# CHAPTER 1

# INTRODUCTION

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## 1.1 INTRODUCTION

Water quality is commonly defined by its Physical, Chemical, Biological and aesthetic (appearance and smell) characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health. Water quality is important for farming, fishing, mining and it also contributes to recreation and tourism. If water quality is not maintained, it is not just the natural ecosystems that will suffer, even the commercial and recreational value of our water resources will also get degraded. Water quality is closely linked to the surrounding environment and land use. Other than in its vapour form, water is never pure and it is always affected by community uses such as agriculture, urban and industrial uses and recreation. The modification of natural stream flows by dams and weirs can also affect water quality.

Ground water, rivers, seas, lakes, ponds and streams are finding it more and more difficult to escape from pollutions. Many rivers of the world receive heavy flux of sewages, industrial effluents, domestic and agricultural wastes, which consist of substances varying from simple nutrients to highly toxic hazardous chemicals.

In addition to leachates from agriculture, over the last decade, industrial wastes and the municipal solid wastes have emerged as the leading causes of pollution of surface and groundwater. Rapid industrialization and economic growth have led to the intensification of consumerism, which in turn has added to the problem of disposing of colossal amounts of garbage generated each day.

Problem pertaining to fresh waters are mainly due to the mismanagement and neglect of this precious resource. In 1965, the WHO stated that "water pollution must be expected to increase very much faster in developing countries than in the developed countries". India with the population of more than 1 billion is finding it difficult to fulfill its people's demand for fresh water from rivers. According to Vijetha, 1995 and Sharma, 1997 water from rivers are severely polluted (there are 44 major, 44 medium and 55 minor rivers in India. Even lakes and tanks near cities and towns have also been polluted. On account of the good quality water is becoming a scarce commodity.

Water is essential to human life and to the health of the environment. As a valuable natural resource, it comprises marine, estuarine, freshwater (rivers and lakes) and ground water environments, across coastal and inland areas. Earth is a watery planet. Estimates vary, but somewhere between 70 and 75 percent of the earth's surface is covered with water.

During last few decades, several researchers have worked on problems related to water pollution. Douglas et al. (1986) have worked on the effects of excavation and diversion in Northeast Mississippi before and during construction on water quality. They observed that all Physico-Chemical parameters including the heavy metals were 50 to 100% greater during construction than before construction. Kornprabha *et al.* (2005) studied on effects of Chemicals on water quality in Thailand and its impact on drinking water production in Thailand. They reported that, groundwater contained higher contents of Uranium than surface water or tap waters. Ground water was found to be contaminated from saltwater intrusion attributable to the over-extraction.

An understanding of Chemical evolution of ground water provides insight into the interaction of water with the environment and contributes to better resource management. Adams *et al.* (2001) studied the Hydrochemical characteristics of aquifers near Sutherland in Western Karoo, South Africa. Antonio *et al.* (1985) have reported that the usage of oil drums for storage of cistern water, (a common practice) may be the cause for immediate public health concern and levels of Cadmium and Lead have increased.

For years, nearly everyone took water for granted as pure item. Only a few persons were worried above limited water resources. They were certain that the contamination or outright removal or that the pressures of a burgeoning population would create physical and chemical stresses on water resources that were not dreamt off only a generation ago. Since 1960's, however, a keen awareness has developed throughout the world. This is not to say that people living in water scarcity hit regions were not already aware that water supply would be a major factor in their lives. For example, there has been a 400 ft (122 m) decline in the ground water table in Phoenix and Arizona over the last 50 years.

The conservation of water quality can present major technological challenges. Once a resource is endangered by the impact of man, society can spend large sums of money and time to determine, what the problems are and to develop potential solutions. Therefore, in recent years, many scientists have dedicated their professional careers to study water quality.

Water is often called "the universal solvent" because, of its extraordinary ability to dissolve a broad range of substances. In fact, it dissolves more substances in greater quantities than any other liquids. In other words, huge amount of heat energy is required to evaporate even small quantities of water. Because of water's high heat capacity, the presence of oceans, lakes and large rivers prevents extreme fluctuations in local temperatures. Coastal communities have much more uniform temperature regimes than do towns farther inland. Even within the human body, water is critical in maintaining uniform body temperatures. Without the large volume of water in our bodies (approximately 75 percent), we would warm up or cool down much more rapidly than we do.

