Chapter 1

INTRODUCTION

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Water is the most versatile liquid which sustains life on this planet and plays vital role for developmental activities. It makes up 50-97% of the weight of plants and animals and about 70% of the human body weight. Water is an essential natural resource for the existence of man and other forms of life. But now this precious natural resource is under threat either from over exploitation or from pollution, exacerbated by human activities and is the most poorly managed resource in the globe (Fakayode, 2005). The most significant public health problems in both rural and urban India is inadequate access to clean water and poor sanitation. The availability of water, proper sanitation facilities and good hygiene services are vital for the protection and development of human resources.

Howard et al. (2003) have pointed out that water contamination can be caused due to seepage from waste lagoons or contaminated surface water or subsurface source of contamination such as septic tanks, broken or leaking sewer lines or an old or improperly designed land fill. Sanitary surveys are usually carried out in and around the wells to assess the drinking water quality and level of contamination.

Unsafe water, poor sanitation and deficient hygiene affect the life of an estimated 1.7 million people annually, particularly as a result of diarrhoeal
diseases (WHO, 2002; Ashbolt, 2004). The major proportion of all water quality degradation worldwide is due to anthropogenic causes (Faniran et al., 1994). Drinking water has become a major habitational source of microbial pathogens in developing regions, in addition to poor sanitation and food sources which are potential areas of enteric pathogenic exposure. World Health Organization estimates that about 1.1 billion people globally drink unsafe water (Kindhauser, 2003) and the vast majority of diarrhoeal diseases in the world (88%) is attributable to unsafe water, sanitation and hygiene (WHO, 2003b).

Howard et al. (2002) have pointed out that more than half of the world’s population living in villages in rural areas are without access to safe drinking water. Ground water is a relatively safer source of potable water in rural areas compared to other unprotected water sources like rivers, springs etc. The lack of safe drinking water supply, basic sanitation and hygienic practices are attributed to high morbidity and mortality from excreta related infections and communicable diseases. Inadequate quantity and quality of drinking water and lack of sanitation facilities cause millions of world’s poorest people to die from preventable disease every year. The victims are predominantly children and women.

Water is the most important fluid nutrient in human diet. It is used both generally and specifically for the purpose of quenching thirst and also for entertainment. So its quality and quantity needs to be monitored regularly. Water quality is a critical factor for determining the usability and reliability of any particular water source. The studies done by Roy and Prakasam (2003) revealed that all drinking water sources in the Kollam region (Kerala State) including open dug wells, tube wells and tap water sources were not safe for drinking due to high percentage of faecal and total coliforms.

The quality of groundwater depends upon the geologic, climatic, environmental, biological and other anthropogenic activities. Rapid growth of population coupled with urbanization and industrialization poses serious concern to the vulnerability of water resources. Water is the most essential commodity for human consumption and hence it must be prevented from deterioration.
in quality. Good quality of drinking water may be consumed in any
desired amount without adverse effect on health, such water is called “potable”.
It should be free from harmful level of impurities such as bacteria, viruses,
minerals and organic substances. It should also be aesthetically acceptable, should
be free of unpleasant impurities, objectionable taste, color, turbidity and odour
(Haman and Bottcher, 1986).

Ground water contributes 0.61% of earth’s total water resources (Subramanian, 2000) which forms one of the principal sources of drinking water all over the world. It is estimated that by the year 2025 about 350 km$^3$ of ground water will be required for India (GOI,1999). In India, rivers, dams, ponds and ground water resources are used for agriculture and domestic purposes. The consumption and utilization of these water sources raise several environmental issues. The major one is how far the quality of water used is safe for domestic purpose, the second one is how far the water resources of the country will meet the demand of rapidly growing population. The first issue is a major environmental problem causing serious human suffering as a high percentage of water used for drinking and domestic purposes is unsafe. The problem is the contamination of water with human and industrial wastes, effluents, agricultural run off and deteriorating quality of surface water.

Water quality is a term used to define the physical, chemical, biological
or radiological characteristics by which a particular variety of water may be
evaluated in order to establish its acceptability for various beneficial uses
(AWWA,1971; Coulston and Mark,1977). Various physico-chemical parameters
like pH, alkalinity, total hardness, total dissolved solids, calcium, magnesium,
nitrate, sulphate, phosphate have some significant role in determining the
potability of drinking water. These parameters change widely due to many
factors like source of water, type of pollution, seasonal fluctuations etc.

