

(iii) RESISTIVITY SECTIONS

Resistivity sections are generated for the same Stations for which pseudo sections have been generated.

Profile 1: Stations 1, 2, 7 have been chosen for generating the section shown in fig.7. Clearly the resistivity trends initially increase, then decrease and again show a steep increase, which marks the occurrence of hard strata at the very deeper layers or partially weathered and poorly weathered strata.The layers having low resistivity imply less dense or loose strata in these regions.

Profile 2: Stations 4, 5, 6 are considered for generating a Resistivity Section of the above profile shown in fig.8.Below Station 4, the resistivity values are moderate with a sudden decrease at greater depths. The low resistivity anomaly is sandwiched between high resistivity layers. It extends horizontally throughout the profile.

Profile 3: Stations 7, 8, 5 are considered for this section as shown in fig.9.At Station-8 (fig.9) the resistivity gradually increases and remains constant throughout the depth of the strata. This shows partially weathered rock which may or may not serve as a ground water prospective zone. Further, as one goes to Station-5 the low resistivity anomaly is persistent which repeats itself at Station-7. These may serve as ground water prospective zones as these low resistivity zones are a possible result of good weathering action.

CONCLUSION

In this study, electrical resistivity method using VES survey was carried out at thirteen locations in the study area using the Schlumberger electrode array with a view to understand the subsurface geologic settings that could guide the successful exploration of groundwater. Analysis of the interpreted results revealed the nature and composition of the subsurface lithologic units. Pseudo-sections and resistivity-sections were generated. Both low and high resistivity anomalies have been demarcated in pseudo-section and resistivity sections. Majority of the VES curves are 'H' type with multi layered geo-electrical sections. From the pseudo-sections it may be revealed that the NW and SW regions are comparatively more weathered than the other parts. Prominent low resistivity anomaly has been exhibited in all the pseudo-section profile (with an exception of Profile 5) indicating more weathered nature of the formation.

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