Surface Geo-Electrical Sounding for the Determination of Aquifer Characteristics in part of the Palar Sub-Basin, Tamilnadu, India

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ABSTRACT

A resistivity survey was carried out to study the groundwater potential in Palar Sub-Basin Walajabad Block, Tamilnadu, India, such as resistivity, depth and thickness by which water can be obtained. The geo-electrical methods used in the survey are Vertical Electrical Sounding (VES) with the aim of determining groundwater potential area. The 110 VES points were conducted using the Schlumberger Configuration in the entire study area. The instrument used is ABEM Terrameter SAS 1000. The VES data were interpreted using IX1Dv2 software which showed that the area is composed of top soil, clay, sandy clay, sand gravel, weathered genies, jointed genies and massive charnockite. The curves are prominently of A, Q, K and H type indicating the presence of three layers followed by combination of curves AK, KH, HK, HA, QH, AA, AH and KA indicating the four layers followed by combination of curves KHA, HKH, KQH, AKH, KHK, HKQ and AAK indicating the presence of five layers sub-surface layers. Interpretation reveals the number of subsurface layers, their thickness and their water bearing capacity within the study area. The best layer which acts as the good aquifer of Walajabad block is the H type and H Combination type occur in the study area except hard rock terrain. H type curve indicate the good aquifer in the study area. The resistivity varying from 0.565 Ωm to 39174.4 Ωm and thickness from 0.105 m to 94.91 m.

Keywords: Vertical Electrical Sounding, Resistivity, Thickness, Depth, Type Curve, Groundwater and Aquifer.

INTRODUCTION

The electrical resistivity technique involves the measurement of the apparent resistivity of soils and rock as a function of depth or position. The most common electrical technique needed in hydrogeologic and environmental investigations is vertical electrical soundings (resistivity sounding). During resistivity surveys, current is injected into the each through a pair of current electrodes, and the potential difference is measured between a pair of current electrodes, and the potential electrodes. The bulk average resistivity of all soils and rock influencing the current. It is calculated by dividing the measured potential difference by the input current and multiplying by a geometric factor specific to the array being used and electrode spacing (AAA Zohdy, 1974).

In a resistivity sounding the distance between the current electrodes and the potential electrodes is systematically increased, thereby yielding information on subsurface resistivity from successively greater depth. The variation of resistivity with the depth is modeled using forward and inverse modeling computer software. The vertical sounding method was chosen for this study because the instrument is simple, field logistics are easy and straight forward while the analysis of data is less tedious and economical (A.N.Amadi, 2012). It also has capability to distinguish between saturated and unsaturated layers.

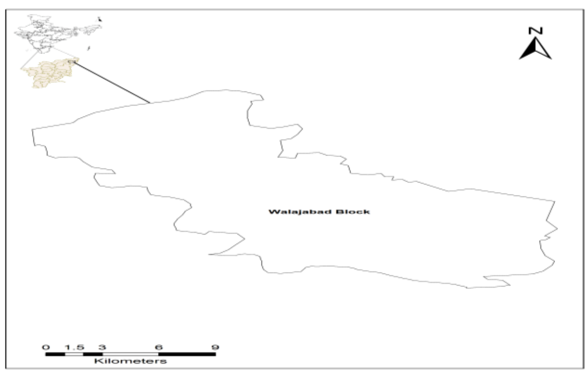
In a resistivity sounding the distance between the current electrodes and the potential electrodes is systematically increased, thereby yielding information on subsurface resistivity from successively greater depth. The variation of resistivity with the depth is modeled using forward and inverse modeling computer software. The Schlumberger method has a greater penetration than the Wenner. In resistivity method, Wenner configuration discriminates between resistivities of different geoelectric lateral layers while the Schlumberger configuration is used for the depth layers (J.A.Olowofela, 2005). Geoelectric method is regularly used in determination of depth, thickness and boundary of an aquifer (G.O. Omosuyi, 2007, M.I. Ismailmohamaden, 2005)in determination of groundwater potential (J.O.Oseji et.al. 2005). The investigation of alluvial aquifers with large resistivity contacts by Gnanasundar D and Elango L, 1999, Identification of the presence and location of a leachate plume, delineation of the groundwater potential aquifers and vulnerability of aquifer contamination by A.I Opera, 2012 . Geo-electrical techniques provide an alternative method for acquiring hydraulic parameters and processes data in order to adequately characterize flow in hard rock aquifers (M.O.K'orowe, 2012) Resistivity value in sedimentary rocks are also controlled by parameters such as water contents, salinity, texture, matrix conductivity and the presence of clay materials (C.N. Nwankwo and G.O.Emujakporue, 2012).