Deterioration of water quality can be broadly attributed to the following
factors viz., pollution of aquifers due to industrial and domestic effluents.
Prolonged consumption of drinking water having certain chemical pollutants
in excess of recommended limits has been found to be associated with
health hazards. There are short-term and long term health risks associated with contaminated water. These may be microbial (bacteria, viruses, parasites), chemical (metals, pesticides, disinfectants by-products, etc.) or toxin related (toxins produced by microorganisms).

Studies have established with evidence the presence of disparities between coastal, midland and highland areas with respect to the quality of ground water as well as of other natural sources. Proper knowledge of the area wise distribution of contaminants as well as of the influence of anthropogenic factors on groundwater loadings is necessary to protect the quality of water at stipulated levels (Zanho and Grim, 1993).

In developing and underdeveloped countries “protected water for all” is still a far cry from reality. In the rural areas people use unprotected water drawn from rivers, lakes, and wells for drinking and domestic purposes. Hydrological investigations are very important for evaluating ground water quality. Central Ground Water Board (CGWB, 1997) studied the ground water provinces and water quality of well waters of the different parts of the state and published many reports. Quality of surface and ground water is inadequate even for customary living and is getting deteriorated due to unwise utilization of water resources, dehumanizing manner of urbanization, industrialization and other developed activities (Elayaraja, 2003).

1.1 GROUND WATER

Water that falls on the earth’s surface in the form of rain percolate through soil and occupies in the subterranean permeable layers is known as ground water. This water occupies the space between the soil particles of an aquifer, a water bearing stratum or formation. In other words, ground water is the water held in the rocks underground by certain forces, replenished by nature according to the climate and local geology and consequently valuable in both amount and quality (Ramakrishnan, 1998). Ground water is a major source of fresh water and fulfils about 97% of fresh water requirement. The great advantage of ground water is its use for drinking purposes without any treatment. Ground water acts as a reservoir by virtue of large pore spaces in earth.
materials as a conduit that can transport water over a long distance and as a mechanical filter that improves water quality by removing suspended solids and bacterial contamination (Harikumar et al., 1999). The quality of ground water is influenced mainly by the quality of its source. Municipal and industrial waste seepage into aquifer is a major source of both organic and inorganic pollution (Tomar, 1999). In urban centers the ground water is exposed to more threat than in rural areas. Groundwater contamination is generally irreversible i.e., once it is contaminated, it is difficult to restore the original water quality of the aquifer. At present about 70% of the population in Kerala depend on open wells for meeting their domestic water requirements.

Water is scarce and in general, a low quality resource in hilly areas. Therefore microbiological and chemical surveillance of drinking water quality is an important component of public health management, particularly in water deficient areas. The greatest risk is in the form of microbial contamination of water used for household consumption. The predominant source of such contamination is human and animal excreta, although other sources and routes of exposure may also be significant. Continual attention to water quality has virtually been a precondition to the eradication of water borne diseases from developed countries (Tebutt, 1983).

Infectious diseases caused by pathogenic bacteria, viruses and parasites are the most common wide spread health risk associated with drinking water. The public health burden is determined by the severity of the illnesses associated with pathogens, their infectivity and populations exposed. The pathogens that may be transmitted through contaminated drinking water are diverse. The occurrence of pollution indicator bacteria (PIB), determined as total and faecal coliforms are used as parameters for the evaluation of the quality of drinking water (WHO, 1971).

The chemical composition of ground water depends upon diverse factors such as soluble products of rock weathering, decomposition and transformations occurring over time and space in addition to the nature of polluting agent (Mariappan et al., 2000). There is always a need for and concern
over the protection and management of groundwater quality as well as surface water. Doran and Linn (1979) have reported that an estimated one third of the pollutants of animal origin gets into ground water and contribute to pollution. Ground water usually contains negligible amounts of suspended and organic impurities along with an appreciable amount of mineral impurities such as calcium, magnesium, iron, bicarbonate, carbon dioxide, sulphate, chloride, nitrate, finely divided clay etc. The traces of these minerals find their way into surface water and ground water due to the disintegration of mineral deposits and insoluble carbonate or of alumino-silicate rocks. These processes are augmented by the combined action of high underground temperature, hydration, dissolved oxygen and carbon dioxide as well as the action of organic acids produced by aerobic and anaerobic decay of organic matter with which the water has been in contact (Veramani and Narula, 1989). Ground water pollution occurs when waste materials are discharged into pits, ponds, lagoons etc. enabling the waste to percolate downwards to affect water table.

