WATER QUALITY STUDIES IN SELECTED AREAS OF MALABAR REGION, KERALA STATE

Thesis
submitted to the University of Calicut
in partial fulfillment of
the requirements for the award of the degree of
Doctor Of Philosophy
In
Chemistry

By

USHA KUMARI S, M.Sc.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CALICUT
KERALA – 673 635
INDIA

JULY 2008

Dr. GEETHA PARAMESWARAN
Professor (Rtd.)
Department of Chemistry
University of Calicut
Calicut University P.O.
Kerala – 673 635

CERTIFICATE

This is to certify that the thesis entitled **"WATER QUALITY STUDIES IN SELECTED AREAS OF MALABAR REGION, KERALA STATE"** is an authentic record of the research work carried out by **Smt. USHA KUMARI S,** under my supervision in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Chemistry** of the University of Calicut, and further that no part there of has been presented before for any other degree.

C.U. Campus
07.2008

Dr. GEETHA PARAMESWARAN

DECLARATION

I here by declare that the thesis entitled **“WATER QUALITY STUDIES IN SELECTED AREAS OF MALABAR REGION, KERALA STATE”** submitted to the University of Calicut in partial fulfillment of the requirement for the Doctoral Degree in Chemistry is a bonafide research work done by me under the supervision and guidance of **Dr. GEETHA PARAMESWARAN**, Professor in Chemistry, (Rtd), Department of Chemistry, University of Calicut.

I further declare that this thesis has not previously formed the basis of any degree, diploma or other similar title.

C.U Campus **USHA KUMRAI S.**
July 2008.

ACKNOWLEDGEMENT

I have no words to express my sincere thanks and gratitude to **Dr. Geetha Parameswaran**, Professor (Rtd), Department of Chemistry, University of Calicut, who is my teacher and guide , gave constant encouragement and wholehearted support at all stages of this research work. I greatfully acknowledge the inspiring guidance, pertinent criticism, pregmatic suggestions and excellent hospitality extended to me during this tenure.

I express profound gratitude to **Dr. Muhammed Shafi**, Professor and Head of the Department of Chemistry and former Heads, **Dr. K.N. Krishnan Kutty**,
Dr. M.P. Kannan and **Dr. K.K. Aravindakshan**, having provided me

with all the facilities to carry out this research work.

I sincerely appreciate the whole hearted co-operation and valuable help rendered by the teaching and non-teaching staff of Department of Chemistry, University of Calicut.

I am gratefully indebted to **Dr. M.D. Nandeswar**, Head of Sub Centers and Executive Director- in- charge, CWRDM, **Dr. E.J. James**, former Executive Director of CWRDM, Major (Rtd) **Permnath.V.K**, Registrar of CWRDM, and senior scientists, friends and colleagues of CWRDM for providing me adequate facilities and valuable suggestions to conduct my research work.

I wish to extend my thanks to **Dr. Raju**. N.A, Professor, Department of Statistics, University of Calicut for helping me in the Statistical Analysis of the data, for my research work.

I am extremely thankful to a host of my friends and fellow research scholars of Calicut University for their sincere co-operation and providing a friendly atmosphere during the course of my work.

I owe my faithful gratitude to **Mr.Balu** of Bina Photostat, Chenakkal and **Miss. Sini.T.M**, **Appoos DTP Center**, Pallikunnu, Kannur for their timely help in the neat execution of data and printing of this thesis in a beautiful way.

Acknowledgements seems to be incomplete without a word of thanks and appreciation to my family, whose co-operation, patience and prayers helped me to materialize my dream of a thesis into reality.

With heartful gratitude I record my obligation to my Gure Yogacharya **Dr. N. Vijaya Raghavan** whose blessings and prayers were very helpful to me in completing the thesis work successfully.

Above all, I thank, **God Almighty**, who enabled me with philosophy, perception and motivation to present this work, after so many, hurdles and obstacles. May THOU help all at times of need and make us obligated

Usha Kumari S.

CONTENTS

PREFACE

Water is essential for the survival of life. Water pollution is a problem all over the world. The world’s water resources are getting polluted due to man’s activities. Domestic, industrial and agricultural wastewater pollutes the environment. Ground water is a replenish able source and is considered to be the least polluted as compared to other inland water sources. Urban areas are thickly populated and the density of wells is high. The major problem encountered in urban areas is the deterioration of the quality of water resources due to sewage and leach pits and seawater intrusion in coastal areas. The ground water available becomes unsuitable for domestic purposes. Recent studies have shown that in rural areas also the ground water resources are polluted due to poor sanitation facilities.