The objective of this research paper is to find useful information on subsurface hydrogeological conditions of the study area such as aquifer resistivity, aquifer thickness, depth and groundwater quality at Palar Basin, Walajabad Block by using Vertical Electrical Sounding.

STUDY AREA

In this research project the study area selected is Walajabad block of Kancheepuram District, Palar sub basin. As per Groundwater Estimating Committee (GEC), 2009 the Walajabad block has been categorized as overexploited block. Palar river is the major river draining across the district from West to East, and the river is a seasonal in nature. As the surface water drying on, the groundwater has become the main source for irrigation and drinking water sectors. The study area is predominantly underlain by hard rocks, sedimentary and alluvium deposits and hence because of heterogeneity in geological formation a suitable methodology is required to identify groundwater potential zones. The areal extent of the study area is 325 Km^2 and lies between the geopgraphical co-ordinates of Latitude 13˚14'12" - 12˚15'38"and Longitude 79˚30'37" and 80˚30'42".

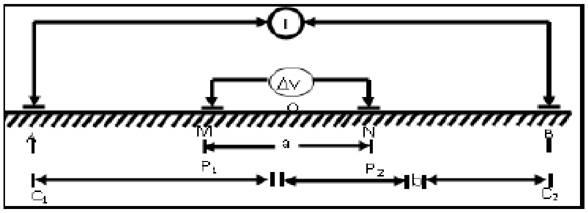
Figure.1. Study Area Map



MATERIALS AND METHODS

The resistivity technique examines horizontal and vertical discontinuities in the electrical properties of the ground. It measures earth resistivity by passing an electrical current into the ground and measuring the resulting potentials created. This method involves the supply of direct current or low-frequency alternating current into the ground through a pair of electrodes and the measurement of the resulting potential through another pair of electrodes (potential electrodes) (AAA Zohdy et.al. 1974). Because the current is known and the potential can be measured an apparent resistivity can be calculated. The apparent resistivity of the subsurface material is a function of the magnitude of the current, the recorded potential difference and the geometry of the electrode array used. The current electrodes spacing (AB) increases after each reading while the potential electrodes spacing (MN) increases only when deemed necessary and controlled by the relation $AB/2 \geq 5MN/2$ as required by the Schlumberger array. For Schlumberger soundings (Fig. 2). This survey used ABEM SAS 1000 Terrameter, Sweden. Then, the sounding curves were interpreted to determine the apparent resistivity and thicknesses of the subsurface layers. Interpretation was used with IX1Dv2 software.

Figure.2. Schlumberger Sounding Or Vertical Electrical Sounding (VES)



A total number of 110 Vertical Electrical Sounding (VES) points were carried out in the Walajabad block at Kancheepuram in Tamilnadu, India. The maximum of outer current electrode spacing is 200 m. Then the inner potential electrode maximum spacing is 10 m. The apparent resistivity data are associated with varying depths relative to the distance between the current and potential electrodes and can be interpreted qualitatively and quantitatively in terms of a lithologic and/or geohydrologic model. In the qualitative interpretation method the shape of the field curve is observed to assess the number of layers and their resistivity. In the quantitative interpretation method true resistivity 'ρ' and layer thickness 'h' as the fundamental characteristics of a geoelectric layer are obtained. The quantitative interpretation of VES curves in this study was done by the well–known method of curves matching. In curves matching technique, the field VES curves are compared with set of theoretical curves to obtain 'ρ' and 'h' (M.Mathizhagan et.al 2012 & 2013).