Deterioration in the quality of ground water due to pollution, large scale overdraft on reserves and indiscriminate disposal of industrial, human and agricultural waste pose a grave threat to the quality of ground water. Frequent outbreaks of water borne diseases are being reported in regions marked by a pathetic absence of proper sanitary conditions and monitoring facilities. Water pollution is widely and frequently caused by human activity where the pollutants discharged into water bodies include oxygen demanding wastes, disease causing gents, plant nutrients, municipal sewage, synthetic organic compounds, oil, sediments, industrial effluents etc (Tyagi, 1998). In recent years, because of the continuous and disproportionate growth in population, and rapid industrialization without proper technologies for waste disposals, the rate of discharge of the pollutants into the environment is far higher than the rate of their neutralization and detoxification. According to a WHO estimate (Bhuvaneswaran et al., 1999) about 80% of water pollution in developing countries like India is caused by domestic wastes released indiscriminately into water bodies.
Increasing population and its necessities have lead to the deterioration of surface and subsurface water (Damodharan and Suresh, 2005). Exponentially increasing urbanization in India is producing large amounts of sewage (about 12500 million liter/day) which has become a serious environmental threat (Kumar and Sagwal, 2000). Due to the rise in soil pollution caused by the dumping of municipal wastes, industrial wastes and heavy use of chemical fertilizers in agricultural land, the properties of underground water are also seen to change. Therefore, it is most essential to analyse underground water to study the variations in quality parameters. Based on certain stipulated physico-chemical parameters, water quality could be rated for various uses such as agriculture, drinking, industrial etc., for their judicious and effective use (Aishwath, 2005). The nature and concentration of various ions in water, particularly the proportion of the divalent and monovalent cations are important for judging water quality (Ghosh et al, 1983).

Variation in ground water quality occurs from place to place, and at particular places it is related to factors ranging from season to depth. Both declining and rising water tables are found to be unfavorable for ground water quality (InderJeet, 2005). The quality of ground water in an area is of great importance for human consumption and irrigation. Ground water irrespective of the source of its origin contains mineral salts and that have their own chemical properties. The category and concentration of these constituents depend upon various geological and physical factors. Most of these factors vary from place to place; the ground water of any region is distinguished by its own physical attributes and chemical content. Since the quality of the water is directly or indirectly dependent upon its intended use, there is always a need to classify the ground water on a regional basis.

Uncontrolled dumping of domestic solid waste on land results in environmental, social and health problems. The adverse impacts of such landfill are contamination of underlying soil and ground water, health hazards to workers, waste pickers and neighboring communities, proliferation of vermin and poor air quality around the landfill site due to intentional burning
of waste. Percolation of leachate from uncontrolled landfill site into the soil aquifer is a serious problem of water environment (Dhage *et al.*, 2005).

India is a vast country with diversified geological, climatological and topographic settings which give rise to divergent ground water situations in different parts of the country. The rainfall pattern too shows similar regional variations. The factors of topography and incidence of rainfall are factors that virtually control run-off and groundwater recharge (CGWB, 2002). Ground water resources have two components viz., static and dynamic. The static fresh ground water reserves of the country have been estimated as 10812 b.cu.m. The dynamic component is replenished annually which has been assessed as 432 b.cu.m. The use of ground water has several advantages over surface water which include (1) availability of ground water as a naturally occurring reservoir in contrast to a specific localized surface source, (2) less susceptibility to evaporation losses and climate variability compared to surface water bodies like lakes and dams, (3) generally superior quality (for most parameters) than surface waters due to the filtering effects of overburden soil and (4) less vulnerability to anthropogenic activities. Despite these advantages the quality of ground water can be impacted by unscientific patterns of land use particularly in urban environments where remediation of polluted ground water is very difficult to achieve. Water utilization is influenced by water quality, whether it is abstracted for drinking, industrial, recreational or irrigation purposes. Geology, hydrology (rain fall and runoff distribution and movement through the soil profile and aquifer) and pollution (source, type and disintegration) are the major factors influencing the quality of ground water. Humid regions tend to have good water quality due to frequent rainfall and perennial discharge, while arid regions tend to have relatively good to poor ground water because of limited rainfall.

