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Delineation and Correlation of Fresh and Salt Water Interface of Shallow Coastal Pheratic Aquifer by Surface and Subsurface Geoelectrical Investigations

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ABSTRACT

Seawater intrusion into the freshwater aquifers is a common scenario in the coastal aquifer system. Since fresh potable water is one of the basic needs of human being, salt water intrusion hazard which pollutes the drinking water is a global problem, causing much concern to the groundwater scientists. The role of science and technology, particularly the hydro-geological investigation techniques help us to assess the seawater intrusion. Among the various geophysical techniques one of the method, Electrical Resistivity Technique (ERT) is useful to delineate the subsurface lithology, quality and groundwater potentiality. Under ERT both surface and subsurface exploration methods were conducted at Vadakkupoigainallur (N10° 738313 & E 79° 846343) which is one of the coastal village of Nagapattinam district of Tamil Nadu. The purpose of the study is to ascertain the depth to fresh water – salt water interface. For this study a detailed hydrogeological investigation and both surface and subsurface ERT have been conducted to correlate the fresh water – salt water interface. The TDS parameter of shallow tube well water samples has been collected. The study reveals that the depth to freshwater – salt water interface is about 7 to 8 m bgl.

Keywords: Pheratic aquifer, seawater intrusion, freshwater – salt water interface, electrical resistivity techniques, well logging.

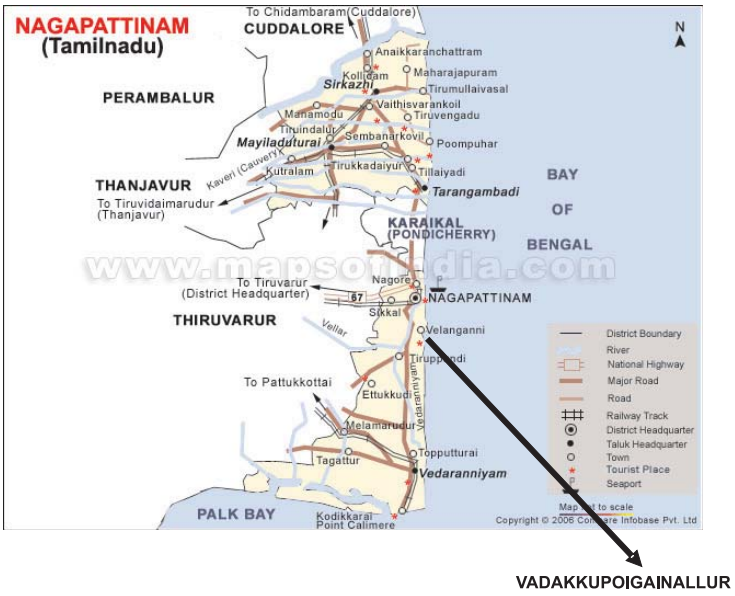

Fig. 1. Location map of the study area.

