CHAPTER I
INTRODUCTION

1.1 Introduction

Water is a prime natural resource, a basic need for human beings, animals and plants. It is renewable but not in-exhaustive. It is generally safe, potable and free from impurities. Hence, it is a widespread and highly used resource for meeting the ever growing demands of different user groups. At present, more than 80% of the domestic water supply in rural areas, about 50% of water requirement for urban areas and industries, and more than 55% of irrigation water requirements are being met from groundwater (Romani, 2006). Hence, understanding groundwater scenario of an area is very important.

1.2 Water Scenario in India

India is a vast country with varying lithological and physiographical conditions. The population of India is around a billion and may go upto 1.6 billion by the year 2050. The need for water for basic requirements will increase day-by-day. The stage of groundwater development in our country as on March 2004 was about 58% (CGWB, 2006). However, the recharge is not uniform all over the country due to intensive usage of groundwater. This has led to a critical situation causing water level to decline and groundwater quality to deteriorate. By the year 2025 it is predicted that, one-third of the population of the developing world will face severe water shortage. A calamity is in store for our country also (Radhakrishna, 2004). The annual precipitation of most parts of our country is restricted to 100 hours and the rest of the year is mostly dry (Seckler, et.al, 1999). Hence, groundwater management is a challenge.

Owing to the ever increasing demand for potable water and water for irrigation, added to the inadequacy of available surface water, the importance of
groundwater is increasing day-by-day. Unscientific usage and over exploitation of groundwater has developed a stress on this resource. As a result, water level is falling persistently, wells are drying up and water quality is deteriorating. This is indirectly causing drinking water scarcity and migration of people to urban areas due to loss of agricultural employment.

The water quality of an area depends on various parameters that are influenced by a wide range of natural processes and human interference. Groundwater pollution is difficult to determine as it is out of sight and it may not be obvious for a considerable time due to kinetics of chemical reactions. Above all, it is very difficult to rehabilitate a severely polluted aquifer. Hence, study of groundwater quality and vulnerability mapping are important for proper development and management of an area.

1.3 Scope of the present work

The presence and movement of ground water in hard rock terrains such as the crystalline rock formations of Karnataka are controlled by the prevalence and orientation of secondary porosity (Krishnamurthy and Srinivas, 1995). The occurrence of groundwater in weathered and fractured granitic layers is highly localized and may not have continuity (Davis and Deweist, 1966). The groundwater development in Karnataka as on March 2004 is about 70% (CGWB, 2006). As per minor irrigation census 2000-01, many of the bore wells in Karnataka have dried up due to decline in water level. This calls for adopting suitable techniques for delineating ground water prospective zones and suggesting appropriate ground water developmental strategies. Though studies on regional scale have been bestowed by earlier reports in the Central part of Suvarnamukhi River Basin, large scale studies using geoinformatic techniques have not been carried out. The details on lithology, lithologic contact zones, structures, landforms, drainage network, etc. form the most important basic data for
exploration and exploitation of ground water resources. The Geoinformatic techniques, Satellite Remote Sensing (RS) and Geographic Information System (GIS) play an important role in understanding the exploration and exploitation of ground water. The satellite remote sensing technique has become one of the most efficient tools for mapping of geological, structural and landform details due to its capability of synoptic coverage, availability of data in different spectral and spatial resolutions with repetitive coverage. GIS helps in integrating various spatial data derived from the remote sensing technique as well as from field sampling which narrows down the suitable areas for ground water development and management. The quality of groundwater varies as its occurrence and movement is controlled by local lithology, as well as the path through which the water moves. Hence, the study of water-rock interaction plays a significant role in understanding and managing the existing resource.

The study area falls in the central dry zone of Karnataka state and is drought prone. Owing to deterioration of the chemical quality of ground water, the people living in this area are facing health hazards such as indigestion and gastric in nitrate polluted zones. They are also facing dental fluorosis in fluoride polluted zones. Hydrogeological studies of the area have been attempted earlier to understand the ground water regime of the Western part of Suvarnamukhi River Basin (Bramhananda, 2004). However, there have been very limited studies using geoinformatic techniques with regard to the groundwater development and management in the Central part of Suvarnamukhi River Basin. Also there have been limited attempts in the study of water rock interaction. With this in view, a detailed hydrogeological study has been undertaken to suggest appropriate strategies for groundwater development and management using geoinformatic techniques.
1.4 Topographical Location, Extent and Communication

