CHAPTER 1

INTRODUCTION

1.1 GENERAL

Water is one of the most precious natural resources and it is most essential for the existence of life on earth, second to air. About 97% of the world's water resources are found in the seas and oceans. It is estimated that, around three-fourth of the remaining 3% water is bound up in ice sheets and glaciers. Surface water, i.e. lakes, streams, rivers etc. account for 0.0025% of the remaining 0.75%, and the groundwater comes to 0.7475%. Hence the freshwater resources are to be utilized properly and judiciously. Groundwater is the largest source of fresh water on the planet. It has been utilized to a great extent in the agricultural, industrial and municipal water supply purposes. The groundwater is likely to get contaminated due to the presence of salinity especially along the coastal regions. Saltwater intrusion is the migration of saltwater into the fresh water aquifers along the coastal regions. It is one of the most common forms of groundwater contamination. Nearly 70% of the world population lives in coastal areas and this fact add additional gravity to the problem of groundwater contamination due to saltwater intrusion. The indiscriminate withdrawal of the groundwater along the coastal regions and the skewed management practices worsen the situation. Large withdrawals of freshwater establish steep hydraulic gradients towards the land which in turn promotes the saltwater intrusion. This alarming condition raises many questions, including the sustainability of the coastal groundwater system and at present saline water intrusion into coastal aquifers is a major apprehension all over the world. A coastal aquifer, characterized by having at least one side of its perimeter in direct contact with sea, besides being exposed to possible urban, industrial or agricultural pollution coming from the mainland, is highly subjected both to saltwater intrusion and deterioration of its quality. Saltwater intrusion can also occur due to various natural events such as climate change and sea level rise. This problem is very common in many parts of the world. Normally, saline water bodies owe their origin to entrapped saltwater (connate water), sea water ingress, leachates from navigation canals constructed along the coast and leachates from salt pans etc.

Urbanisation refers to general increase in population and the extent of industrialisation in a settlement. It symbolizes the movement of people from rural to urban areas. Urbanisation process refers to much more than simple population growth; it involves changes in the economic, social and political structure of a region. Rapid urban growth is responsible for many environmental and social changes in the urban settlements. When urbanisation takes place, it also destabilizes many natural systems operating in the area. The water environment is one of the most fragile systems where immediate impacts of the urbanisation occur.

The Kerala State is blessed with a very long coastal stretch of about 560km, where the population density is also very high. The population density of Kerala as a whole is 749/km^2, where as the population density in the coastal regions of Kerala is as high as 2176/km^2. This is one of the world's highest population densities in any coastal stretch. Kerala has diverse hydrogeological characteristics, especially along its coastal stretch. The unusual population pressure coupled with the uncontrolled reclamation of the invaluable wetlands has created a tremendous stress on the quality and quantity of the coastal groundwater system (Laluraj et al, 2005). Many studies indicated that the coastal groundwater system of Kerala experiences setbacks in terms of the quality and quantity (CWRDM, 1985; Laluraj et al, 2005; Ahmed et al, 1987; Basak and Vasudev, 1987; CWRDM, 1984). It is to be noted that majority of the problematic blocks identified by CGWB (CGWB, 2005) fall in the coastal stretch, which in fact should be an eye opener. High population pressure, intense human activities and the associated landscape alterations, inappropriate and indiscriminate resource use and the absence of proper management practices worsen the situation. As a result, an aggravated saltwater intrusion is expected all along the coast in the near future. The newly initiated coastal tourism boom may further deteriorate the system. A review about the coastal aquifers of the entire west coast of India reveals that incidences of groundwater pollution due to saltwater intrusion has increased manifold in the last two decades (Chachadi et al, 2003). Appropriate and comprehensive management techniques have to be adopted to control the intrusion of saltwater into the coastal aquifer system.

1.2 NATIONAL COASTAL GROUNDWATER SCENARIO

Indian sub- continent is endowed with diverse geological formations from the oldest Achaeans to the recent alluviums and characterized by varying climatic conditions prevailing at different parts of the country. The natural chemical content of groundwater is influenced by depth of the soils and sub-surface geological formations through which groundwater remains in contact. In general, at greater part of the country, groundwater is of good quality and suitable for drinking, agricultural or industrial purposes. Groundwater in shallow aquifers is generally suitable for use for different purposes and is mainly of calcium bicarbonate and mixed type. However, other types of water are also available including sodium-chloride water. The quality in deeper aquifers also varies from place to place and is generally found suitable for common uses. Salinity problem is encountered along many coastal tracts and isolated pockets of high content of fluoride, Arsenic, Iron and heavy metals etc have also been reported. The distributions of various constituents present in groundwater at different parts of the country have been discussed in following paragraphs. The main groundwater quality problem in India is salinity in groundwater. This can be broadly categorised into two types such as inland salinity and coastal salinity.