## 1.2 SCOPE OF THE PRESENT WORK

Good quality water in rural areas appears to be still a distant dream. This is evident for the poor quality of the available drinking water in villages, towns and cities of India. About 35% of the diseases treated in the hospitals and primary health centres in the country are because of unhygienic drinking water. Sanitary conditions are an apology for WHO standards.

A critical perusal of the water quality in the rural and urban areas reveals that, two prime causes degrade the quality of water these are agricultural pollutants and the domestic sewages and the resulting eutrophication (Petra Judova, 2005).

Although, considerable work has been carried out on the work, it has been carried out on the water pollution problems of the urban and rural areas, there are still large gaps with respect to the understanding of the environmental aspects that govern the water quality of the rural and urban areas. This is specially evident in India and Karnataka in particular.

In view of the above, the present work is an attempt to understand the water quality criteria by the study of the Physico-Chemical and Microbiological parameters of the water samples from rural areas of 15 districts in Karnataka.

## 1.3 OBJECTIVES OF THE PRESENT STUDY

The present work has been taken up with the following objectives:

1. To understand the Physico-Chemical parameters of freshwater bodies of rural areas of 15 districts in Karnataka State including the samples from borewells.
2. To study the microbiological aspects of water in the water bodies of the above districts.
3. To evaluate the hydrogeological aspect and classification of groundwater and surface water bodies of the above districts.
4. To examine the data in the light of statistical analysis and make assessments on water quality in the study area.
5. To study the heavy metals in the samples to assess the water quality.
6. To suggest measures for water quality improvements in the districts of Karnataka.

## 1.4 STUDY AREA

### KARNATAKA

Karnataka has a rich heritage, inspiring its people to create a bright future. The state of Karnataka, confined roughly within $11^{0}35'$ North and $18^{0}30'$ North latitudes and $74^{0}5'$ East and $78^{0}35'$ East longitudes, is situated on a tableland where the Western and Eastern Ghats ranges converge into the Nilgiri hill complex. It is located in the Western part of Deccan peninsular region of India. The state is bounded by Maharashtra and Goa states in the North and North-west; by the Arabian Sea in the west; by the State of Andhra Pradesh in the East. The State extends, to about 750 km from North to South and about 400 km from east to west (Fig. 1.1).