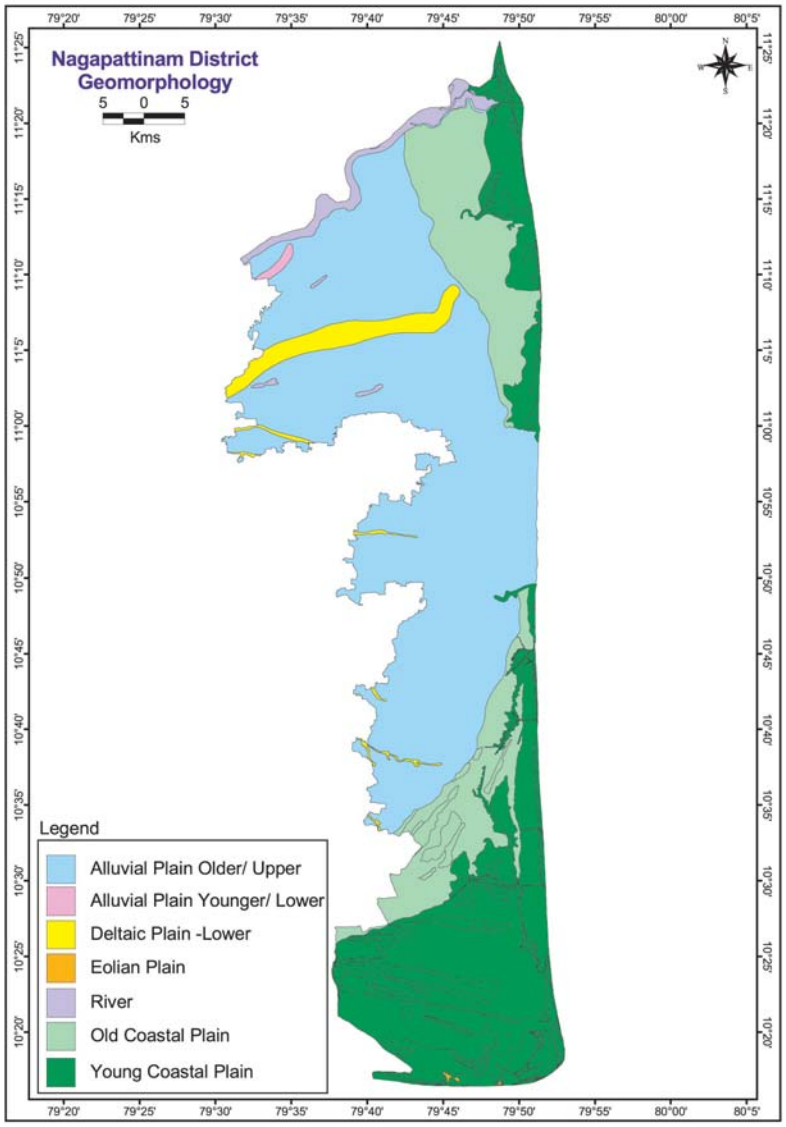

Fig. 2. Geomorphology map of Nagapattinam district.

the district is covered by black clayey soils. Some patches of arenaceous soils are found along the coastline. The tail ends of the Cauvery and Kollidam rivers are rich with fertile alluvial soils. Geomorphology of Nagapattinam district shown in Fig. 2.

GEOLOGY

The study area is a sedimentary terrain underlain by various geological formations ranging in age from Pliocene to the Recent alluviums. The main lithological units of Pliocene deposits are

sands, sandy clay, grey and variegated clay with gravel beds. Pliocene formations underlie the Quaternary deposits in the Cauvery and Vennar sub basins.

HYDROGEOLOGY

The occurrence and movement of groundwater are controlled by climate, topography, geomorphology, geology and structures, etc. Groundwater occurs in all geological formations under unconfined, semiconfined and confined conditions. In major parts of the district, the depth to water table lies within 4.0 metres below ground level. In the north eastern part, the depth to water table is shallow i.e. less than 2.0 m. The general post-monsoon water level ranges between 0.2 m and 4.0 m bgl. The water level fluctuations in the district are related to recharge from different sources, hydrogeological setting, topography and status of groundwater developments. The study area receives maximum rainfall during North-east monsoon period, i.e. October to December. The normal annual rainfall of the district is 1372 mm. Precipitation is the main source of groundwater recharge. The impact of surface water irrigation is very significant. The lateral surface water flow through the river channels and canals form the principal source of groundwater recharge in the area. The principal and potential aquifers are the sands, gravel and alluviums.

THE COASTAL AQUIFER SYSTEM

The entire coastal belt of Nagapattinam district is occupied by the Quaternary formations. In the coastal areas, the groundwater occurs in the alluvial, flood and deltaic plains under pheratic conditions. The principal and potential aquifers are alluvium and sands. The quality of groundwater of shallow aquifer is generally good along northern, north-eastern and central parts. The quality deteriorates in the south and south-eastern parts, i.e. along Vedaranyam coast, which may be attributed to the marine and semi-marine origin sediments. The groundwater occurring in the sand dunes are generally fresh in nature. Seawater intrusion in coastal aquifers occurs when permeable formation outcrops into the body of seawater and the freshwater is underlined by salt water. A landward slopping freshwater – salt water interface will be formed with the depth governed by Ghyben-Herzberg relationship.