The topography and landforms have strong influence on well yield, especially shallow wells, as they influence the thickness of weathered zone (LeGrand, 1967; Henriksen,1995). Wells located in valleys will normally yield significant quantity of ground water than those located on steep slopes, sharp
ridges and interfluvial areas. Therefore, to a certain extent the yields from the well can be predicted using topographic considerations. Approximately two fifth of Indian agricultural production comes from areas irrigated with ground water, and about 1.93 lakh sq.km area in the country is estimated to be affected by the problem of inland salinity in ground water (Chanda, 2000).

Over 65% of Indian villages use well water (ground water) for domestic purposes. Rivers, lakes and springs come next in importance, being used in about 15% of the villages. Less than 2% of the villages are served with protected water supply. Eight percent utilize tube-well water while rest depends on tank, ponds and sundry resources (Kapoor, 2001).

The annual rainfall of Kerala is about 3000mm, the bulk of which (70%) is received during the South-West Monsoon. The Ground Water Year Book of Kerala (1994) contains detailed source of ground water recharge through rainfall and the occurrence and movement of ground water which is controlled by physiography and geological setting. A rough estimate of the source wise dependence of rural households for domestic water supply tells us that about 80% of rural people depend on traditional ground water system, 10-15% on piped water supply system and 5% on traditional surface and other sources.

1.1.1 Ground water potential of Kerala

Although water is the most abundant liquid on the planet, nearly 1.2 billion people do not have access to safe drinking water (Reshma and Prakasam, 2003). Out of the total world population, only 20% has the benefit of safe drinking water. Similarly India receives about 400 million hectare meters of precipitation every year but only 10-12% people get clean drinking water and rest are left with no safe source of water (Jivendra, 1995). About 4% of the world population is estimated to use as much as 400 liters of water per day (Rajavaidya and Markandey, 1998).

Ground water potential of Kerala is very low as compared to other states in the country. The estimated ground water balance is 5590 Mm³. Dug wells are major ground water extraction structures in Kerala. Dug wells have a maximum depth of 10-15 m and a diameter of 1-2 m in coastal regions and
2-6 m in the midland and high land regions. The open well density in Kerala is perhaps the highest in the country, 200 wells /sq.km in coastal region, 150 wells/sq.km in the mid lands and 70 wells/sq.km in the high land areas (Anon,1991). All India censuses (2001) have reported that 76% of people of Kerala depend on well water for drinking purpose.

The rate of ground water withdrawal is estimated as 980 Mm$^3$ and the State Ground Water Department has assessed the effective discharge as 8134 sqMm$^3$. Drastic depletion of ground water level during the summer season and the resultant drying up of wells are common features in many parts of Kerala. Depletion of groundwater table due to indiscriminate sand mining, shrinkage of natural forest cover and reclamation of wetland and paddy field has resulted in drinking water scarcity in several parts of southern Kerala. Apart from the rivers and wells, other sources like tanks, ponds and springs provide water for drinking as well as irrigation in Kerala. Natural springs that occur in the highland regions of the Kerala State have the potential to be developed as good sources of drinking water supply, especially in remote and underdeveloped areas.

With regard to ground water, water quality characteristics of wells in Kerala are found to be affected by biological and chemical contaminants. Open wells of Kerala have been found to be seriously affected by bacteriological contamination (Malayala Manorama, 2007). In Kerala about 60% of the population relies on ground water for drinking. The open structure of the wells, conventional or even non-existent maintenance habits, and use of buckets and ropes to draw water, indiscriminate disposal of kitchen wastes, pit latrines with an average family load factor of 5 members at a distance less than 15m from wells are some of the factors which are found to be contributing to bacteriological contamination. There is still a dearth of proper information on health risks related to water stress and sanitation deficiencies, particularly in rural and less developed areas. The WHO has taken a leading role in developing and promoting the use of environmental health indicators (EHI), that are intended to ensure the safety of drinking water and sanitary facilities in proportion to the population (WHO/UNICEF,1993; Murray,1994).
People residing in various parts of Pathanamthitta district of Kerala State also lack adequate access to safe drinking water as they mainly depend on ground water for drinking and domestic purposes (Janakeeyaasoothranam, Vikasanarekha, 1996). The tribal people residing in the hilly areas of the district also depend on well-water, river water and other drinking water sources like ponds, streams and "olis" for domestic purposes. This study is an attempt to analyse the physico-chemical and bacteriological characteristics of the ground water of tribal areas and rural areas (better developed than tribal area) of the Pathanamthitta district in Kerala.