RESULTS AND DISCUSSION

Qualitative interpretation of VES curves: For qualitative interpretation method, the shape of the field curve is observed to assess the number of layers and their resistivity. It gives information about the number of layers with their continuity through area and reflects the degree of homogeneity or heterogeneity of an individual layer. Figure 3, 4 and 5 shows examples of resistivity sounding curves in the study area with three, four and five layers respectively. In this study area, three geological formations namely alluvium, sedimentary and hard rock are present. Totally, 110 Vertical Electrical Sounding (VES) points have been covered with 25, 58 and 27 points respectively. Alluvium occurs in the north and south end of the study area. Hard rock followed by south side alluvium formation towards north. Then sedimentary followed by north side alluvium formation towards south. These soundings are characterized by relatively high resistivity values in the first layer (AB~8m) reflecting dry zone for the entire study area. But the difference are clear in the second and third layer (AB > 8m) reflecting the groundwater on the geophysical parameters (resistivity) as the variation in the depths of the layers and their nature.

The form of the geoelectrical sounding curves throughout the study area are considerably of the types A, Q, K, H, AK, KH, HK, HA, QH, AA, AH, KA, KHA, HKH, KQH, AKH, KHK, HKQ and AAK. The interpretive models for each VES station as well as the percentage relative Root Mean Square (RMS) errors which provide quantitative assessment on the quality of the interpretation method the RMS error ranges from 3.33% to 16.56 %.

