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SEAWATER INTRUSION - FRESHWATER SHALLOW AQUIFER IN COASTAL REGION OF CUDDALORE DISTRICT, TAMILNADU

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Abstract - *In the long coastal line of India, the coastal line of Tamilnadu is located at southeast coast of Bay of Bengal and Indian Ocean. This coastal line extends from Thiruvallur to Kanniyakumari district and holds about 13 districts along the coastline. The rapid urbanization and industrialization along the seashore have increased the water demand and causes over exploitation of the groundwater. The rapid depletion of groundwater, shrimp farm and aqua culture activities resulted in the seawater intrusion in the freshwater aquifer. Therefore, preventing and conserving of the groundwater aquifer has become the essential action. This study deals with the assessment of salinity intrusion in freshwater aquifer by means of geophysical investigation and borehole lithology data at the coastal zone of Parangepettai block which covers the area in the southeastern coast of Cuddalore district, Tamilnadu. The geophysical investigation was carried by of electrical resistivity tomography survey to identify the subsurface layer along with their resistivity values which provides the pseudo section. Finally, by referring to the geophysical resistivity ERT profiles and the lithology data were used to identify the seawater intrusion. The interference seawater in freshwater was discussed and concluded to recommend the remedial measures in order to prevent the extend salinity intrusion in the freshwater aquifer.*

Keywords - Coastal zone, Seawater intrusion, Electrical resistivity Tomography

I. INTRODUCTION

Water is the major source for all the living beings and their for life like agriculture and drinking. But the qualityand characteristics of the water was damaged due to over exploitation, urbanization, industrial waste etc. Sea water intrusion is a major problem all over the world. While investing the salinity intrusion, the flow pattern of salinity distribution and groundwater is necessary.

A. Sea Water Contamination in Ground Water

Figure-1 indicates a typical sample of a normally good ground water, slightly contaminated ground water and sea water. Temporary increase of TDS may lead to

misconception of salt water contamination REVELLE (1941). The interaction between sea-level rise and seawater intrusion can be calculated by the Ghyben–Herzberg relationship (sharp-interface model). This relationship states that the depth of the interface, below the mean sea level, is equal to 40 times the height of the potentiometric surface above the mean sea level

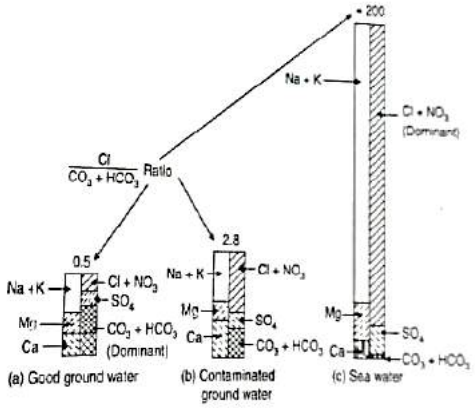


Fig 1: Sea water contamination

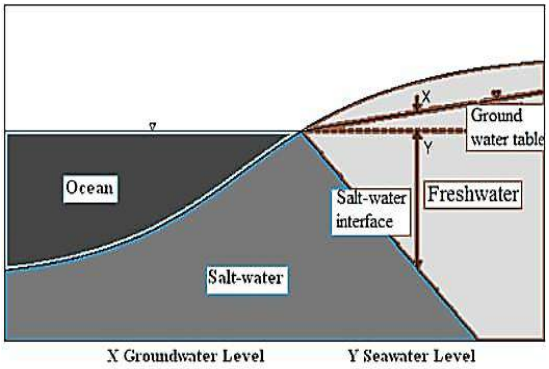


Fig 2: Ghyben- Herzberg relation

B. Need for the Study

Salinity intrusion is a major problem in the coastal areas around the world.The coastal zone of Parangepettai block is already under the constant threat of salinity.This study is intended to identify the sea water intrusion in the freshwater aquifer.This study also attempts to quantify the impact of salinity in groundwater and recommend the possible remedies to address the problem.

C. Objectives of the Study

- *To identify the lithology*
- *To identify the salinity intrusion by resistivity method.*
- *To assess the relationship between the lithology and geophysical*
- *To determine the extent of the salinity intrusion.*

II. STUDY AREA

LOCATION (PARANGIPETTAI BLOCK)

Parangipettai is known as PORTNOVO (a Dutch Team). Parangipettai refers to a town of white inhabitants, the Europeans. Parangipettai block is located at 11o 56' and 11o41'latitude(N) and at of 79o 65' and 790 83' longitude(E). The total geographical area of the block is 22898 ha with a coastal line of 24 km. the boundaries of the block include Bay of Bengal on the east, Keerapalayam and Bhuvanagiri on the west, Kurinjipadi on the north and Kumaratchi on the south. There are two major, medium or even minor industrial units in the block. So, the block is industrially backward. The ancient place called Thiruvetkulam (now being called Tiruvakkulam) and the present Annamalainagar are located near the block. The chola built town Chidambaram (Nataraja Temple) is located 21Km away from the block headquarters. The world-famous Mangrove forests of Pichavaram and the Annamalai University Marine Biology Research station are located in the parangipettai block. The Mangrove forests of Pichavaram attract Tourists from far and near.

From the figure 4, the geology of the Parangipettai is clearly understood. The study area contains about 70% of fluvio marine sediment/ shale and silt in the places of Thillaividangan, Pinnathur, Sithalapadi,Melthirukazhipalai,Nakkaravanthangudi, Chidambaramthanpettai, and Najaimahathuvalkai. Totally, 20 percent of the study area like Killai and Kelthirukazhipalai hold marine sediment and beach sand. Up to 5 percent of the area is covered by silt and the region of Pallipadai holds small percent of alluvium soil.

From, the figure of geomorphology of the study area, it is identified that the Parangipettai region mostly contains coastal plain and flood plain. The coastal plain has the threat of seawater intrusion problem. So, we can study the area and predict the seawater intrusion in the study area. The villages like Thillaividangan, Pinnathur, Nakkaravanthangudi, Chidambaramthanpettai, Najaimahathuvalkai. Kumaramagalam, Kanakkarapattu, Pichavaram fall under coastal plain areas. The villages like Melthirukazhipalai, Sithalapadi and Kelthirukazhipali fall under alluvial plain areas and Nanjaimahathuvalkai is categorized as flood plain.