Inland salinity in groundwater is prevalent mainly in the arid and semi arid regions of Rajasthan, Haryana, Punjab, Gujarat, Uttar Pradesh, Delhi, Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu. There are several places in Rajasthan and southern Haryana where EC values of groundwater is greater than 10,000 µS /cm at 25° C making water non-potable. At some areas of Rajasthan and Gujarat, groundwater salinity is so high that the well water is directly used for salt manufacturing by solar evaporation. Excess irrigation can also bring the inland salinity. The gradual rise of groundwater levels with time has resulted in water logging and heavy evaporation in semi arid regions lead to salinity problem in command areas.

The Indian subcontinent has a dynamic coast line of about 7500 km length. It stretches from Rann of Kutch in Gujarat to Konkan and Malabar Coast to Kanyakumari in the south to northwards along the Coromandal coast to Sunderbans in West Bengal. The west coast is characterised by wide continental shelf and is marked by backwaters

and mud flats while the east coast has a narrow continental shelf and is characterized by deltaic and estuarine land forms. Groundwater in coastal areas occurs under unconfined to confined conditions in a wide range of unconsolidated and consolidated formations. India has a very long coast line which is the backbone of its national economy. Three out of the four metros, the major industrial hubs, about one fourth of the country's population and the most fertile agricultural land are situated in this area. This is the region where natural calamities like tsunami, cyclones etc; frequently affect the normal life. The coastal region occupies some of the most potential aquifer systems of the country. The coastal aquifers of India range from that of Jurassic to Recent and is seen almost all along the coast right from Gujarat to West Bengal. Some of the aquifers especially the Tertiary to Recent ones are highly potential and are developed extensively. The small island aquifers of Lakshadweep are highly sensitive since fresh water is seen floating as a thin lens over sea water here. Large scale saltwater intrusion is reported in Gujarat and Tamil Nadu and the salinity in other areas are mostly derived from the aquifer materials. Coastal sedimentary aquifers are the most productive aquifers and hence these aquifers are being stressed immensely. Caution needs to be exercised while developing these aquifers, as over development can result in various adverse environmental impacts like saltwater intrusion, land subsidence etc.

1.3 STUDY AREA

Thiruvananthapuram is the southernmost district of Kerala. The district stretches along the shore of the Arabian Sea for a distance of 78kms. The main geological formations in Kerala are the Archean crystalline, Tertiary sedimentary formations, Laterites and the recent deposits. Geology of the coastal tracts of Thiruvananthapuram comprises Quaternary Formation (recent and sub-recent), Sands, Tertiary Formations (Warkallai Formation composed of sand and clay) and hard rock. The groundwater occurs in unconfined condition in the area. Rainfall is the major source of groundwater recharge and the rainfall pattern plays an important role on the water levels in the aquifers.

The study area extends over 45kms of the coastal tracts of Thiruvananthapuram district extending from Pozhiyur in south to Menamkulam towards North, which lies between 8°19'34''- 8°35'53''N and 76°50'8' - 77°7'38''E as shown in Fig.1.1. The area covers about 104 km^2. The study area is divided into 9 sections such as Menamkulam, Karikkakom, Valiyathura, Poonthura, Pachalloor, Vizhinjam, Pulluvila, Poovar and Pozhiyur towards south. Each section has length 5km, and width of 2km.

1.4 IMPORTANCE OF PRESENT STUDY

Groundwater is considered as a national asset and an important component for development. Though Kerala State receives as much as 3100mm of rainfall annually, which is of 2.8 times of the national average, the per capita availability of freshwater in the State is one of the lowest among the other states of India. In such conditions, understanding the behaviour of the water system and groundwater chemistry is the primary need to arrive at some meaningful planning strategies.

The capital city of Kerala State, Thiruvananthapuram is one of the fastest growing cities of South India. The city is in the verge of a quantum leap of urbanization because of the expansions of Technopark, international airport and west coast canal, proposed international harbour at Vizhinjam, and many others. All these activities are concentrated along a narrow coastal stretch of the district. The degree of landscape modification being made along the coastal zone of this district is distressing, Earlier research works carried out along this narrow coastal stretch have brought out the fact that the stretch is vulnerable to saltwater intrusion (Deepthi & Letha ,2009) . These two aspects have to be further analysed to assess whether the urbanisation has a pronounced effect on advancement of saltwater intrusion. Hence the present study is taken up to understand the coastal groundwater system of Trivandrum city and also assess whether urbanisation has any impact on the extent of saltwater intrusion.