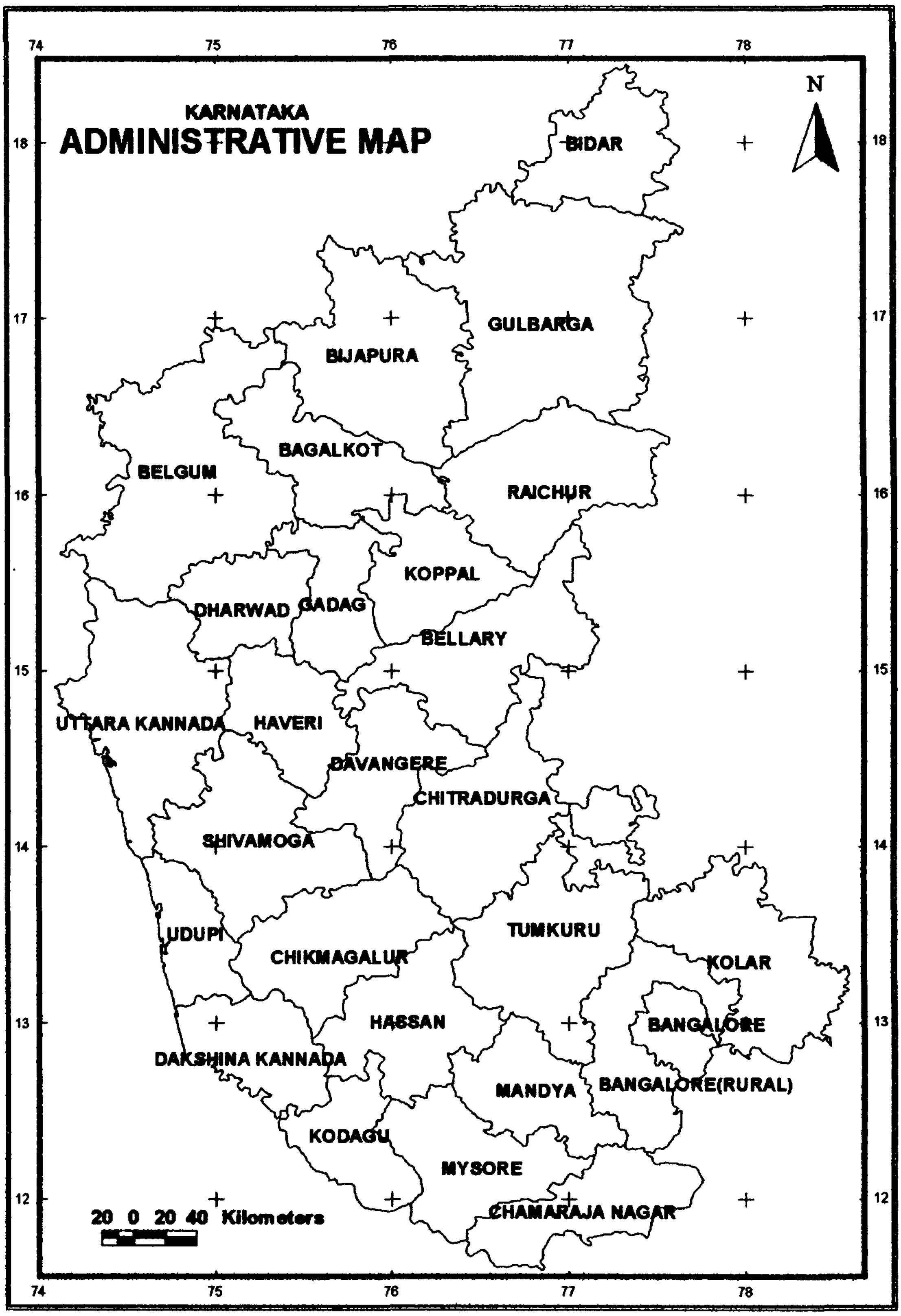
KARNATAKA
ADMINISTRATIVE MAP
N
BIDAR
GULBARGA
BIJAPURA
BAGALKOT
BELGUM
RAICHUR
KOPPAL
DHARWAD
GADAG
BELLARY
UTTARA KANNADA
HAVERI
DAVANGERE
CHITRADURGA
SHIVAMOGA
TUMKURU
UDUPI
CHIKMAGALUR
KOLAR
HASSAN
BANGALORE
DAKSHINA KANNADA
MANDYA
BANGALORE(RURAL)
KODAGU
MYSORE
CHAMARAJA NAGAR
20 0 20 40 Kilometers
74
75
76
77
78
18
17
16
15
14
13
12

FIG : 1.1

## AREA AND POPULATION

Karnataka's total land area is 1,91,791 sq. km. It accounts for 5.83 percent of the total area of the country (32.88 lakh sq. km) and ranks eighth among major states of the country in terms of size. As per 1991 census, the state's population was 449.7 lakhs. It was 5.3 percent of whole Indian population of 8,463 lakhs. Among different states, Karnataka occupies eighth place with regard to population. The density of population as per 1991 census was 235 persons per sq. km, which was lower than the country's overall density of 273 persons per sq km (among the States, Karnataka was in the thirteenth position).

Karnataka has been divided into four Revenue Divisions, 52 subdivisions, 27 Districts, 175 Taluks and 745 hoblies/ Revenue circles for administrative purposes.

## WATER RESOURCES

Karnataka accounts for about six per cent of country's surface water resources of 17 lakh million cubic metres (Mcum). About 40 per cent of surface water resources is available in the east flowing rivers and the remaining from west flowing rivers.

## GROUND WATER RESOURCES

Traditionally, ground water in the state has been exploited by open dug wells, constructed in the weathered mantle. After fast drilling rigs became available, borewells have been drilled extensively, tapping the water stored in rock fissures and fractures.

About 4.4% of India's ground water resources (2.7 lakh Mcum) lie in Karnataka. The total annual recharge of ground water estimated in the state is about

17,99,591 hectare meters (ham). Net annual utilization is estimated at 5,76,921 ham as on 31-3-1991. In the Malnad region, the annual recharge is estimated to be 10% of the annual rainfall. In the region where the rainfall is less than 700mm, the evapotranspiration is also high and the re-charge is less than 5% for the rest of the state. The recharge is estimated to be between 5 to 10%. As per Minor Irrigation Census 1986-87, there were more than 3.5 lakh open dug wells in the State. The depth to water level in these wells, from the surface ranges between 2 to 3.5 metres in valley regions and in some places the depth goes even upto 18 metres. A large majority of the wells dry up in summer. Nearly half of the open wells are in a poor state of maintenance.