From the figure 6, the landuse and landcover of Parangipettai region is understood. The land in Parangipettai is mostly used for agricultural activities. The villages like Thillaividangan, Pinnathur, Sithalapadi, Kumaramangalam, Melthirukazhipalai and Nanjaimahathuvalkai lands are used for agricultural activities. The areas Killai, Pichavaram and Keelthirukazhipalai contain water bodies. The study area also holds forest region which is mostly covered with mangrove forest. The Parangipettai holds some built- up area in very smaller percentage. The yellow shade indicates the wetlands of the Parangipettai area.

From the figure 7, it is identified that the soil of Parangipettai is classified into 3 categories like entisols, inceptisols and vertisols. Entisols is formed in the coastal region of study area. The places like Killai, Pichavaram, and Keelthirukazhipali contain the entisols and the inner part of the study area like Thillaividangan and Kanakkarapattu are formed with inceptisols and the outer side of the Parangipettai region contains vertisols.

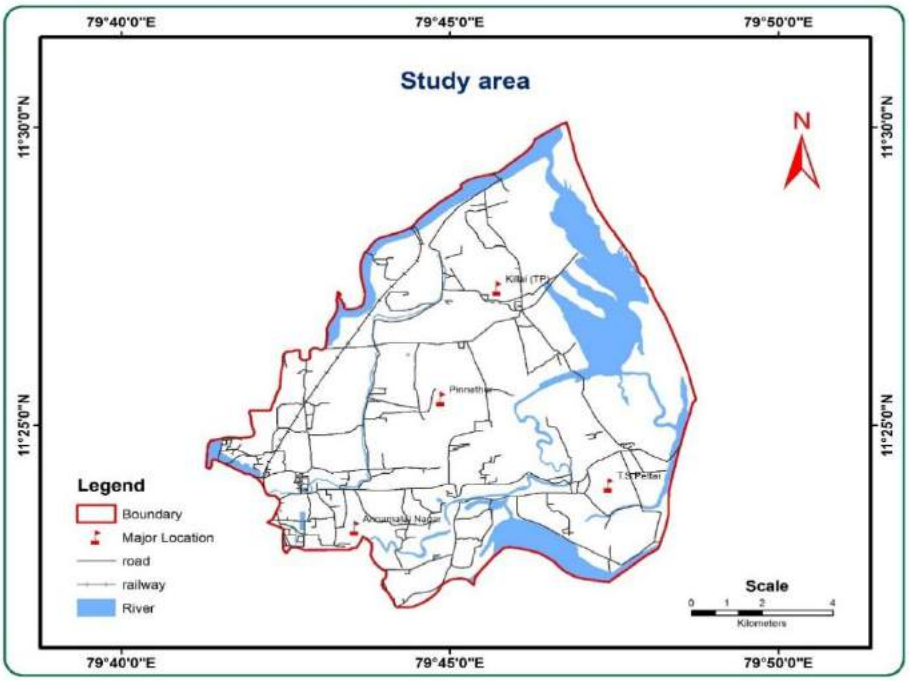


Fig 3: Study area map of Parangipettai region

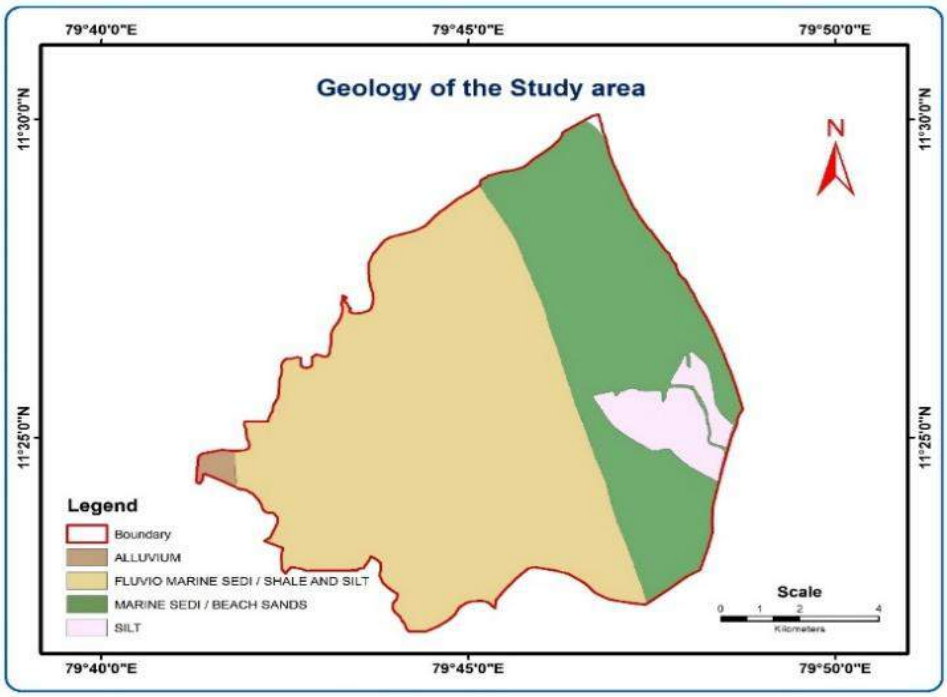


Fig 4: Geology map of study area

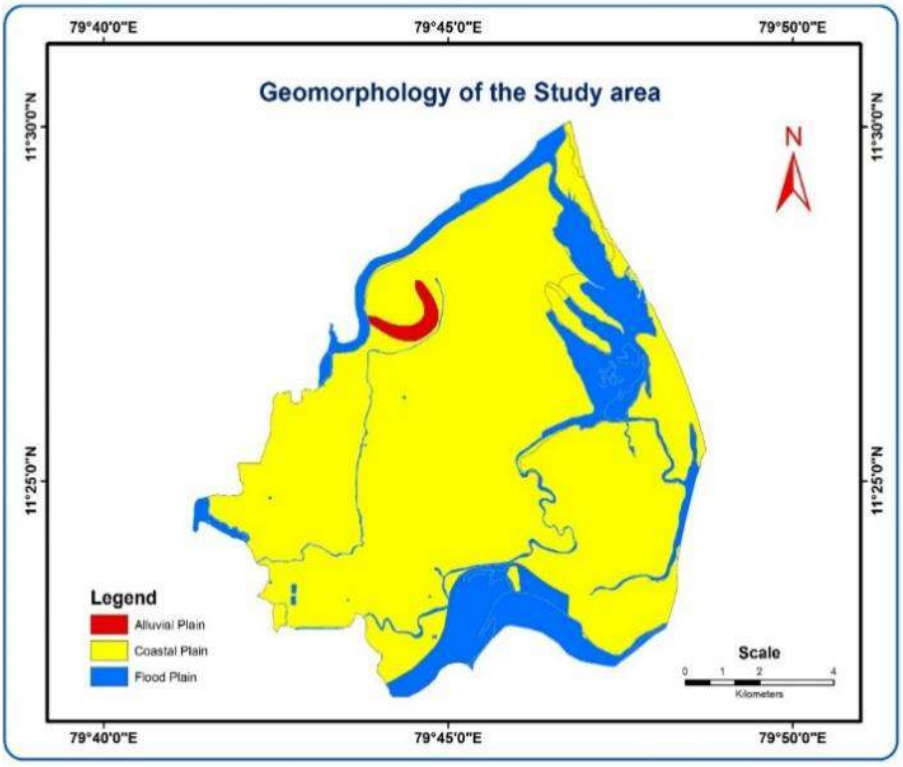


Fig 5: Geomorphology map of study area

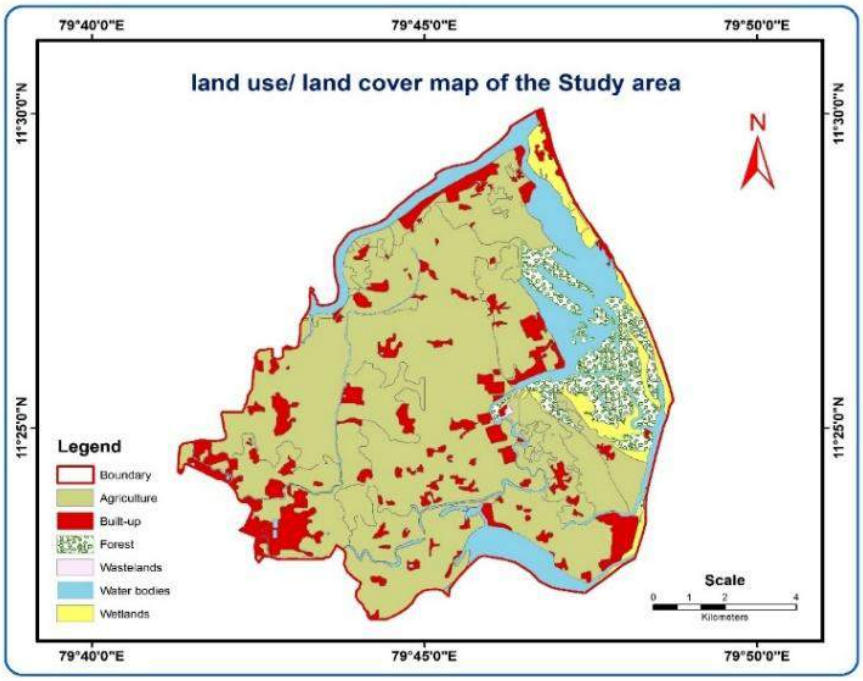


Fig 6: land use/land cover map of the study area

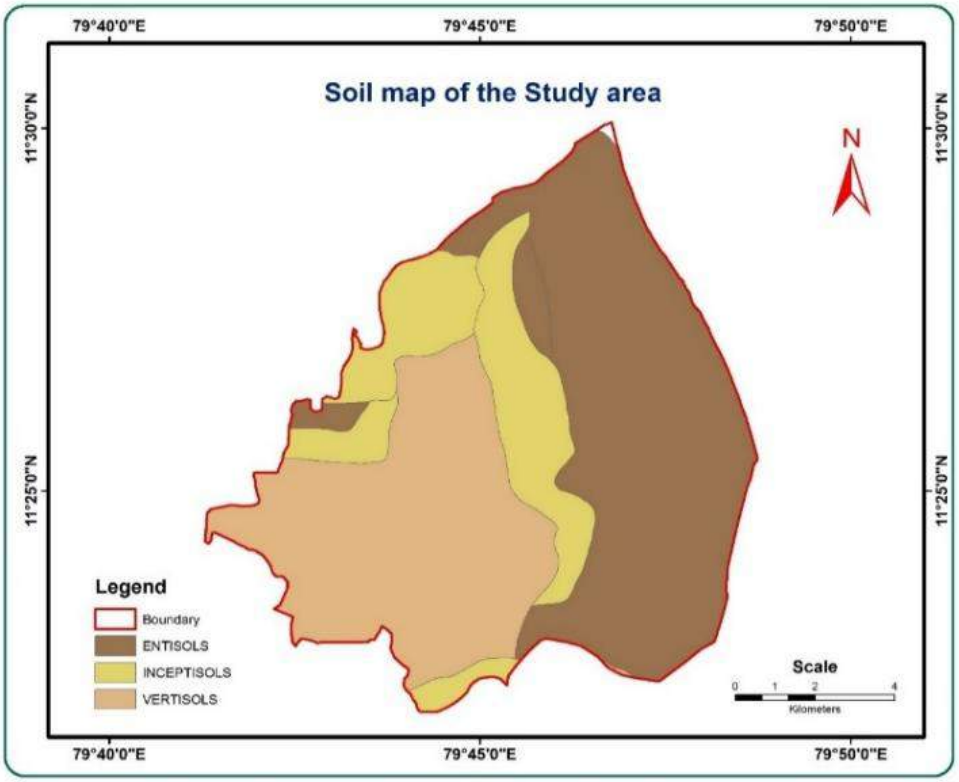


Fig 7: Soil map of the study area

III. METHODOLOGY

Electrical Resistivity Tomography (ERT)

The ERT method was used to identify the characteristics of the subsoil layers with their resistivity valueMulti- electrode resistivity survey is the useful technique for profiling and sounding which involve a number of electrodes with a fixed inter electrode spacing. The multi-electrode survey gives thehorizontal (lateral) and vertical subsurface soil characteristics. The multi-electrode resistivity imaging system IRIS SYSCAL pro-96 was uded. The multi-core cable is used along with the instrument which supports the 5m maximum inter-electrode spacing.