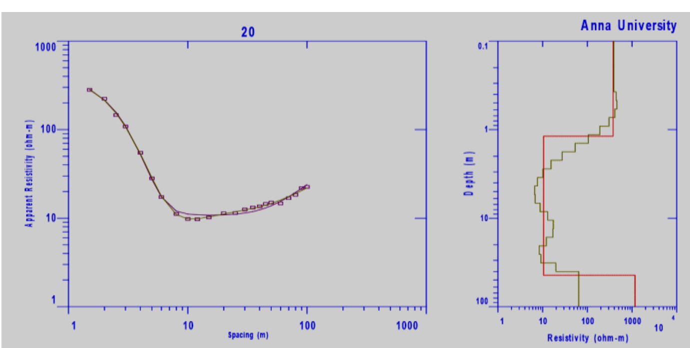


Figure.3. Geophysical interpretation results for three

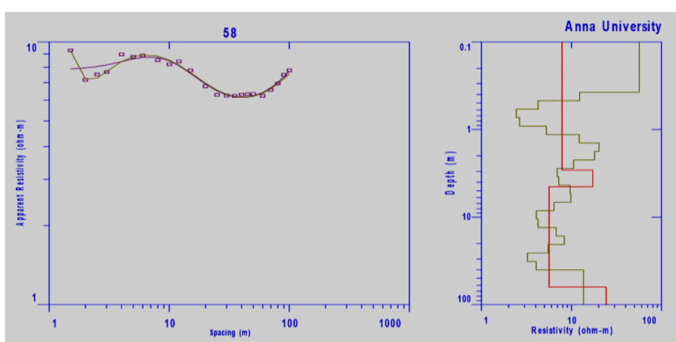


Figure.4. Geophysical interpretation results for four

layers curve **layers curve**

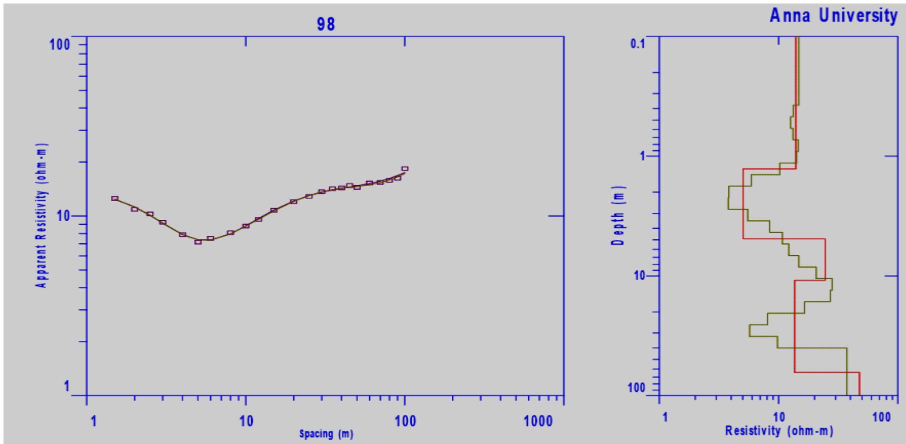


Figure.5. Geophysical interpretation results for five layers curve

Generally in northern and southern sides, 10 different curves of alluvium nature occur i.e. H, Q, A, HA, QH, HA, KH, AK, HK and KQH. Different curves reflect the heterogeneous nature of the study area. In the northern alluvial formation three layers curves of H, Q and A types and four layers of QH, HA, KH, AK, HK types and KQH the five layer curves occur. Hard rock formation with 11 different curves occur i.e. A, K, AK, AA, KA, HK, KH, HA, HKH, KHK and AKH. It also clearly indicates the heterogeneities nature of the hard rock formation. In this formation three layer A and K types; four layers AK, AA, KA, HK, KH and HA types; five layers HKH, KHK and AKH types occur. In sedimentary formation with 11 different curves occur i.e. H, A, HK, AA, HA, KH, HKQ, KHK, AAK, KHA and HKH. It also clearly indicates heterogeneities of the sedimentary formation. In this formation three layer H and A types; four layers HK, AA, HA and KH types; five layer curve HKQ, KHK, AAK and HKH types occur.

Quantitative interpretation: The VES curves were also interpreted quantitatively though from a purely theoretical view point to delineate the subsurface succession of the geoelectric layer in the study area. The results of the data analysis show that the area under investigation can generally be interpreted as a three, four and five layered region down to the depth of investigation main features of each of the layers is as follows.

Alluvium formation: Five layers are occurring in the alluvium formation with the resistivity of the surface layer ranging between 5.17 Ωm to 2219.5 Ωm and are typically indicative of dry layer (alluvium and clay soil) with top soil variation. This layer reaches a maximum 4.73 m thickness at VES 38 and about minimum 0.44 m at VES 45. Depth variation ranges from 0.44 m to 4.73 m. Second layer is characterized by relatively low resistivity values of 2.64 Ωm to 380306.2 Ωm. This layer is shallow and is unconfined aquifer with weathered/sandy clay. The thickness of this layer varies greatly from one locality to another with its maximum thickness of 46.04 m as recorded at VES 38 and its minimum thickness 0.0236 m at VES 37. Depth variation ranges from 0.819 m to 50.78 m. Third layer is characterized by relatively low resistivity values of 15.95 Ωm to 3334.2 Ωm. This is confined aquifer with Weathered Genesis/Sandy clay/Jointed Genesis. The thickness of this layer varies with its maximum 94.91 m thickness at VES 63 and about minimum 2.24 m at VES 37. Depth variation ranges from 3.06 m to 99.29 m. Fourth layer is characterized by relatively low resistivity values 10.27 Ωm to 386.2 Ωm. This is confined aquifer with Weathered Genesis/Jointed Genesis/Massive Charnockite. The thickness of this layer varies from 42.37 m to ∞. Depth variation ranges from 45.44 m to ∞. The resistivity of 5th layer ranges from 1325.5 Ωm was interpreted as Jointed Genesis/Massive Charnockite.