There were 38,899 shallow and 6,673 deep tube wells as per the above census. During recent years, borewells are increasingly coming into prominence. These are generally 150 mm in diametre and drilled to depth ranging from 30 to 60 metres. The average yield ranges from 60 to 80 litres per minute. During 1993-94, there were 1,64,728 borewells, 4,70,981 wells used for irrigation purpose, 3,03,698 wells used for domestic purpose and 74,730 wells were not in use.

**CLIMATE**

The state enjoys a tropical climate. The winter season from January to February is followed by summer season from March to May. The period from October to December forms the post-monsoon season. The period from October to March, covering the post-monsoon and winter seasons, is generally pleasant over the entire state except during a few spells of rain associated with north-east monsoon which affects the south-eastern part of the state during October to December. The months April and May are very hot, dry and generally uncomfortable. Weather tends to be oppressive during June due to high humidity and temperature. The next three months

(July, August and September) are somewhat comfortable due to reduced day temperature although the humidity continues to be very high.

**RAINFALL**

The annual rainfall in the state varies roughly from 50 to 350 cm. The rainfall increases significantly in the western part of the state and reaches its maximum over the coastal belt. The southwest monsoon is the principal rainy season during which the state receives 80% of its rainfall. Rainfall in the winter season (January to February) is less than one per cent of the annual total, in the hot weather season (March to May) about 7% and in post monsoon season about 12%.

Out of the 14 heavy rainfall stations in India, with annual rainfall of more than 500 cm., four stations are situated in Karnataka. They are Agumbe in Tirthahalli taluk of Shimoga district (annual rainfall 828 cm) and Bhagamandala (603 cm), Pullingoth (594 cm) and Makut (505 cm) in Kodagu district. Agumbe can be called as the Chirapunji of Southern India.

**FOREST**

Karnataka State has a geographical area of 1,91,791 sq km of which 38,284 sq.km (19.96 per cent) is under the control of the forest department. The percentage of forest area to geographical area in the state is less than the country's overall average of about 23% and 33% prescribed in the national Forest policy.

## 1.5 BRIEF RESUME OF PREVIOUS INVESTIGATION

Generally, the water quality of rivers is best in the headwaters, where rainfall is often abundant. Water quality often declines as river flows through regions where land use and water use are intense and pollution from intensive agriculture, large towns, industrial and recreational areas.

Denitrification has been used for years in wastewater treatment but its application to water treatment is complicated by the dilute substrate and nutrient concentrations generally found in ground water (Gayle *et al.* 1986). Jurate *et al.* (2005) studied the Chemical evaluation of potable water in Eastern Qinghai Province, China.

Chemical and Physical baseline survey data are an important pre-requisite for monitoring hydrological changes. The rate of environmental change in modern times is relatively rapid. Industrial and agricultural developments have accelerated pollution. Climate change and other factors may also soon become important. Petters *et al.* (1985) worked on the Physico-Chemical quality of Mokuro Dam in Ile-Ife, Nigeria. Robin (1998) studied the quality of Shallow groundwater in Northen Ireland.

Heavy metals such as Zinc, Copper, Manganese and Iron are essential for the growth. However these are likely to show toxic effects when organisms are exposed to a level higher than normally required. Other elements such as Lead, Chromium, Nickel, Mercury and Cadmium are generally not essential for common metabolic activities and exhibit toxic properties (Rezaul *et al.* 2005). Yoshiyuki *et al.* (1992) have reported Physico-Chemical speciation of trace elements in river water by size fractionation.

Like agriculture and transportation, mining is a transitory use of land. The degree of pollution due to coalmine drainage can be evaluated by determining the various water quality parameters. Mas-Pla *et al.* (1999) studied the ground water resources and quality variation caused by gravel mining in coastal streams in North Eastern Spain. According to them, instream mining has caused a decline of water table head of the unconfined aquifer along the Fluvia River. Further, dredging in its lower most reaches reduces its stages and decreases its stop to zero, which facilitates mixing with sea-water and thus salty water intrusion from the river into the aquifer.