The general lack of sufficient quantities of safe drinking water to the developing world continues to be a serious problem. Providing safe water can dramatically and immediately improve the health of communities and also lead to the elimination of serious illnesses. Very little information is available on the removal and inactivation of harmful micro organisms. Many communities either suffer from chronic shortage of fresh water or the readily accessible water resources available there are heavily polluted. Hence it is essential to develop an eco friendly home treatment method for purifying drinking water that can be adopted by common man.

The present study was aimed at evaluating and studying the extent of pollution of ground water in selected areas of Kozhikode, Kannur and Kasaragod districts. An attempt has been made to improve the water quality. Domestic wastewater treatment and domestic solid waste disposal has also been attempted.

Based on the following objectives, the work was carried from 2000 to 2008.

(i) to evaluate the quality of drinking water in the wells of the selected area

(ii) to see whether the quality of these water meets the drinking water quality standards.

(iii) to study the seasonal and spatial variation in the quality of the well waters

(iv) to identify the contaminants, their sources and concentration

(v) to attempt a method for domestic waste water treatment

(vi) to utilize plants, aquatic organisms, nuts, mixture of plant materials etc. for water quality improvement

The work is presented in 7 chapters. Chapter one gives an introduction of the subject. Chapter two gives the review of literature. Chapter three gives the details of the areas under investigation and information on sampling procedures and various techniques employed in the analysis of the different components. Chapter four describes the analysis of seasonal and spatial variations of different physico-chemical parameters and the treatment to improve its quality. In chapter five an attempt has been made to calculate water quality index of various samples. Chapter six deals with the domestic wastewater treatment using constructed wetland and solid waste disposal. Constructed wetland is the eco-friendly and low-cost method of treating the wastewater. Vermicomposting is the safest and cheep method of converting solid waste into vermicompost. In chapter seven, safe methods to treat drinking water for each household is dealt with.

Detailed list of references have been arranged in serial order and are given at the end of the thesis. The thesis concludes with a brief summary.

The research work presented in the thesis has partly been published/ under publication as indicated.

1) **Treatment of wastewater using artificial wetland -Acase study**, P.S.Harikumar, S.Ushakumari and K.

Madhavan, paper presented at the *National seminar on Biological treatment of waste water and waste air*, organized by RRL, CSIR, Thiruvananthapuram, August 28-29, 2003.This paper got the award for best paper in the seminar.

2) Water quality studies of Ground water resources of Kozhikode Corporation area and its treatment by indigenous knowledge.

[Communicated to Indian Journal of Hydrology]

3) Bacterial contamination of ground water resources of four panchayats of Kannur and Kasaragod districts of Kerala state, India.

[Under Communication]

4) Improvement of drinking water quality using Rudraksham and plant materials.

[Under Communication]

Projects funded by agencies

(1) "Integrated Development plan for Calicut City", funded by Mission Application of technology for urban renewal under UNDP as a sub programme through Department of Science and Technology (DST), Government of India.

(2) "Study for assessing the risk to ground water from on – site sanitation in rural Kerala" funded by MGP [Modernizing Government Programme] of the Government of Kerala and initiated by the Water and Sanitation Programme South Asia (WSP-SA).

(3) "Water quality studies and water conservation techniques at a tribal area of Kannur district, Kerala State" – funded by Western Ghat Cell, government of Kerala. [2007 – 2009].

CHAPTER I

INTRODUCTION

It is said in ancient scriptures that “Jalam Jeevamrutham”. This shows the importance of water to life.

Water forms a necessary constituent of all animal and plant tissues and that life cannot exist even for a limited period in the absence of water. The protoplasm of most living cells contains about 50% water. Most of the biochemical reactions that occur in the metabolism and growth of living cells involve water. Most of the water present in living organisms acts as an irrigant, distributing nutrients and removing waste products. Most diseases connected with water result from irregularity in the rate of blood flow, the composition of the intestinal and cellular aqueous media and partial dehydration or hyper hydration. Water is acting as a solvent and dispersing and lubricating medium and is also a versatile reactant. Water is also required in industries for power generation, navigation, irrigation of crops, disposal of sewage, etc. Water is an important part of our environment. All the living creatures depend upon water in one way or other. Water is the most vital resource for the existence of life on earth. No other natural resource has had such an overwhelming influence on human history. But this most precious resource is getting deteriorated. Human activities have played a prominent role in degrading air, water and soil. The air we breathe, the water we drink, the soil we stand and the food we eat are polluted. Civilization itself cannot survive if the natural environment collapses and man must balance the resources of the planet if he wants to survive [**Camp Thomas, 1929**].