The survey was done to the total length of 88 to 128m which can give result for the depth up to 12.5 to 26m. The survey was totally taken at 6 locations. The survey was conducted in the locations of Sithalapadi, Keelthirukazhipalai, T.Spettai, Pinnathur, Killai and Pichavaram.

In order to create the pseudo section, the RES2D.INV inversion program was applied to convert the measured apparent resistivity to true resistivity. The multi-electrode resistivity imaging system was used for data acquisition along with the IRIS syscal switch resistivity meter. The data inversion was calculated with the least squares inversion method Finally, we received the three sections namely measured and calculated apparent resistivity pseudo sections and inverse model resistivity section.

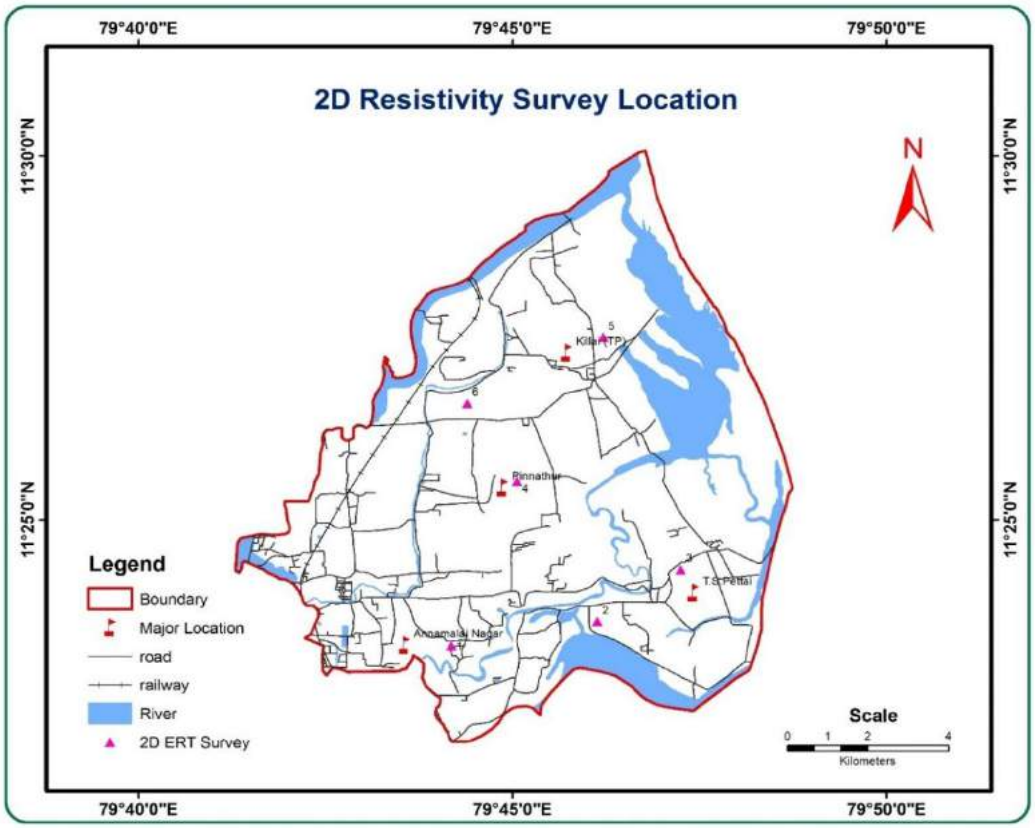


Fig 8: Resistivity survey location map

IV. RESULTS AND DISCUSSIONS

A. Geophysical Investigation

The multi-electrode tomography survey was carried out in 6 locations of Parangipettai region. The profile 1 indicates the pseudo-section of Sithalapadi location. Figure:9 (profile1), shows the subsoil characteristics along with the resistivity value are obtained. The RMS error was about 7.7 The top- layer, up to the depth of 2.70m, showing a low-resistivity value of about 1 to 2 ohm-m indicates in-situ salinity. The second level, up to the depth of 5.37m, shows the resistivity value 5.4ohm-m. The third level, about 10.5m depth contains the resistivity value which was varying from 17.3 to 30.2ohm-m. and at the fourth level, there is drop in resistivity value of 5.64ohm-m up to the depth of 12.5m. From the profile 1, the top layer of Sithalapadi location has the influence of sea water intrusion.

The Figure-10 (profile 2) indicates the pseudo-section of keelthirukazhipalai region. The survey was carried out up to the length of 88m which could give the results for the depth of 12.5m. The RMS error value is about 2.6%. The pseudo section was classified into 2 level on the basis of depth. The top level from the depth 0.500m to 5.37m, shows the resistivity value varies from 10.6 to 67.4 ohm-m. The second level, to the depth of 12.5m, shows the low resistivity value below 1ohm-m indicates the in-situ salinity.

The Figure-3 (profile 3) indicates the pseudo- section of T.S Pettai. The survey was carried out at a length of 88m with 2m inter electrode spacing up to the depth of 12.5m. The RMS error is about 5.2% and the inner electrode spacing is about 2m. The pseudo-section of T.S Pettai showing the low-resistivity value below1ohm-m indicates the in-situ salinity.

The ERT profile 4 (Figure:12) shows the pseudo-section of Pinnathur region. The survey was carried out for a length of 88m and to the depth of 12.5m. the RMS error is about 8.9% and the inner electrode spacing is about 2m. The pseudo-section was classified into 3 level. The top level up to the depth of 5.37m, showing the low resistivity value below 2ohm.m, indicates the presence of salt water. The second level, which is up to the depth of 8.60m, shows the resistivity value 89.2 to 621ohm-m. The third level, was the depth of 12.5m, showing the greater resistivity value of about 4325 to 30110 ohm-m, indicates the presence of hard bed-rock or granite. Finally, the pseudo-section of Pinnathur, the top level affected by salinity intrusion was determined.