Moshood (1996) has reported on Iron in shallow groundwater in Moro area, Kwara state, Nigeria. Belgihan Nas *et al.* (2005) studied ground water contamination in the city of Konya (Turkey). They have evaluated this by using GIS technology. Nair *et al.* (2005) observed nitrate pollution in the groundwater of some stations in North East Libya. They found that certain parameters like EC, TDS, Alkalinity, Chloride and Copper were generally high in many stations. Shahzad Afzal *et al.* (2000) has examined the extent of pollution in Hudiara Drain water. The pollution here is due to untreated industrial and sewage waste of India and Pakistan.

Diffuse source contamination of water resources as a result of the use of livestock waste as fertilizers is increasingly recognized as an important problem. Vidal *et al.* (2000) has investigated the effects of slurry application on water quality in wells, pasture - drainage conduits and rivers. They concluded that, in all water resource types of study area, contamination was most severe in the area of highest livestock density and highest frequency of slurry application.

In India, the percentage of sewered population is nearly negligible in most of the rural areas and is quite meager (0 to 50%) in most medium and small towns. As a result, the contamination of groundwater by pollution from unsewered areas is one of the most important environmental problems facing the country.

About 80% of India's population lives in villages and 90% of its rural population depends on agriculture and allied activities for their livelihood. Ground water is the major source of drinking water in rural areas in India. However, uncontrolled extraction without commensurate recharge and leaching of pollutants from pesticides and fertilizers into the aquifers has resulted in pollution of ground water supplies.

Shoe Kumar *et al.* (1996) have reported that the river water as well as, municipal, and bore well waters were highly polluted in Bhagalpur. Garg, *et al.* (2004) conducted hydrochemistry of underground drinking water in Southern zone of Hisar city. Sunitha *et al.* (2005) carried out studies on hydrogeochemstry of ground water of Gooty area in Andhra Pradesh. Dhankar, *et al.* (2004) conducted water quality assessments from different regions of Mahendergarh, Maharastra.

Of late, the disposals of urban domestic sewage and industrial effluents into water bodies have acquired dimensions of a serious nature. These pollutants produce severe harmful effects on aquatic ecosystems, which include damage of food chain components, reduction of reproductive ability of aquatic organisms and fishery potentiality and productivity (Manzer, *et al.* 2005). Almost all rivers in India have become polluted with the domestic and industrial wastes.

Therefore, in many states in India, water quality studies have been taken up (Chakraborty *et.al.*, 1959, Bhagarva, 1985 and Khadsan *et.al.*, 2004 Amathussalam, *et al.*, (2004), Dwevedi, *et al.* (2004) and Sajay, *et al.*, (2004)).

Ikbal *et al.* (2004) carried out studies on the effect of irrigation on the water quality of a village situated near river Kothari, Rajasthan. According to them, groundwaters of 6 villages are unsuitable for irrigation purpose due to the impact of a textile industry in Bhilwara city.

Groundwater pollution due to Nitrate, Iron and hardness has been reported by Usha Madhuri *et al.* (2004) in commercial areas of Visakhapatnam. Studies on Nitrate concentration in ground water from unconfined or confined aquifers in India have shown that in a majority of cases the Nitrate concentration exceeded 50 mg/L (Sunita *et.al*, 2004). Water pollution due to rising Nitrate level in some parts of Jaipur was observed by Shalini, *et al.* (2001).

Thirunganana *et al.* (1994) have analysed the water quality of the coastal aquifers of Tuticorin, Tamil Nadu. From the study they found that the area was affected by salt water contamination which will have to be considered for any development activity. Venkateswaran *et al.* (1993) carried out some Hydrogeochemical studies of Cumban Valley, Madurai District of Tamil Nadu.

Nidhi *et al.* (2004) have revealed ground water contamination was due to the presence of industries in Ranjhi areas of Jabalpur. Dhankar *et al.* (2004) have attributed high levels of EC in government canal of Shamura and tank water of Pali and Kharkara due to detergents coming from washing of clothes and other pollutants by villagers. They found a high concentration of fluorides in potable water, which may cause serious health hazards including dental and skeletal fluorosis. Secondary neurological complications are due to the locations of the well sites which that are exposed to laundry and seepage of fertilizers in addition to the geochemical composition of their soils.