Many human activities require water. The property of water of dissolving many substances makes it very useful in industries and in daily use. After use in home, agriculture and industry, water gets contaminated. The used water may contain waste and harmful substances called pollutants. Pollutants are residues of substances made by us as waste products which pollute the environment in one way or other. Potable water is rare. So water must not be wasted. It should be conserved. Conservation means careful and economic use. It also means less wastage. In order to conserve water, efforts should also be made to minimize the pollution of the sources of water. The quality of water is now the concern of scientists all over the countries of the world. The recent decision of WHO emphasizes that water given to people should meet high requirement of modern hygiene and it must be free from toxic substances and pathogenic organisms. Water balance is causing changes due to human activities like industrialization, deforestation and over population [**Trivedi PR, 1989**].

Domestic waste water and the method of their disposal are of prime concern in urban areas. Solid wastes are the potential source of contamination as they are partly burnt and partly incorporated into soil and pose serious danger to the ground water. Most industries generally produce water containing heavy metals along with hazardous organic and inorganic effluents. These chemicals contaminate ground water and severely pollute it. The industrial effluents include poisonous chemicals ranging from suspended solids, heavy metals, cyanides, several acids and alkalis to fluorocompounds. Pollutants from agricultural sources comprise pesticides and fertilizers and their breakdown products. Thermal pollution of water is caused by the discharge of hot water from cooling towers of power plants and other industries. Effluents from different sources contaminate valuable freshwater sources such as lakes, rivers, streams, ground water and ocean water. Pollutants impart color, turbidity and unpleasant taste and odour and foamness to water and contribute to eutrophication. A large number of infectious diseases are spread through contaminated water. Water pollution is detrimental to aquatic life and also affect the composition of flora and fauna. Consequently food chains and food webs are disturbed. Some chemical pollutants are so poisonous that they kill the aquatic organisms. Some others are persistent and pass through the food chain [**Freedman B, 1989**].

1.2 STRUCTURE AND PROPERTIES OF WATER

Water is an unusual substance. Its physical properties and behaviors are very different from those of most other liquids.

The water molecules consist of two parts of hydrogen and one part of oxygen. Pure water is a colourless, odourless, bluish green clear liquid having no odour and no taste. The pure water has freezing point O^0C and boiling point 100^0 C. The dielectric constant and electrical conductivity at 18^0C are 81.0 and 4.3×10^{-8} ohm^{-1} cm^{-1}. If pure water is heated from 0^0C to 4^0C, its volume does not increase but contracts and thus attains its maximum density at 4^0C. Similarly if water is allowed to freeze, it expands instead of being contracted, and this is the reason that big ice slabs float on the surface of water bodies freely. Water is a universal solvent because of its high dielectric constant. The dielectric constant of a substance is a measure of the attraction of opposite electric charges for each other in that substance. For liquid water at18^0 C the dielectric constant is 81. This means that two charges in water attract each other with a force only 1/81 as strong as in vacuum. The combination of a high dielectric constant and the fact that water molecules tend to attach themselves to ions results in water having an extraordinary capacity to dissolve ionic substances. When a compound such as NaCl is dissolved in water, the attraction between the sodium ions and chloride ions is weak because the dipolar water molecule aligns their positive and negative sides in such a way that the attraction is partially neutralized. In addition each positively charged sodium ion is surrounded by several water molecules with the negative sides attached to the ion. The positive side of other water molecules attach themselves to chloride ions. This formation of hydrated ions also weakens the attraction of sodium and chloride ions for each other. Thus water can dissolve and hold large amounts of those compounds and elements that form ions in solution. Most organic compounds do not form ions and thus will not dissolve easily in water. They will dissolve intensely in liquids such as benzene that have low dielectric constants [**Mark J Hammer, 1975**].

Water molecules are characterized by hydrogen bonding because hydrogen atoms donate its only electron for a covalent bond with oxygen, Thus hydrogen atom turns to a very small nucleus and so it is not reported by the electron shell of the oxygen of another water molecule. The hydrogen bonds have been shown in two water molecules as below [**Weston RS & Turmer CU, 1917**].

Among the various types of intermolecular interactions, the hydrogen bond plays the most significant role in determining the structure and properties of molecular systems of importance to chemistry and biology. The phenomena of hydrogen bonding has been investigated extensively by a variety of spectroscopic and other physical methods.

Pure water contain hydrogen and oxygen in ionic form as well as in the combined molecular form. The ions are formed by the dissociation of water.

$$H_2O \leftrightarrow H^+ + O\,H^-$$

where the plus and minus sign indicates the charge on the ionic species. Although the ionic form of hydrogen in water is usually expressed in chemical equations as H^+ it is normally in the form of H_3O+ which denotes a hydrogen core surrounded by oxygen with four electron – cloud pairs.