The ERT profile 5 (Figure-13) shows the pseudo section of coastal region of Parangipettai block. The survey was carried to the length of 88m to depth of 12.5m. The RMS error is about 1.84%.and the inner electrode spacing is about 2m. For the analysis purpose, the pseudo section was classified into two sections on the basis of length. The first section, up to the length of about 48m, showing the resistivity value 1.05 to 2.47 ohm-m, indicates the slightly in-situ salinity. And the second section up to the length of 88m, showing the low resistivity value below 1 ohm-m indicates the presence of salt water.

The ERT profile 6 (Figure:14) represents the pseudo-section of Pichavarm region of Parangipettai block. The survey was carried out to the length of 164m and to the depth of 25.9m. The RMS error was about 3.3% and the inner electrode spacing was about 3m. The pseudo-section was classified into 3 levels on the basis of depth. The top level, up to the depth of 4.06m shows the resistivity value 24.3ohm-m, the second level, up to the depth of 8.06m, shows the resistivity value of 6.16 ohm and the third level, up to the depth of 25.9m, shows the low resistivity value of 0.786ohm-m which is below 1 ohm-m indicating the in-situ salinity i.e. the sea water intrusion happened.

B. Lithological Investigation

For the assessment of sea water intrusion, the lithology investigation was carried out in three locations namely Sithalapadi, T.S Pettai and Pichavaram. The available borehole lithology has been used to correlate with the ERT pseudo section for the better identification of salinity. The comparative data analyses of the borehole log data and the geoelectrical profile data accomplishes the objective (Hadlur, et al.2010).

1. Profile 1 versus B1

The pseudo-section was compared with the lithology of Sithalapadi. The correlation between the ERT profile 1 and B1 shows a good deal. The resistivity, up to the depth of 5.37m of 5.64ohm-m, represents the presence of fine sand. The resistivity of 30.2ohm-m is due to the medium sand and shells to the depth of 12m. Further, the drop in the resistivity was related to the presence of very fine sand.

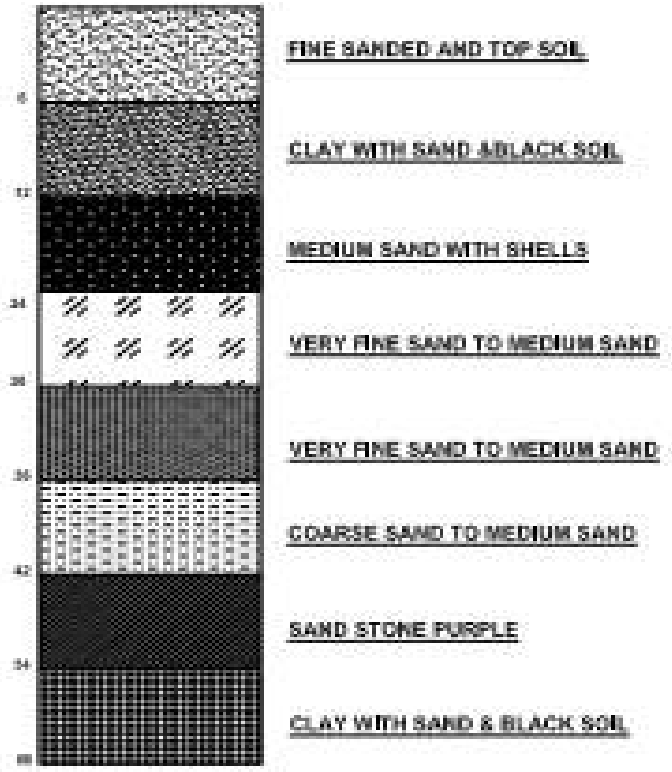
2. Profile 3 versus B2

The ERT pseudo-section of T.S Pettai indicating the very low resistivity of below 1ohm-m represents the clay formation and the presence of fine sand, which strongly confirms the presence of salt water.

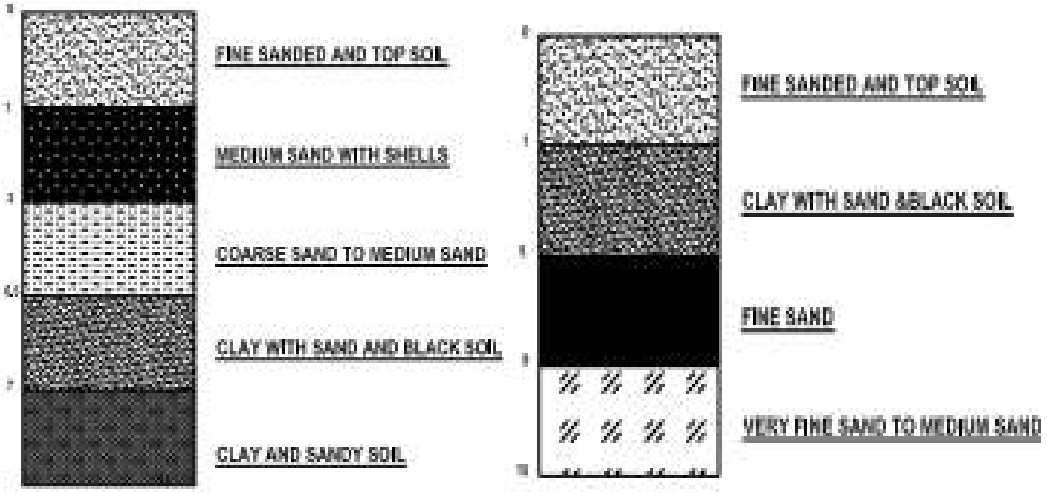
3. Profile 6 versus B3

There is a great agreement between the ERT pseudo-section and the borehole lithology. Here, the borehole data play a useful tool for the identification of SWI. The ERT section showing the resistivity of 24.3ohm-m to the depth 5 m is the indication of coarse sand and shells. The presence of clay formation is confirmed with the resistivity value of 0.786 ohm-m.

