CHAPTER ONE
INTRODUCTION

1.1 INTRODUCTION

Groundwater resources are an increasingly important component of socio-economic development. The growing needs for drinking water call for protection of groundwater quality, especially in coastal areas and islands. Coastal aquifers contain much needed freshwater resources. The rational use and management of water resources in coastal areas are of particular importance because of the rapid growth in settlements, urbanisation and industrialisation. The available limited quantity of potable water resources due to the salinity problems generated by the adjacent sea water, enhances the need for rational management and development within the safe limits. These resources may also experience disastrous and almost irreversible impacts if improperly managed or unwarrantedly mined. The use of coastal aquifers as operational reservoirs requires the development of efficient integrated tools that make it possible to evaluate the behaviour of aquifer under different stress conditions.
1.2 SCOPE AND OBJECTIVES OF THE PRESENT STUDY

Saltwater intrusion is a major hazard to the public in all coastal regions of the world. Both lateral and vertical intrusions are expected to occur and are widely caused by over-pumping in certain sensitive portions of an aquifer. It has been found to be a matter of great concern in India, to study these problems in different parts including the State of Tamil Nadu. Tiruchendur Coast, located in the Chidambaranar District of Tamil Nadu, is facing the threat of salinity intrusions in aquifers and this led the author of the present work to investigate the aquifer horizons by adopting an integrated hydrogeological approach.

There has been so far no systematic integrated hydrogeological study conducted in the coastal belts of Tamil Nadu.

It is aimed to make an earnest attempt to study the interrelationship of the existing geological characteristics of different formations, hydrometeorological elements, aquifer parameters, potable zones marked out of a hydrogeochemical study, potential zones demarcated through geophysical techniques in one another. All these have a bearing on the determination of recharge potential, the draft of water, planning of water management practices, delineation of favourable sites for wells and in determining
the optimum yield of water for domestic, industrial and
irrigational consumption.

The following are the major objectives of the present
work;

1. To evaluate the groundwater resources potential of
the coastal zone by adopting an integrated
hydrogeological study.

2. To assess the geological, geomorphological,
hydrogeological and socio-economic factors
responsible for the landward saltwater
encroachment.

3. To develop and model the aquifer zone and simulate
it for determining the effects of stress into the
system.

4. To propose the possible water management practices
for limiting sea water intrusion and to tap fresh-
groundwater within the safe yield conditions.

1.3 RESUME OF PREVIOUS STUDIES

Though quite a lot of systematic hydrogeological
studies have been carried out in different parts of the hard
rock terrain, limited attention has been paid to analyse the
groundwater conditions in the coastal aquifers of India. A
few of the notable works have been discussed here.

1.3.1 On Coastal Aquifers in India

The hydrogeological and hydrochemical characteristics
of saline aquifers along the Mangrol-Chorwad Coast of
Saurashtra, Gujarat State have been studied by Desai et al.,
(1979). Chandrasekaran and Ushakumari (1982) analysed and
interpreted the chemistry of groundwater along Malappuram
Coastal aquifers of Kerala State. The agro-chemical characteristics of groundwater along the west coast of India have been investigated by Gajendragad et al., (1984). The potential zones of groundwater in the coastal aquifers of Tambraparni basin, Tamil Nadu have been demarcated by Balasubramanian et al., (1985) using geophysical and geochemical techniques. Saltwater intrusion and related problems in South Kanara have been assessed by Gajendragad et al., (1986). The hydrogeochemistry of Karaikudi Coastal Zone, Tamil Nadu, has been evaluated by Sastri and Lawrence (1988).

Sukhija et al., (1988) assessed the validity of environmental chloride method for recharge estimation of coastal aquifer in India. James et al., (1989) studied the salinity intrusion problems in the estuaries of Malabar Coast. The general groundwater conditions of the Chidambaranar District, Tamil Nadu have been discussed by Varadaraj (1989). Hydrogeochemical studies in the coastal aquifers of Tuticorin, Tamil Nadu have been conducted by Balasubramanian et al., (1991). Saltwater intrusion in open wells close to Kadalundi Estuary of Malappuram Coast have been identified by Nazimuddin et al., (1993).

The groundwater potential and quality rating for irrigation and domestic needs in coastal Karnataka State have been studied by Ranganna et al., (1991). Thrivikramji
et al., (1991) assessed the problems of salinisation in coastal aquifers due to sea level rise. Hydrogeological studies in the Kaniyakumari District, Tamil Nadu have been attempted by Sankar et al., (1993).

Subramanian et al., (1993) studied the Hydrogeology along Tuticorin Coast, Tamil Nadu. The chemistry of groundwater in the coastal aquifer around Trivandrum, Kerala have been evaluated by Narayanan Nair and Reena Thomas (1993).

In almost all these studies, integrated approaches to obtain valuable solutions to problems have not been attempted. Detailed hydrogeological study by adopting such techniques has not been conducted so far in India especially along the coastal aquifers of Tiruchendur, Chidambaranar District, Tamil Nadu.

1.4 TIRUCHENDUR COAST

1.4.1 Geographic Setting

Tiruchendur coast is the southern most part of Tamil Nadu state, India. It is located (Fig.1.1) between latitudes
FIG 1.1
LOCATION MAP OF TIRUCHENDUR COAST

[Map showing locations such as Madras, Tiruchendur, etc., with indices for Taluk HQTS, Rivers, Highways, and Railways.]
8°8' to 8°40'N and longitudes 77°35' to 78°8'E lying mostly in Chidambaranar and partly in Tirunelveli Kattabomman Districts of Tamil Nadu. The coastal zone occupies an areal extent of 1428 sq.km. It falls within the Survey of India topographic sheets 58 H/11, 12, 14, 15, 16, 58 L/2 and L/3.