Water is a solvent for many salts and some types of organic matter. The thermal agitation of ions in many materials is great enough to overcome the relatively weak charge attraction that exists when surrounded by water, thus allowing large numbers of ions to dissociate into aqueous solution. Stability of ions in the aqueous solution is permitted by the formation of hydrated ions. Each positively charged ion, cation, attracts the polar ends of the negative water molecules and binds several molecules in a relatively stable arrangement. The number of water molecules attached to a cation is determined by the size of the cation. Negatively charged ions, known as anions, exhibit a much weaker tendency for hydration. The anions attract the negative ends of the polar water molecules and the sizes of the ions in their hydrated form are important with respect to many processes that occur in the ground water environment [**Werner Stumm and Morgan J, 1924**].

1.3 AVAILABILITY OF WATER RESOURCES ON EARTH

About 97.3% of the reserve on earth is saline water. Only 2.7% is fresh water. Of that nearly 70% is frozen in the ice caps of Antartica and Greenland and most of the balance is present either as soil moisture or lies in deep underground aquifers as ground water not accessible to human use.

In India, 12% of the people get clean drinking water, the rest 88% quench their thirst from polluted lakes, tanks, rivers and wells due to which more than three million people get affected or die of enteric diseases every year [**Trivedi PR, 2004**].

Every activity of man involves some use of water. Often the water that is withdrawn is returned to the water sources either with pollutants or with an increase in temperature, or both and if taken from large water courses, this water is used over and over again by downstream communities, with further impairment in quality each time. In agriculture a large portion of the water is lost by transpiration and evaporation [**Petty John WA, 1972**].

Water polluted with human sewage is likely to contain germs and viruses and is not safe for drinking and swimming. As a consequence, the prevention of water borne human diseases remains the most important reason for water and sewage treatment. There are also many wastes that are by – products in the manufacture of chemicals and whose composition and toxicity are largely unknown [**Ramakrishnan S, 1998**].

The obvious approach to problems of water quality is to identify the impurity, develop methods of analyzing for its presence and concentration in water, determine the limiting concentration in water for a particular water use, and estimate whether this concentration will be exceeded for a particular case. The best and cheapest solution for a particular problem is to control the impurity at the source where it is manufactured or used before it is discharged to the receiving water [**Kudesia VP, 1980; Shuval HI, 1970**].

When water comes in contact with minerals, dissolution of the minerals begins and continues until equilibrium concentrations are attained in the water or until all the minerals are consumed. The solubilities of minerals that are encountered by ground water as it moves along its flow paths vary over many orders of magnitude [**Steven JE, 1981**]. Thus depending on the minerals that the water has come in contact with during its flow history, ground water may be only slightly higher in dissolved solids than rain water, or it may become more times salty than sea water. Ground water can be viewed as an electrolyte solution because all its major and minor dissolved constituents are present in ionic form. The concentration of the dissolved inorganic constituents is increasing by man’s activities [**Hem JD, 1991; Samuel DF, 1981**].

1.4 WATER RESOURCES PROBLEMS OF KERALA

Kerala is blessed with water resource, 44 rivers originate from Western Ghats which has a length of more than 35 km. Of these 41 rivers fall in the Arabian Sea, 3 rivers flow to the east and fall in the Bengal Bay.

Even though Kerala receives 3000 mm of annual rainfall, availability of safe drinking water is a problem, especially in summer. 74% of the urban and 48% of the rural population is getting protected water supply. The sources of drinking water in many of the rural and urban areas is ground water, but ground water gets polluted due to garbage, domestic sewage, industries, effluents, leach pits, salt water intrusion, etc. Since public water supply is scarce in peak summer, measures must be taken to irradicate the pollution of the sources of ground water. Disposal of man made wastes adds additional pollutants to ground water and soil, thus degrading the quality of ground water so that it is no longer potable. People depend upon open wells, ponds, streams and rivers for their drinking water needs. Untreated water contains bacteria and virus which cause diseases [**Clark John, 1977**].

Kerala gets average 3000 mm of rain per year but still there is water scarcity. Water scarcity is caused by population growth, environmental change and degradation and unequal distribution of water resources. Water is getting scarce due to rising of population, rapid urbanization and growing industrial demands. The world's population in 2003 is estimated to be 6.45 billion. Nearly 170 million people are being added to it annually and will increase up to 10 billion by the year 2025. The high growth rate of population is posing a serious threat to the future prospects of human well being. If the population continue to grow at this rate, it will perhaps be too large to be supported by the limited resources of earth in a few decades. People dump wastes, untreated sewage and chemical discharges, which pollute the sources of water like the rivers, lakes, ponds and the underground reserves. The ever increasing demand for water has resulted in two billion people craving for this fundamental resource worldwide [**Kudesia, 1980**].