B1



B2 **B3**



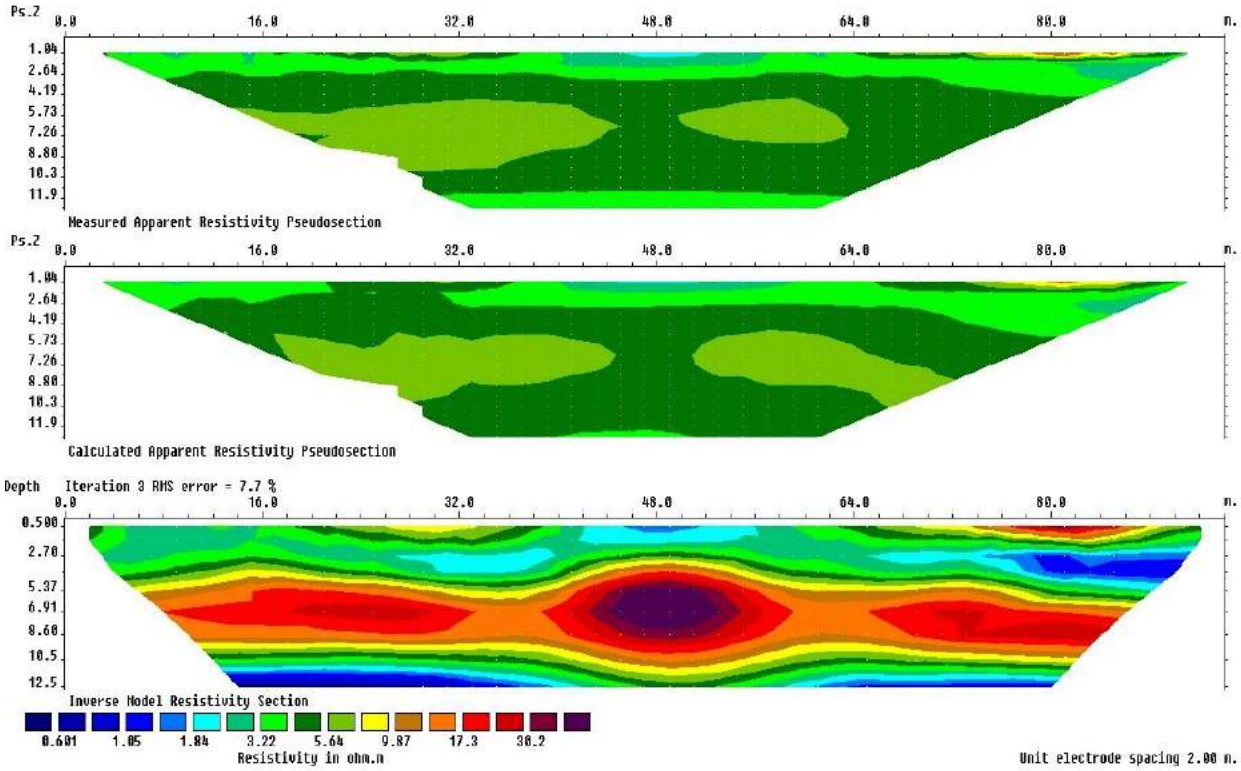


Fig: 9 pseudo-section (profile1) of Sithalapadi

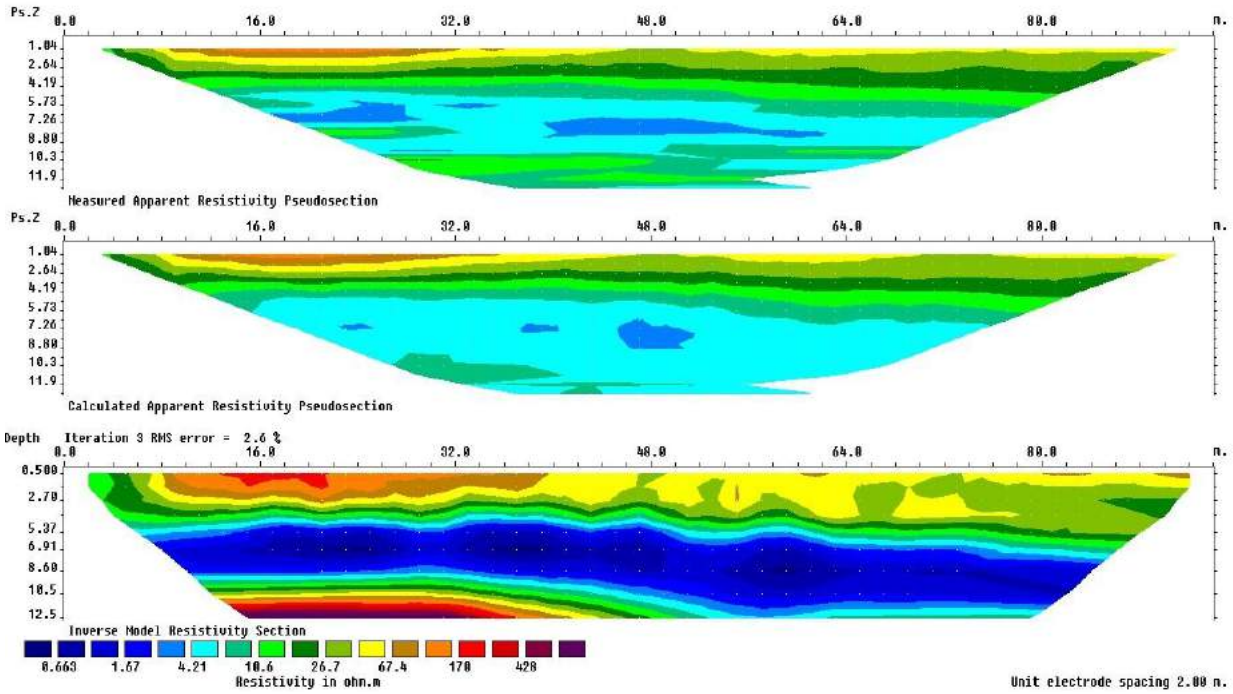


Fig:10 pseudo-section (profile2) of Keelthirukazhipalai

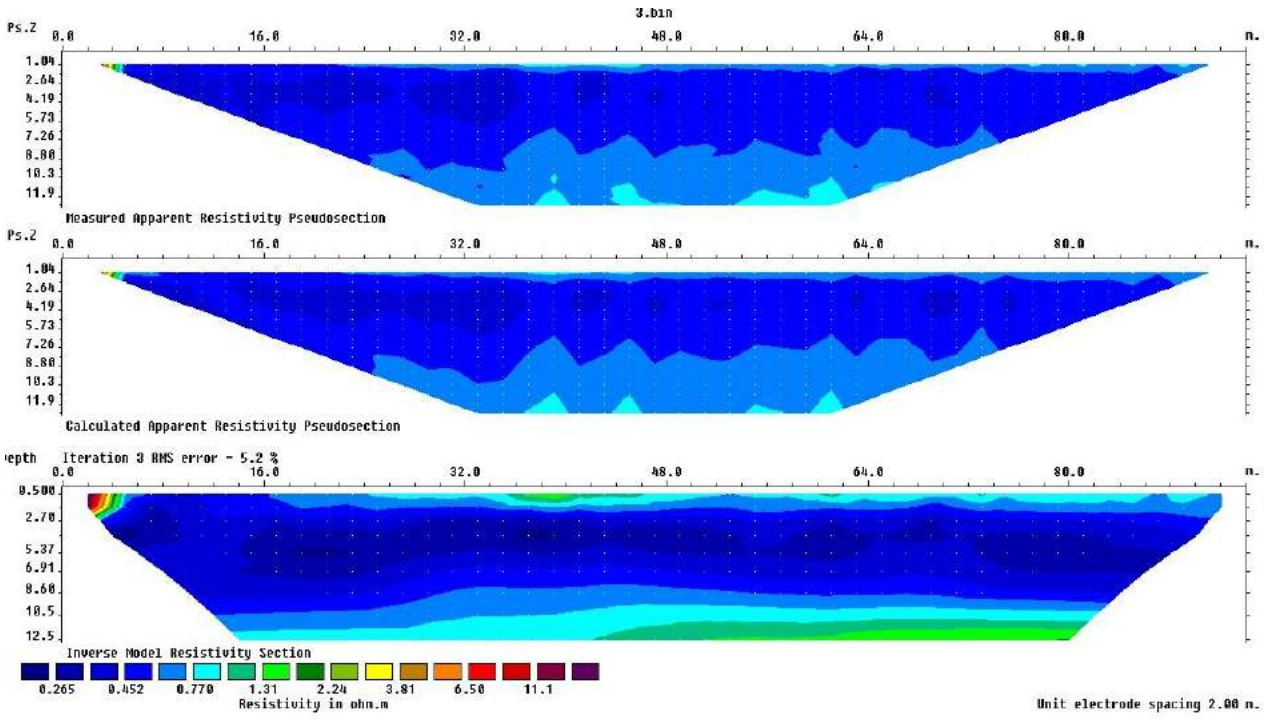


Fig :11 pseudo-section (profile3) of T.S Pettai

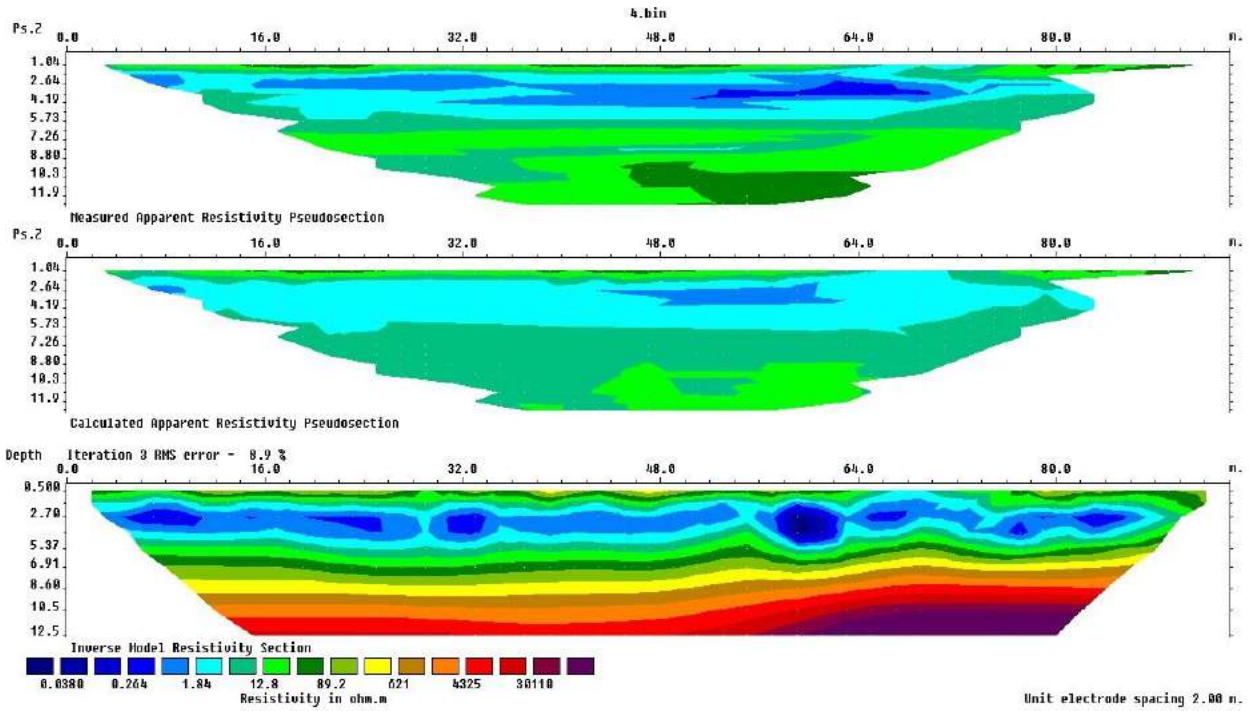


Fig:12 pseudo section (profile 4) of Pinnathur

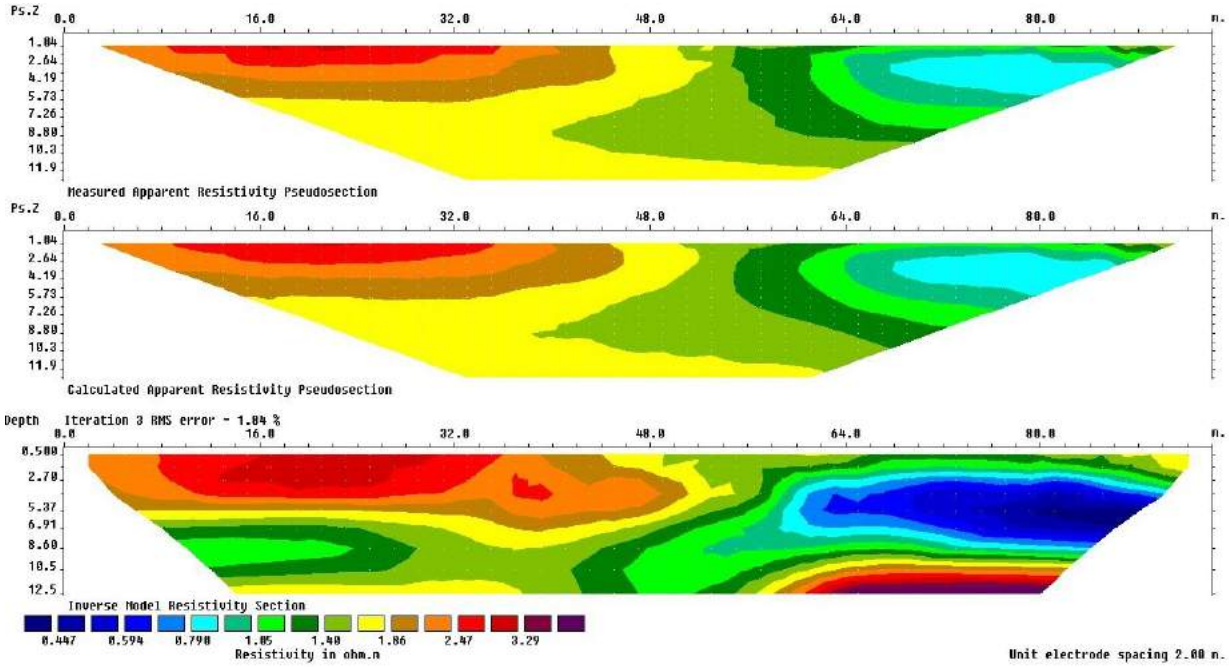


Fig:13 pseudo-section (profile 5) of coastal region of Parangipettai

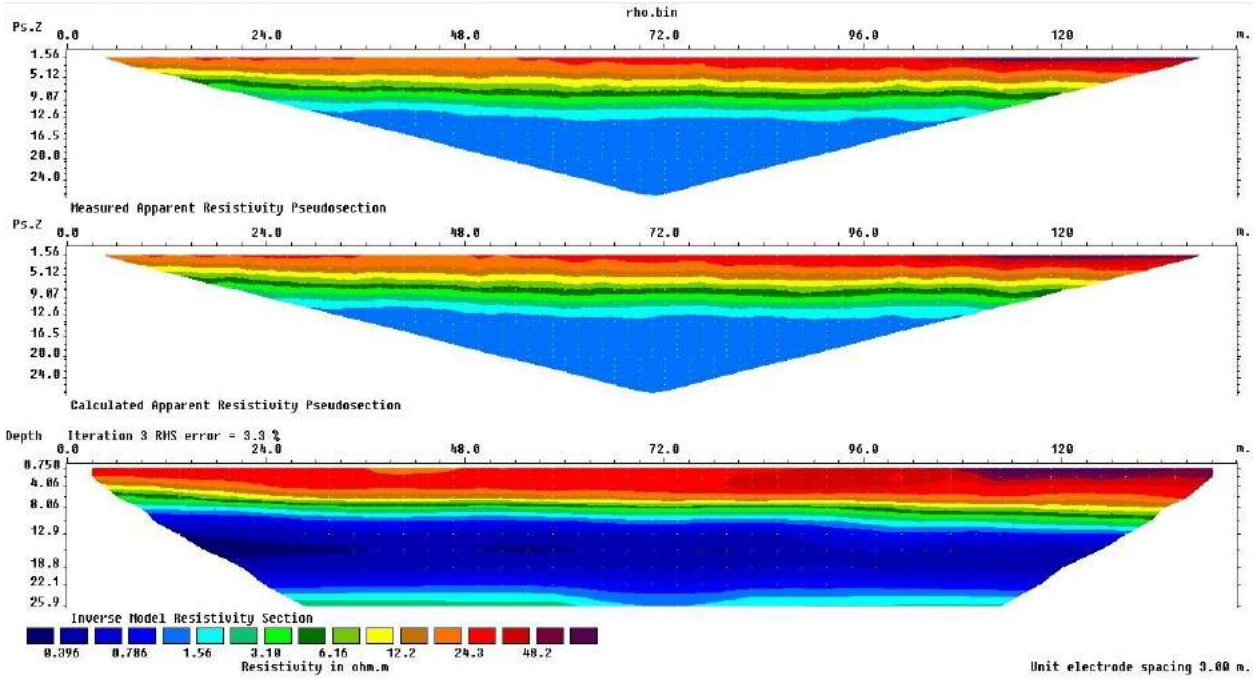


FIg: 14 pseudo-sections (profile 6) of Pichavaram

V. CONCLUSION

- *Using the integrated assessment with the geophysical and lithology, the SWI of the Parangipettai region was studied.*
- *The ERT pseudo-section provides the detailed information and the present condition of the Parangipettai block clearly, the borehole data were used to compare and confirm the presence of salt water in the study area.*
- *The profile 1 and B1 showing the low- resistivity below 1ohm-m and the clay formation indicates the sea water intrusion in the top layer up to the depth of 3m.*
- *The profile 2, showing the 0.67ohm-m from the 6 to 12.5m, confirmed the SWI. The profile 3 confirmed the in-situ salinity in the T.S Pettai with low-resistivity.*
- *The profile 4 and 5 of the location Pinnathur and coastal zone of Parangipettai might have the SWI in future and with the profile 6 and B3, the Pichavaram area is under the threat of SWI.*
- *The location like T.S Pettai, Keelthirukazhipalai and Pichavaram were identified with SWI problem. So, necessary action to be taken to recover and restore the quality of groundwater by employing the techniques like artificial recharge or some other measures*

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