Suvarnamukhi river basin occupies the area between 13°N -14°N latitude and 76°-77°15’ East longitude in Karnataka and Andhra Pradesh states. The area chosen for study is the Central part of Suvarnamukhi River Basin which occurs between 13°35’ N to 13°55’E latitude and 76°35’N to 77°05’ N longitude with an areal extent of around 1471 sq.kms within Karnataka state. This includes 5 sub basins namely Doddahalla, Devarahalli, Lakshmi Saagara, Ajjanahalli and Chikkatore from east to west respectively and the area towards north which is draining to the main stream directly (Map. 1.1). About 90% of the study area lies in Tumkur district covering parts of Sira, Gubbi, Koratagere, Madhugiri and Tumkur talukas and the rest fall under Hiriyur taluk of Chitrarurga district. The sub-basins are well connected with a good network of roads connecting the prominent towns and villages.

1.5 Physiographic Setting

Physiographically, the Suvarnamukhi river basin has an undulating terrain and is located in the southern part of Karnataka state. The study area gently slopes towards north with hills in the western region. The hillocks present are residual/structural and dome shaped running in NNW-SSE direction. The maximum height of the basin is 1022 m above mean sea level (MSL) in the hills, situated in the western part (Chikatore sub-basin) and a minimum of 620 m above MSL situated near the mouth that is the confluence of the sub streams to the main stream in the northern part. The basin exhibits dendritic drainage pattern with the number of segments being controlled structurally. All the sub-streams flow only during the monsoon season for about 2 to 3 months. The study area comprises 4th - 6th order streams and all the sub-basins are elongated in shape.
Geologically, the area is covered by the schistose rocks of Chitradurga Schist Belt in the west and Peninsular Gneiss in the east. Chikkatore Sub-basin is marked by a prominent belt of amphibolites and quartzite interspersed by small patches of iron formations, argillites and greywackes belonging to the Dharwar Supergroup. Basic intrusives are gabbros and dolerite dykes cutting across the schists and gneisses without any particular orientation, whereas the ferruginous chert bands are confined to the northwestern part. Lakshmi Saagara sub-basin and a part of Devarahalli sub-basin consist of amphibolitic schists which come under the Javagondanahally schist belt. Javagondanahally schist belt extends roughly in NNW-SSE direction parallel to the Chitradurga schist belt and has a maximum width of 12 kms around Bukkapatna. The two belts have a faulted contact, marked by a strong mylonite zone located in the western part of the study area. This narrow strip of granite (commonly called Bukkapatna Granite) passing through Hagalvadi and Bukkapatna separates the Javagondanahally belt from Chitradurga group.

The climate of an area can be determined by the geographical location, altitude with respect to sea level, monsoon winds and physiography. The study area falls in the central dry zone of Karnataka state. The average elevation of the study area is 820 m above MSL. The study area experiences semi-arid climatic condition. December – January are the coldest months and April-May are the hottest months. The sub-basin receives an average rainfall (for 25 years) of 558 mm (Radhika, et.al, 2009). The area experiences South-West monsoon from June to September, and July is the rainiest month.

The study area consists of dry deciduous type of forests. The main species include Kaggali, Pale, Kare, Bandre, Tangadi, Kakke and Chujalu trees. Barks of Kakke and Tangadi are useful in tanning industry. The other important minor forest resources include alalekai, hunisehannu, maradi, beedi or tupra leaves and sitaphala. Tobacco plantation is also observed in the study area (Plate 1.1).
The wild animals like foxes, wild boar etc. are occasionally seen in the forest area. Peacocks are found abundantly in Manchaldore State forest (Plate 1.2). The other birds include jungle fowls, parrots and ducks. Poisonous and non-poisonous snakes are also found.

Agriculture is the major occupation of the people of this area. However, there are no major irrigation projects within the sub-basins. Traditional type of agricultural practice is followed in the area which depends on rain. The major agricultural crops include paddy, pulses, cereals, toordaal, coconut and areca nut.

1.6 Objectives

A detailed hydrogeological investigation of the Central part of Suvarnamukhi River Basin has been attempted in the present study to suggest some appropriate groundwater development and management strategies. The objectives are -

1. To prepare a set of thematic maps for demarcating groundwater prospect zones using Remote Sensing Data and GIS techniques.