Hard Rock formation: There are five layers in the hard rock formation with first layer having resistivity variation from 2.31 Ωm to 251.1 Ωm. They are typically indicative of dry layer (clay/sandy clay soil) with top soil variation. This layer reaches a maximum 5.22 m thickness at VES 23 and about minimum 0.42 m at VES 6. Depth variation ranges from 0.42 m to 5.22 m. Second layer is characterized by relatively low resistivity values of 0.565 Ωm to 1755.4

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Ωm. This layer is shallow and is unconfined aquifer with weathered/highly weathered Genesis. The thickness of this layer varies greatly from one locality to another with its maximum thickness 44.62 m as recorded at VES 23 and its minimum thickness 0.245 at VES 41. Depth variation ranges from 0.689 m to 49.84 m. Third layer is characterized by relatively low resistivity values of 2.83 Ωm to 22088.9 Ωm. This is confined aquifer with Weathered Genesis/Jointed Charnockite. The thickness of this layer varies its maximum 75.6 m thickness at VES 59 and about minimum 0.112 m at VES 41. Depth variation ranges from 5.05 m to 79.32 m. Fourth layer is characterized by relatively low resistivity values 29.08 Ωm to 35476.3 Ωm. This is confined aquifer with Weathered Genesis/Jointed Genesis/Massive Charnockite. The thickness of this layer varies its maximum 67.56 m thickness at VES 30 and about minimum 11.32 m at VES 62. Depth variation ranges from 18.37 m to 78.58 m. The resistivity of fifth layer ranges from 75.98 Ωm to 4835.6 Ωm was interpreted as Jointed Genesis/Massive Charnockite.

Sedimentary formation: There are five layers occurred in the sedimentary formation with the resistivity of the surface layer ranges between 1.8 Ωm to 945.8 Ωm and are typically indicative of dry layer (clay/sandy clay soil) with top soil variation. This layer reaches a maximum 4.92 m thickness at VES 10 and about minimum 0.424 m at VES 11. Depth variation ranges from 0.424 m to 4.92 m. Second layer is characterized by relatively low resistivity values of 4.35 Ωm to 1737.2 Ωm. This layer is shallow and is unconfined aquifer with sandy clay/clayey sand. The thickness of this layer varies greatly from one locality to another with its maximum thickness 43.04 m as recorded at VES 20 and its minimum thickness 0.123 m at VES 99. Depth variation ranges from 1.74 m to 44.22 m. Third layer is characterized by relatively low resistivity values of 3.3 Ωm to 3763.2 Ωm. This is confined aquifer with Sandy Clay/Clayey Sand/Sand Gravel/shale. The thickness of this layer varies its maximum 72.74 m thickness at VES 9 and about minimum 1.45 m at VES 11. Depth variation ranges from 4.69 m to 83.6 m. Fourth layer is characterized by relatively low resistivity values of 7.03 Ωm to 1046 Ωm. This is confined aquifer with Sandy Clay/Sand Gravel/Boulders. The thickness of this layer varies its maximum 92.17 m thickness at VES 11 and about minimum 28.33 m at VES 107. Depth variation ranges from 37.9 m to 97.95 m. The resistivity of fifth layer ranges from 4.82 Ωm to 39174.4 Ωm was interpreted as Boulders.

The above fig.6. Geophysical survey locations with cross section map. There are four cross section plotted i.e. AA' BB' CC' and DD'. In the AA' cross section comes under South Alluvium formation, BB' cross section comes under Hard rock formation, CC' cross section comes under Sedimentary formation and DD' comes under North Alluvium formation. This cross section shows the South Alluvium formation fig.7. It is shows the five layer cross section map. First layer is top soil followed by fine sand for the second layer that is maximum occur in the VES 38 (Palayasevaramapuram) at 52 m and VES 44 (Vengudi) at 45 m depth and it is very good aquifer. The third layer is Highhly weathered rock its hold in more water area. It is fall on VES 39 (Sankarampuram), VES 42 (Pulliyampakkam), VES 43(Walajabad) and VES 47 (Villivalam). Fourth layer is Jointed Charnockite rock It is fall on VES 45(Kelaottivakkam) and VES 48 (Nayakenpatai). And last layer Massive charnockite.