1.2 SURFACE WATER

Lotic water bodies like rivers and streams play a very important role in maintaining biodiversity and ecological balance in nature. Rivers are the most fascinating and complex ecosystems in tropical and subtropical regions. For centuries, mankind has been enjoying the natural benefits provided by rivers without much insight into how the river ecosystem functions and maintains its vitality. Recent advances in ecological studies reveal that most of the world’s rivers are under threat consequent to over exploitation of natural resources as well as discharge of toxic contaminants from various sources. But now the fluvial systems is getting deteriorated due to the disposal of wastes into them and results in jeopardizing survival of aquatic life.

Rivers which are the most prominent sources of irrigation, are used as repositories for disposal of domestic sewage, industrial effluents containing toxic substances and heavy metals, agricultural run off etc. There are also certain non-degradable substances and often accumulate through trophic level causing a deleterious biological effect. Nowadays, maintenance of healthy aquatic ecosystems is very essential and is dependent not only on physico-chemical characteristics but also on the biological diversity of aquatic ecosystems.

Quality of surface water is degraded by point and non-point sources of pollutants. Surface water is by nature rich in turbidity, suspended impurities of decaying organic matter, sand, finely divided clay, microorganisms, bacteria and traces of mineral salts (Ca, Mg, Na⁺, SO₄, Cl⁻ etc.) dissolved
Studies on the status of drinking water quality of Pathanamthitta District (Kerala State, India) with special reference to tribal settlements.

From top soil (Veramani and Narula, 1989). The quality of water from a river depends mainly on factors such as character and areas of catchment, topography, extend and nature of development of catchment by human beings and weather as well as seasonal conditions. Generally water is available in adequate quantity from non-perennial rivers throughout the year, but normally gets depleted in the summer when demand for water is maximum (Sharma and Kaur, 1998).

Non-static bodies of surface water usually carry low contents of salts, whereas groundwater tends to have a high content of soluble salts (Livingstone, 1961). The amount and ratio of constituents of salts are significant factors that determine the quality of water to be used for irrigation. Kerala, the south west State of India, known as “God’s own country”, and is bestowed with 44 rivers that play a pivotal role in the social, economic as well as cultural life of its people. Water supply schemes of the State are largely dependent on strategically constructed dams across these rivers.

As per the national norms, rivers with a drainage areas of more than 20,000 km\(^2\) are to be considered as major rivers, those between 20,000 km\(^2\) and 2000 km\(^2\) as medium rivers and those rivers with less than 200 km\(^2\) as minor rivers (Rao, 1979). Kerala does not have a single major river and has only four medium rivers (Chaliar, Bharathapuzha, Periyar and Pamba) spanning a total area of 14454 km\(^2\). The remaining 40 rivers are only minor rivers with a total catchment area of 23430 km\(^2\). Anthropogenic, natural, chemical, biological and physical processes together with hydrological factors determine water quality. Growing population densities, progressive industrialization and intensification of agriculture tend to aggravate the pollution of surface water around the globe (Soman et al., 1997). It is reported that about 70% of India’s surface water resources is contaminated (Rao and Mamta, 2004). However the uses of such polluted river water by many settlements as well as downstream users, often utilize for various purposes such as drinking, recreation and irrigation which create serious health risk to the end users (Verma and Srivastava, 1990). The above information suggests certain control measures to protect riverine ecosystem for health, hygiene and sustainable environment.
Pathanamthitta district is drained by three major perennial rivers of Kerala - the Achencovil, Pamba and Manimala. The basin area of these rivers is 1484sq.km, 2235sq.km and 847sq.km respectively (James, 2000). Of these Pamba and Achencovil rivers drain more than seventy percent of the total area of the district. Sabarimala, a major pilgrimage centre is situated in the upper region of the Pathanamthitta district. During the pilgrimage season huge quantity of wastes and sewages are dumped into the river Pamba. The lower reaches of the Pamba also receive waste water from human settlements. Applications of pesticides and fertilizers in the plantations and wastes from rubber factories also deteriorate the water quality of Pamba, Achencovil and Manimala rivers. These rivers are also the victims of unregulated sand mining and unscientific patterns of urbanization. They are also the principal drinking water sources of this district.

The utilization of surface water for drinking purpose is largely through piped water supply schemes. The people residing in hilly areas and the tribal people depend on river water for their domestic purposes during summer seasons. Hence in the present study the attempt is to investigate the physico-chemical and bacteriological characteristics of water in these rivers.