2. To assess the hydrogeological set up using geoinformatics.

3. To study groundwater quality and rock-water interaction studies.

4. To evolve appropriate techniques for development and management of groundwater.

1.7 Organization of the present work

With the above objectives, the present study has been attempted and the results have been presented in eight chapters with conclusion in the ninth chapter. The following paragraphs brief the contents chapter wise.
Chapter-1 describes the water scenario in India in general; depletion of groundwater; the challenges ahead and scope for the present work. The need for scientific management, aims and objectives of the present study are also discussed.

Review of literature pertaining to the study area and related to geology and hydrogeology are enumerated in Chapter 2.

The database used and methodology adopted are discussed in Chapter 3. The database used for the study include satellite data (IRS 1C/ID PAN+LISS merged) has been collected from Karnataka State Remote Sensing Application Centre (KSR SAC). Rainfall data for 107 years (1901-2007) has been collected from the Department of Economics and Statistics. Monthly water level data for past 10 years has been collected from Department of Mines and Geology. The meteorological data such as temperature, wind speed and relative humidity from 1975 to 2004 have been collected from the Indian Meteorological Department, Bangalore. In addition, groundwater samples during pre-monsoon and post-monsoon, along with soil samples collected in the pre-monsoon season in the vicinity of the groundwater sample form a database. The database thus collected and compiled is brought into the GIS environment and further used for understanding the spatial distribution and for preparation of groundwater prospect zones, artificial recharge zones and groundwater vulnerable zones.

The hydrometeorological studies are discussed in Chapter 4. The precipitation data has been subjected to statistical analysis using GIS and its amount, intensity and distribution in space and time have been discussed. Other climatic elements such as temperature, wind speed and relative humidity are also discussed. The climatic type of the area is determined using precipitation and temperature data. The meteorological drought is assessed using various methods.

Chapter 5 highlights the generation of various thematic maps for understanding the hydrogeological setup. Geomorphology, Landuse/ Landcover,
Lineaments and slope maps are generated using satellite imagery. The geology map of the study area is extracted from district resource map of Tumkur and Chitradurga district (GSI, 2000) and superposed on the imagery to update the changes. Soil texture map is extracted by the published map of Tumkur and Chitradurga districts (NBSS & LUP, 2001). The drainage characteristics have been derived from Survey of India toposheets and updated using IRS-1C, PAN+LISS merged satellite data. A detailed morphometric analysis has been carried out. Then thematic maps are integrated in the geoinformatic environment and groundwater prospect zones have been delineated.

Water level fluctuations, aquifer media, subsurface geology and water balance studies are discussed in Chapter 6. The groundwater resources estimation has been carried out using water table fluctuation method (GEC, 1997). The stage of groundwater development in the sub-basins is evaluated.

The quality of groundwater is discussed in Chapter 7. The major constituents such as Ca, Mg, Na, K, HCO₃, CO₂, SO₄, Cl, NO₃, SiO₂, etc. and trace elements such as Cu, Zn, Fe, and Mn have been analyzed. Spatial distribution maps have been prepared in the geoinformatic environment for all the above parameters to demarcate the anomalous zones. The parameters such as groundwater facies, Index of Base Exchange and total hardness have been calculated. The groundwater samples have been classified for their usefulness for domestic and agricultural purposes. Soil analysis has been carried out for essential parameters like macro nutrients such as N, P, K and micro nutrients such as Zn, Cu, Mn and Fe to check its suitability for irrigation and for comparing its nature with respect to its presence in water. Spatial distribution maps have been prepared for all these parameters and the anomalous zones are identified. The interrelationship of chemical constituents within water, elemental stability, weathering processes and rock-water interaction studies have been discussed in this chapter.
Chapter 8 deals with the identification of artificial recharge zones assigning appropriate weightages to the parameters discussed in the previous chapters. The locations for site specific artificial recharge structures are also discussed. The vulnerable zones prone for pollution are identified by integration of various thematic maps. On the basis of the quality parameters of groundwater, the remedial measures for improvement of quality have been suggested.

Chapter 9 consists of the conclusion drawn from the above studies with a brief scope for future work. The conclusions are followed by a detailed reference.
Plate 1.1: Tobacco Plantation near Obalapura, Hiryur Taluk

Plate 1.2: Peacock in Manchaldore State Forest, Gubbi Taluk