GROUNDWATER EXPLORATION

The groundwater exploration may be broadly classified as aerial, surface, sub surface and esoteric methods. Groundwater exploration comprises a number of stages. The first stage is identification of suitable well sites by integrated hydrogeological and geophysical method while the next stage is drilling and the last stage is development. Geophysical technique is one of the common techniques used for groundwater exploration. One of the geophysical technique is electrical method wherein the electrical conductivity of the subsurface formations is measured. The ERT is a non-invasive method and cost-effective. The inverse of conductivity is resistivity. In the ERT the conductivity is measured in terms of apparent resistivity. The ERT for groundwater exploration is of two types. One is surface and the other is subsurface exploration. In the surface method the resistivity of the subsurface formations is measured from surface itself. In the subsurface method the resistivty of the different geological formations encountered in the bore hole is measured through the probe traversing the borehole.

ELECTRICAL RESISTIVITY TECHNIQUES (ERT)

Surface Exploration

In the Electrical Resistivity Technique (ERT) of surface method, vertical electrical soundings have been conducted in the study area using DC resistivity meter adopting Schlumberger configuration. The depth of investigation AB/2 is 30 m. The VES curves have been qualitatively and quantitatively interpreted, analyzed and correlated by software packages IPI2WIN version 3.0 and INVERSE SLOPE version 1.0. The VES curve is a typical 'Q' type curve with six layered geoelctrical section. The geoelectrical parameters were obtained (Figs. 3 and 4).

Subsurface Methods

Well logging is the subsurface exploration method. There are several methods of well logging. The common methods employed in groundwater exploration, are the self potential (SP) log and resistivity logs – lateral. Short normal and long normal logs. In this study electrical well logging in pilot bore hole drilled by calyx rig to a depth of 75 m, has been carried out using portable spot logger with DC resistivity meter. The logging modes measured are SP and LN 64". SP and resistivity measurements have been recorded for 2 m interval. SP measurements are highly useful in deciphering the saline and clay predominant zones. Saline water saturated zones produce sharp – SP and low resistivity. Normal resistivity logs are four electrode system widely used in groundwater hydrogeology which measures the apparent resistivity. There are two types of normal resistivity logs SN 16" & LN 64". The normal resistivity logs clearly distinguish the clay, saline & freshwater zones. The interpretation of electro logs have been done in correlation with the litholog of boreholes (Figs. 5 and 6).

RESULTS AND DISCUSSION

The VES curve is a typical 'Q' type curve with six layered earth. The top three layers with the true resistivities of 543, 317 and 126 Ωm; indicate the shallow pheratic sandy aquifers. The sudden drop of resistivity from 126 to 12 Ωm may be attributable to the salinity of aquifer. The litho units of the pilot borehole very well coincide with that of geoelctrical section. The electro log curves of normal resistivity log LN-64" exhibit an increasing trend up to a depth of 8 m and below which the curve shows a decreasing trend with a steep fall of resistivity of 6 Wm, indicating the saline nature of aquifers. Below 10 m depth though the normal resistivity log curve shows an increasing trend, aquifers are saline. Again below 30 m depth the resistivity falls to 4 Wm which can be attributed to the brine water. Generally, in Nagapattinam areas brine waters are encountered in the depth range of 40-60 m. The TDS of water samples of the shallow tube well in Vadakku & Therkkupoigainallur are within the ranges of 654 to 1240 ppm. reflecting the fresh water aquifers.

SUMMARY AND CONCLUSION

Vadakkupoigainallur of Nagapattinam district in Tamil Nadu is a coastal sedimentary terrain with unconsolidated formation ranging in age from Pliocene to the recent alluvium. Groundwater exploration of both surface and subsurface geoelectrical investigations has been conducted to