This cross section shows the Hard Rock formation fig.8. It is shows the five layer cross section map. First layer is top soil followed by clay for the second layer that is maximum occur in the VES 52 (Kaliyanor) at 5 m and VES 25 (Uthukadu) at 1 m depth. The third layer is Weahered Gneiss its hold in more water area. It is fall on VES 52 (Kaliyanor), VES 61 (Neikuppam). Fourth layer is Jointed/Fracture Charnockite rock It is fall on VES 61 (Kelaottivakkam) and VES 25 (Uthukadu) it is maixmum 75 m thickness. And last layer Massive charnockite it is very near by ground surface at VES 70 (Kattavakkam). This cross section shows the Sedimantary formation fig.9. It is shows the five layer cross section map. First layer is top soil followed by clay for the second layer that is maximum occur in the VES 8 (Alappakam) at 20 m and VES 73 (Vedal) at 8 m depth. The third layer is Sandy Clay/Clayey Sandy its hold in more water area. It is fall on VES 19 (Rajakulam), VES 13 (Singadivakam), VES 11 (Athivakkam) and VES 8(Alappakam) these area wide thickness of this layer. Fourth layer is sandy gravel It is fall on VES 73 (Vedal) and it is maixmum 45 m thickness. And last layer Boulders.

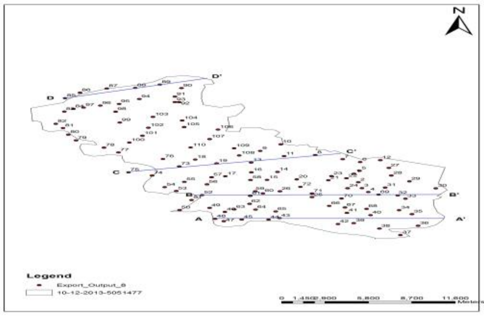


Figure.6.Geophysical survey locations with cross section map

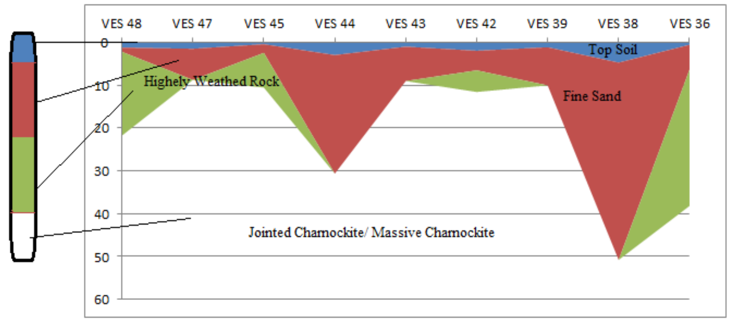


Figure.7. Shows the cross section AA'

Figure.8. Shows the cross section BB'

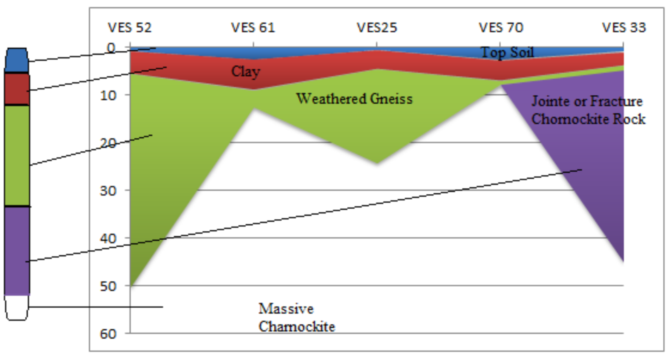


Figure.9. Shows the cross section CC'