The area includes fully Srivaikuntam, Tiruchendur, Sathankulam taluks of Chidambaranar District and certain portions of Radhapuram and Nanguneri taluks of Tirunelveli Kattabomman District. It is bordered by the Gulf of Mannar in the East which belongs to the Bay of Bengal.

1.4.2 Accessibility

This area is easily approachable by all weather state Highways and Indian Railways (Southern) from any part of the State and the Country. As Tiruchendur and Srivaikuntam are the popular pilgrimage centres, most of the locations are well connected with adequate transport facilities. Tiruchendur is located around 700 km away from the State Capital, Madras.

1.4.3 Climate

The area lies in a hot and semiarid climatic zone. A maximum temperature of 36°C is noticed during the month of May. December seems to be the coldest month and the mean daily maximum and minimum temperatures are about 27.0°C and 22.3°C respectively. This area receives a scanty rainfall and the average annual precipitation is only 746.55 mm.
1.4.4 Landuse and Agriculture

Development of agriculture is pronounced in the area nearly 5 km away from the coastline. A portion of this coast is covered by forests (Fig. 1.2) and the total area under cultivation is more. The major crops grown are paddy, cholam, cumbu and ragi. Cash crops grown are chillies, cotton and to a limited extent banana. Along the fertile pockets around the river courses, two crops are taken in a year. Thorny bushes and palmyra trees are common along this coast.

1.4.5 Intrusion Problems

Groundwater is mined in all places through large diameter wells for agriculture and the water level has gone deep, sometimes even below the depth of the wells (Fig. 1.3).

Saltwater intrusion is a major problem to the public who are mainly involved in agriculture. A few press releases (Dinamalar, Tamil daily dated 29th March 1993) reported from this area specifically mention the effects of intrusion in some localities (Thattarmadam, Chokkan Kudiirruppu, Kommadikottai, Periyathalai, Chettikulam, Padukapathu) and
Fig. 1.2 photographs showing a portion of the forest cover in a Teri mound (view of North-Northwest taken 10km Southwest of Manapad)
Fig. 1.3 Photographs showing the nature of large diameter dug well and dug-cum-bore well used for groundwater extraction
call for an immediate and effective solution to this problem.

1.4.6 Surface Water Facilities

Tambraparni River, a perennial stream, flows towards the Bay of Bengal in the northern boundary of the area and it forms a major surface source along the river banks. A small ephemeral stream, Karaimaniyar, exists at the central part. There are a few small, medium and large scale tanks within the study area. Surface water availability in these rainfed tanks is about three to four months per year. A few tanks adjacent to Tambraparni river show enough water throughout the year. The farmers depend only on groundwater resources from March onwards for irrigation.

1.5 ORDER OF PRESENTATION

The work presented here deals with various aspects pertaining to the hydrogeology, aquifer horizons delineated using geophysical techniques, hydrochemistry of groundwater and the problem of saline intrusion of this study area.

The thesis has been divided into nine chapters and the nature of the investigations covered are as follows.

Chapter I, which deals with the location and extent of the study area, includes the

i) the scope and objectives of the present work

ii) the review of previous studies made in India

iii) general features of Tiruchendur coast and
iv) an outline of the various aspects covered in this work.

Chapter II deals with the geomorphological features like physiography, drainage, topography, hydrogeomorphic units, the general geology, soil types, surface lithology and structural characteristics of various lithologic units. The boundary conditions of the aquifer have also been explained. The influence of surface landforms over aquifer recharge and discharge is presented.

The hydrometeorological processes broadly covering the details of rainfall, climate, evaporation, evapotranspiration and humidity have been analysed and are given in Chapter III.

Hydrogeology, which forms the most important part of the present investigation is dealt with in Chapter IV. The various aspects considered are

i) Description of groundwater conditions, behaviour of the groundwater system using water level and water table fluctuation,

ii) Pattern of groundwater flow and the factors of salinity intrusion,

iii) Grid deviation water table analysis for delineating the recharge-discharge zones, and

iv) The evaluation of aquifer transmissivity, storage coefficients, specific capacity indices, time for full recovery of open wells and optimum yield of the wells.
In Chapter V, the chemical characteristics of groundwater have been discussed.

The study includes the

i) Presentation of major ions of groundwater samples collected and analysed,

ii) Assessment of suitability of groundwater for domestic, agricultural and industrial purposes and

iii) Development of a hydrogeochemical facies model by adopting a few numerical methods.

Chapter VI deals with the groundwater geophysics. The results of Vertical Electrical Sounding and geoelectric profiling have been analysed and interpreted to demarcate the salt-freshwater interface and groundwater potential zones. This study also highlights the suitability of resistivity measurements for the identification of saline zones and the interface between salt and fresh water.

Chapter VII is devoted entirely to the numerical modelling of saltwater intrusion with simple approaches. It also explains the available techniques for application of controlling such hazards in coastal aquifers. Results of a set of simulation runs have been presented.

An integrated approach to obtain a solution to the problem with all characteristics of aquifers derived from the above mentioned studies and derivation of their inter-relationship for groundwater development, demarcation of salt and freshwater zones and better water management
options have been discussed in Chapter VIII of the present work.

Estimation of water budget and safe yield limits have also been done with the available database.

Chapter IX concludes the thesis by giving the summary and the significant findings related to various analysis. Documentation of the work has been carried out with adequate number of maps, figures and tables followed by detailed references. The computer programs used for processing the data relating to many aspects of this study have been included in the appendixes.