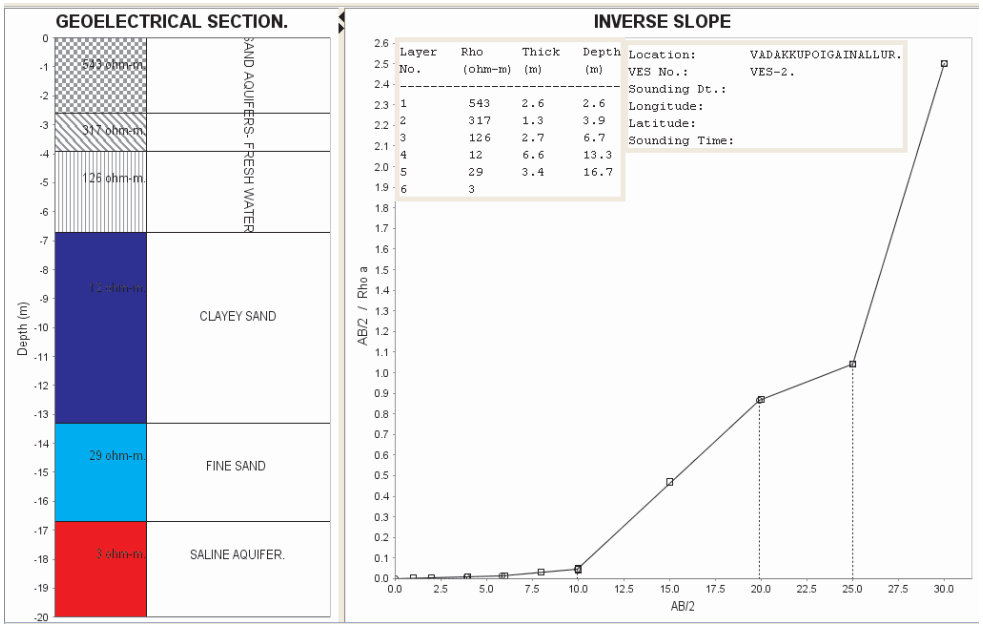

Fig. 4. Vadakkupoigainallur geoelectrical section – inverse slope.

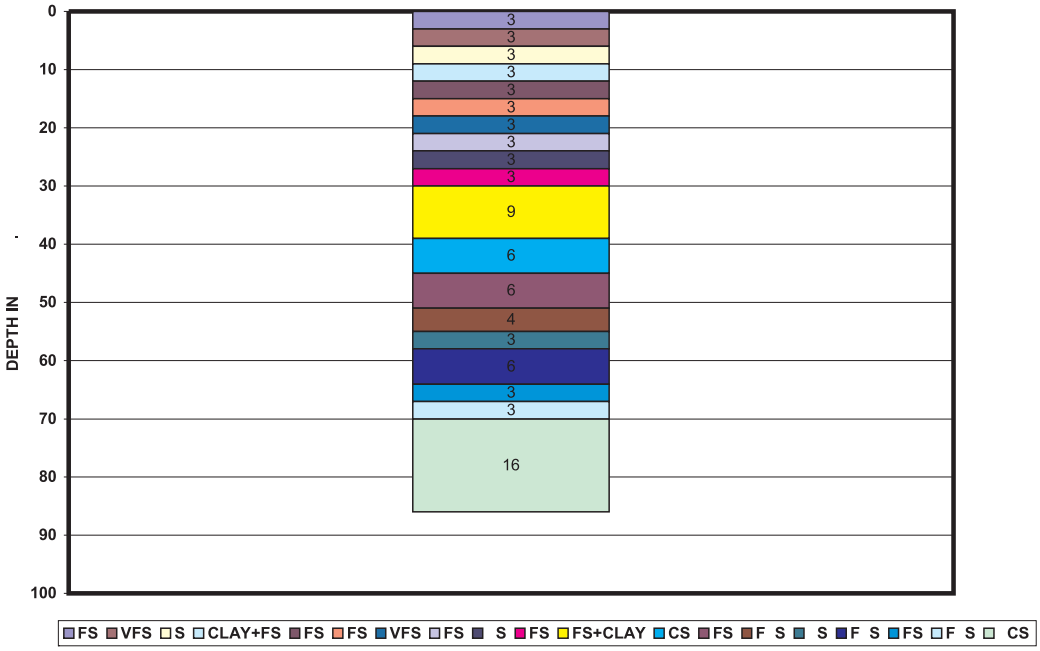

Fig. 5. Vadakkupoigainallur lithology section.

hydrogeological set up, geoelectrical investigation and TDS parameters, it may be inferred that the shallow pheratic aquifers up to a depth of 7 to 8 m are fresh in nature and below 8 m depth it is brackish. The depth to freshwater – saline water interface is 7 to 8 m bgl. Both the surface and subsurface geoelectrical investigation findings reveal that it very well coincides. Thus, the surface and subsurface geoelectrical investigations are good tools to ascertain and delineate the fresh water – saline water interface.

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