1.3 MUNICIPAL WATER SUPPLY (WATER IN THE DISTRIBUTION SYSTEM)

The three municipalities demarcated in Pathanamthitta district in the present study are Adoor, Pathanamthitta and Thiruvalla. A majority of the population in these municipalities draw water from the municipal water supply schemes. Public water system is generally disinfected with chlorine. Chlorine usually provides residual disinfection throughout the public water distribution system. The action of chlorine on water is determined by many factors including duration of storage and temperature. Besides excessive nutrients such as nitrogen and phosphorus contribute to high levels of organic matter in extensive water supply system.

As water flows through the pipes from the treatment plant, its quality deteriorates due to the action of pollutants in the pipe causing corrosion, loss of pipe integrity and other various factors. According to the NSSO report
(1999) on drinking water and sanitation in Kerala only 28.8 percent of the households receive water of the stipulated quality. In rural areas only 10.1 percent of households are provided with piped water of the requisite quality, while the corresponding proportion in urban areas is 41.6 percent, which is the lowest in India compared to other major States. An attempt has been made to study the physico-chemical and bacteriological characteristics of water in the distribution system of the three municipalities of Pathanamthitta district.

1.4 SIGNIFICANCE OF THE STUDY

The area chosen for study is the Pathanamthitta district in the Kerala State of India. Situated near the Western Ghats and bordered by hills with tremendous tropical diversity, the district is adorned by fertile agricultural terrains, plantations and forests. This district faces water scarcity mainly due to hard rock formations in the perspective ground water zone. Severe drinking water problem in four districts including Pathanamthitta has been detected (James, 2000). Tribal people reside in the highland part of this district. In this study special emphasis has been given to tribal areas where scarcity of the potable water is very severe. People living in hilly areas, as well as downstream users, often utilize water from wells and rivers for drinking, recreation and irrigation purposes.

The tribal population, dispersed over numerous settlements and colonies in different parts of the Pathanamthitta district has strength of 6579 individuals (Tribal Department, 2003). From the estimates of the Government of Kerala, there are about 62 tribal settlements and 1672 tribal colonies in this district. Most of the tribal colonies are situated in hilly regions and they face severe water scarcity and related problems during summer, and also suffer from various water borne diseases. They depend on water sources such as wells, rivers, streams, ponds and “olis” (pit filled with water) for domestic purposes. Since most of the tribal areas are on sloping regions water supply system is ineffective. Hilly regions of Pathanamthitta district face severe water scarcity problem during summer seasons. For effective maintenance of water quality continuous monitoring of the physico-chemical
and bacteriological factors of water is necessary. Most of the wells in the tribal areas are panchayat wells maintained by the respective Panchayats. These wells are not subjected to proper maintenance and cleaning. All these could lead to water quality problems.

Fatally infectious diseases such as Chickunguinea, Dengue fever, Leptospirosis, Jaundice and Diarrhoea have been prominently reported from this district. So it is important to focus urgent attention on drinking water quality and its impact on health in the tribal areas as well as rural areas of the district.

A number of studies on groundwater quality with respect to drinking and irrigation purposes have been carried out in various parts of the State, but no work has so far been reported from Pathanamthitta district particularly from the tribal settlements.

River water sources are chiefly used by Kerala Water Authority for the supply of water through the public distribution system. People residing in municipal areas rely on public water supply for their daily needs. The pollution of surface water or river water directly or indirectly affects the ground water and water in the distribution system.

In the present study an attempt has been made to analyse the physico-chemical and bacteriological characteristics of drinking water in Pathanamthitta district in general giving emphasis to tribal settlements. The study is expected to help in evolving strategies to derive remedial measures and to avoid further drinking water quality deterioration in the district and also for developing a Total Water Quality Management (TWQM).

1.5 OBJECTIVES OF THE STUDY

1. To assess the water usage profile, sanitation facilities and waterborne diseases of Pathanamthitta district through survey.

2. To monitor the quality of ground water used for drinking in Pathanamthitta district at tribal and rural areas (better developed than tribal areas) with respect to physico-chemical and bacteriological factors over a period of two years.
3. To monitor water quality of other drinking water sources (ponds, streams, and "olis") in tribal areas.

4. To assess the quality of water in rivers flowing through this district viz. Achencovil, Pamba, Manimala and Tributaries of Pamba (Perunthenaruvi, Kallar and Kakkad Ar)

5. To assess the water quality in the distribution system of three municipalities (Adoor, Pathanamthitta and Thiruvalla) of Pathanamthitta district.

6. To find out the water quality index (WQI) of all stations and to derive a system of water quality Modeling.