Sanjay Gupta *et al.* (2004) have shown a high fluoride content of ground water of Sanganer area, Jaipur in Rajasthan. This is due to the occurrence of fluoride apatite and certain amphibole cryolite (in igneous rocks and fluorspar in sedimentary rocks). Pande (2005) has studied the status of fluoride in Chetrawati river water and ground water of Puttaparthi town, which is used for drinking water. He found fluoride in higher concentration than the permissible limits both in surface and ground water.

Mishra *et al.* (2001) carried out studies on the quality of Drinking water in Rourkela. They opined that the water treatment facilities should be improved to control, Iron, Turbidity and pH of water. Jain (2004) examined ground water quality of Dehradun district with reference to trace element contamination. He found Iron and nickel in higher concentrations than the permissible limits due to the weathering of rocks and discharge of effluents on land. Prajapati *et al.* (2005) have reported that all the well water samples from Sheopur town in MP state is contaminated and unfit for drinking purpose during the rainy season. It is, however, uncontaminated during summer and winter seasons.

Discharge of acid drainage from surface coal mine areas to the surface water changes the quality of water in lowering of pH, reduction of natural alkalinity, increase of total hardness and amount of Iron, Manganese, Aluminum and other elements (Tiwari, 1996). Tripathy (2005) has worked on the water quality index for some coalmines of Jharia coalfields.

Wagh *et al.* (2005) carried out studies on the impact of heavy metals on soils and ground waters in Nasik city. They reported that in the ground water samples, the concentration of Copper, Zinc and Iron was found to be higher than the desirable limits. The higher concentration of iron in ground water is due to the streams carrying industrial effluents around the areas from where the samples were collected.

All ancient civilizations emerged on the banks of rivers. Rivers have been central to the growth of human society. The river is an indicator of the society's standards. A dirty river means a dirty society. In order to save the water quality of the rivers there is a need to water quality of the river. There is a need to create a data base report on the water quality for the future (Rajeshwari Devi, 2005). Subramanian *et al.* (1987) have reported that the heavy metal distribution in the Ganges and Brahmaputra vary spatially and temporally.

An essential goal for the provision of safe drinking water is that, it should be essentially free from (low risk containing) disease causing microorganisms. The ability to easily, rapidly and affordably detect faecal contamination in drinking water is still a desirable and worth endeavor in the overall effort to provide microbiologically safe drinking water (Tambekar, *et al.* 2005).

All natural waters (rivers, lakes etc.) contain microorganisms but ground water usually has fewer microorganisms than the surface water because of its long travel time in the subsurface environment (Abdul *et al.,* 2005). Pandit *et al.* (2005) have studied the Physico-Chemical and Bacteriological studies of ground water in Bhavnagar city, Gujarat.

Agarkar et.al (2005) reported that microbiological parameter such as MPN of Coliforms were found above the permissible limits in drinking water of schools in Buldana District of Maharastra. This may be due to the presence of stagnant waters in the nearby water source, where domestic sewage runs through an improper drainage, open field defecation and improper method of disinfections of water.

The ground water of Sanganer Tehsil in Jaipur District is demonstrated as unfit for human consumption as it may lead to various health problems like dental, indigestion, growth retardation, fatigue and crippling fluorosis (Sharma *et al.,* 2005). They (Sharma *et al.,* 2005) have reported that the groundwater of Sanganer Tehsil of very poor quality.

Pandey *et al.* (2005) have reported that the marble slurry leads to deterioration of ground water quality in Kishagarh and later Madhavi *et al.* (2005) who has studies the ground water quality of the marble industrial area of Kishangarh (Ajmer) in Rajasthan has reported that the ground water of this areas is not suitable for drinking purpose because of the marble slurry.

In Karnataka, water quality studies are not adequate- Jayanthi (1993), Ayed, (2002) Mahadev, *et al.* (2004) have investigated the water quality of some places. Meenakumari *et al.* (2003) have observed that Hardness, TDS, Calcium and Iron were very high in the ground waters in Mysore city. Thirumala *et al.* (2005) have reported that water quality in Ayyankere Tank of Chikkmangalore District was good and could be used for drinking irrigation and agriculture. The significant contribution to the field of fresh water ecology from this region for the past two decades are by Bharathi and Hosmani (1973, 1977) on Hydrobiology studies in pond and lakes of Dharwad. Somashekhar (1978) has studied river water quality around Mysore. The subsequent work is that of Ayed (2003) who studied water quality in polluted lakes around Mysore.