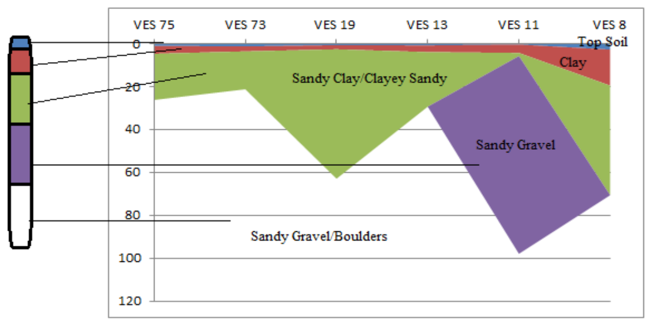
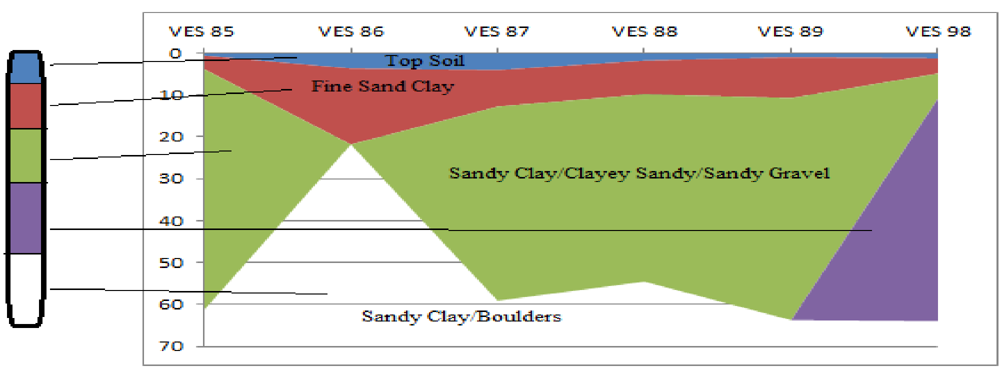


Figure.10. Shows the cross section DD'



This cross section shows the North Alluvium formation fig.10. It is shows the four layer cross section map. First layer is top soil followed by Fine Sand/Clay for the second layer that is maximum occur in the VES 86 (Pullalur) at 30 m and VES 98 (Samanthipuram) at 8 m depth. The third layer is Sandy Sandy Clay/Clayey Sandy/Sandy Gravel its hold in more water area. It is fall on VES 85 (Palur), VES 87 (Pullalur), VES 88 (Thandalam), VES 89 (Purisai) and VES 98 (Samanthipuram) these area wide thickness of third layer. And last layer Boulders it is occur VES 86 (Pullalur) near to another area.

CONCULSION

In qualitative interpretation clearly indicate the heterogenetic of the entire study area. In predominantly H type and H combination type curve occur in the study area except hard rock terrain. H type curve indicate the good aquifers in the study area. But H type curve is very less in hard rock terrain. In hard rock area, mostly A type and A combination type curve occur. This indicates hard rock. K type and K combination type curve indicate aquitard of the two aquifers. Then last one Q type and Q combination type curve indicate clay or salinity of the subsurface aquifer.

In quantitive interpretation most of the points have the good aquifer thickness and have good quality of bearing the water. Northen side of alluvium aquifer thickness maximum 85.88 m VES 90 at Purisai and minimum thickness 41.53 m VES 83 at Govindavadiagaram. Southern side of alluvium aquifer thickness maximum 94.91 m VES 63 at Bossivakkam and minimum thickness 46.4 m VES 38 at Palayasevarampuram. Hard rock terrain of aquifer thickness maximum 75.6 m VES 59 at Puthagaram and minimum thickness 44.62 m VES 23 at Thenneri Tank. Sedimentary formation aquifer thickness maximum 92.7 m VES 11 at Athivakkam and minimum thickness 43.04 m VES 20 at Sinnivakkam.

The best layer which acts as the good aquifer of Walajabad block is the H type and H Combination type occur in the study area except hard rock terrain. H type curve indicate the good aquifer in 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.

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