1.5 ORGANIZATION OF THE THESIS

The thesis is conveniently divided into nine chapters and the aspects covered in each chapter are as follows. The first chapter is introductory in nature and gives a brief account of global freshwater demand. The national coastal groundwater scenario and the importance of present study are also described in the introductory chapter. The details of study area are also included. The chapter II deals with the literature review and gap area related to the present study and the objectives. The third chapter describes the hydro geochemistry of groundwater such as spatial and temporal variation of groundwater quality parameters based on groundwater sampling from 63 observation wells in pre monsoon and 73 observation wells in post monsoon season, interpretation of groundwater quality by factor analysis etc. The fourth chapter discusses hydrogeology, geomorphology, water table contours and temporal change of land use. It also unravels the digital elevation model (DEM) of the study area. The fifth chapter includes the assessment of aquifer vulnerability to contamination by using GALDIT model and the area prone to saltwater intrusion was identified using indicators of saltwater intrusion.

The estimation of lateral extent of intrusion is also included in this chapter. Sixth chapter describes the geophysical investigations conducted along the coastal stretches of the study area. Seventh chapter addresses the modelling of groundwater flow and contaminant transport so as to predict both lateral and vertical extent of contamination based on different scenarios. An optimization model for the management of groundwater using simple genetic algorithm is discussed in the eighth chapter. The last chapter gives the conclusions derived out of the study.

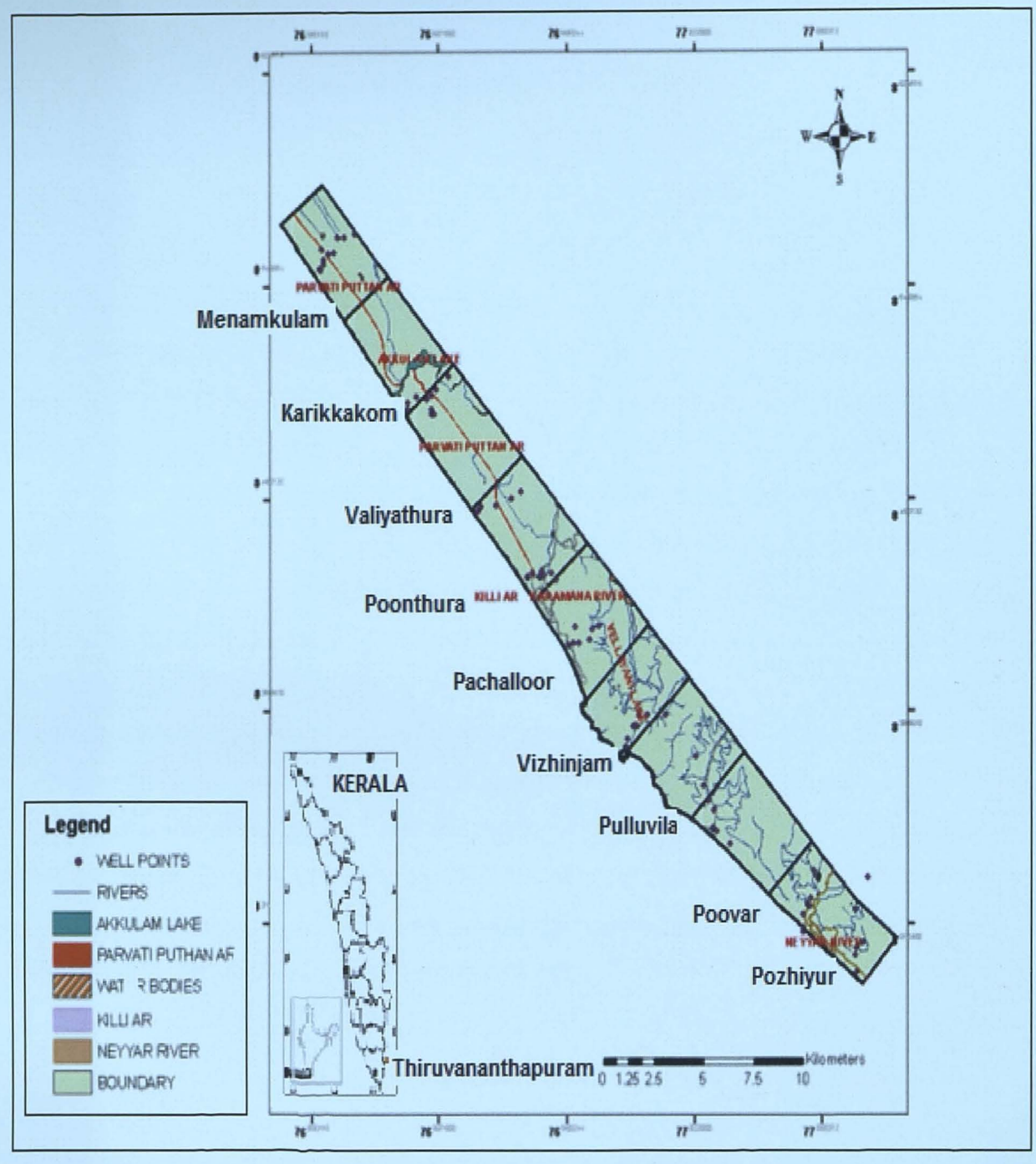

Fig. 1.1 Study Area