Mahesha *et al.* (2004) have studied on Physico-Chemical characteristics of borewell water in Arsikere Taluk, Hassan. They observed that, fluoride concentration is very high in all the sample stations and such ground waters are not suitable for drinking purpose without prior treatments. Due to a high concentration of fluoride, mottling of dental enamel in cattle and people, skeletal fluorosis and forward bending of vertebral column, deformation of knee joints and of body in the persons who live in that area is common. Manjappa *et al.* (2004) have also reported a high fluoride level in the groundwater samples of Davangere District.

Sachidanandamurthy *et al.* (2004) have studied Yennohole in Mysore district. They have recorded higher values of Alkalinity, Phosphate, Nitrate and BOD when compared to the desirable limits. Recently, Devaraju *et al.* (2005) studied the Physico-Chemical parameters of Maddur Lake in Mandya District with reference to find out the suitability of water quality for aquaculture.

Narayana *et al.* (2005) investigated the drinking water quality of Basavanahole tank (Shimoga District) with reference to Physico-Chemical characteristics. Suresha *et al.* (2005) carried out studies on heavy metal pollution in River Tunga, Bhadra and TungaBhadra at Kudali near Shimoga, Karnataka. Manjappa *et al.* (2005) also have studied the heavy metal distribution in water and sediments of the river Bhadra near Bhadravathi town, Karnataka. They have concluded that all the metals in river water except iron and Manganese at above areas are well within the limits of BIS standards. This can be attributed to discharge of industrial effluents and municipal wastes, geology of river bed and catchment areas.

Vijaykumar *et al.* (2004) worked on water quality management for Jagath Tank of Gulbarga district during pre monsoon, monsoon and summer- seasons. Harish *et al.* (2004) worked on evaluation of ground water quality in Tarikere Taluk. They proved that the quality of the ground water in the studied area varies from bore well to bore well.

Lakes are maintaining the groundwater table and also act as sediment and prevent clogging up of natural valleys and reduce erosion by regulating run off. Over the years, they have acquired the status of wetlands, wherein their ecological and biological role also becomes significant (Kanchan, 2001).

The chemical water quality functioning of river systems is important in relation to ecological status and environmental management. For example, nutrient environment, resulting in excessive growth of aquatic plants and reduction in dissolved oxygen is a growing problem particularly in the lakes of the rural areas (Neal *et al.* 2005).

The above researchers have contributed only to Physico-Chemical parameters. Microbiological analysis has so far not been done on a wider scale. Therefore, the present work is taken up.

### 1.6 ORDER OF PRESENTATION

The thesis is conveniently divided into 7 chapters and the aspects covered are as follows:

**Chapter One, Introduction** - which is introductory, deals with the aims and objectives of the present work, importance of the study, brief details of the study area and an overview of previous investigations carried out in this field.

**Chapter Two, Environmental Settings** - deals with the study of physiographical conditions including Geology of Karnataka and drainage, environmental conditions and environmental problems have been described.

**Chapter Three, Materials and Methods** - consists materials and methods which deals the analytical methods, sampling and preservation of different water samples including the details of the instruments used for the study, methods of interpretation and location and code number of samples with respective to the location maps.

**Chapter Four, Interpretations of the results** - deals with regional qualities of Physico-Chemical of water, Heavy metals and microbiological parameters, interpretations, hydrochemical facies. The observed values from the study has been analysed briefly and presented in tables

**Chapter Five, Water Quality Comparisons-** water quality comparisons with overall world, observed values and impacts of Physico-chemical of water, Heavy metals, microbiological condition and distribution of Facies are discussing. It also compares the results with earlier studies, which show the important differences between the present study and also the differences due to the standards chosen for study

**Chapter Six, Statistical Analysis** - gives an overview of the methods of Statistical Analysis that include Cluster analysis, correlation analysis and Hydrochemical condition. The variation patterns, reasons for some of the peaks, and major differences found are explained.

**Chapter Seven, Summary and Conclusion** - concludes the thesis by giving the summary and conclusions arrived in this work. The chapter also highlights those areas where in-depth work is still to be made to draw further conclusions.