The amount of water available per person in India has decreased steadily. According to the Ministry of Water Resources, it is expected to decrease further in 2050. India already faces an alarming situation. Its fragile water resources are stressed and depleting while various sectorial demands are growing rapidly even as about 200 million people in the country do not have access to safe drinking water and nearly 1.5 million children die each year due to water borne diseases. Presently six of India's major river basins fall into water scarce category. By the year 2025, five more river basins are feared to be water scarce [**Trivedi PR, 2004**].

1.5 SOURCES OF WATER

The basic source of water is precipitation. This is the water falling from the atmosphere to the surface of the earth as rain, snow, etc. Part of the rain and melted snow seeps into the soil under the influence of gravity through the pore spaces of soil or fractures of rocks. This actually becomes ground water. Only one-tenth of the annual rainfall turns into effective ground water. The rest becomes what is called surface runoff, which flows down slopes and gather in ravines and gullies into numerous rivulets that discharge into rivers. Ground water does not occur everywhere below the earth's surface [**David KT, 1995**] .

1.6 WATER QUALITY

Pollution has come hand in hand with development. Generally water contains Ca, Fe, Mg, Mn, Si, fluoride, nitrate, phosphates, sulphates and chlorides. When the quantity of these parts increases they affect the body systems and cause destruction of health. Arsenic salts create cancer; cadmium affects kidney while barium carbonate has had bad effects on veins, nerves and heart. If the quantity of iron exceeds 30mg/l, then vomiting starts. Silver containing water causes liver and lung diseases. Excess of fluoride affects teeth and causes a disease called 'fluorosis'. The presence of manganese in water causes loss of memory, impotence and eye diseases. Vanadium spoils the fertility of soil and creates cancer in the body while Beryllium gives inflammation in pulmonary tissues. Mercury poisoning systems include loss of vision, hearing and intellectual abilities. There is no treatment for it and damage is permanent [**Hughes, 1985**].

Besides industrial waste, the use of pesticides like DDT has posed a serious water pollution problem and a potential hazard not only to livestock and wildlife but also to fish and other animals. The most hazardous property of the pesticides particularly organochlorine, is its persistence in the soil which causes long time effects.

According to a study by the National Institute of Oceanography, Goa, Bombayites discharges more than 2,000 million cubic meters of sewage into the sea each year. The story is the same in all big cities. Even in smaller towns, municipalities are having a different time with the ever-growing problem of pollution, which has, of late assumed frightening dimensions. We have still to recognize that good environment is the fundamental right of every citizen as it is essential for its physical, mortal of social health [**Ciaccio, LL et al., 1971**].

Although several drastic measures have been taken during the last few years, the problems of pollution continues to pose a serious challenge as the threat of nuclear war. In the evolution of human race man has reached a stage when he has acquired the power to harness and transform nature in various ways. Unless the power is used discretely the whole human race and environment stands in danger of annihilation [**Jenkins SH, 1974**].

Similarly heavy metals and plasticides accumulate at the base of the sea and eventually reach us through the food chain. Lately there has been an unusual increase in the concentration of phosphates in the sea which has adversely affected the sea's ecosystem completely [**Barry L, 1991**].

Information on environment should form an integrated part of the school curriculum so as to enable children to understand the inner dependence of various components of the system of which they form a part. Mass media could be used for publicizing the facts and providing information of the environment.

Water pollution is turning India's famous lakes into dirty ponds and its major rivers into sewers threatening the health of millions of rural folk at the receiving end of the city wastes. Reports from PTI bureaue indicates that the problem is increasing in almost all states, particularly in Kerala and Maharashtra, whose capital is virtually ['g.heared'] by filthy, stinking creeds with floating oil sticks that have destroyed the breeding grounds of fish.

Mercury pollution which was responsible for the deadly Mina Mata disease in Japan, has been noticed in two places in waters and sediments of the Thana Creek in Bombay and the Rushikulya river in Orissa recently [**Kudesia, 1980**].

Effluents from industries have changed the color of the waters of several southern rivers that were crystal clear only a few years ago. The Damodar is black, the Chaliyar in Kerala, is brown, and Ganga at Kannauj, Kanpur and other places is either brown or dark brown.

In the whole of India, there are only 5,000 large and medium industrial units that can pollute but their contribution to total pollution load is less than 10%. The rest is of domestic origin especially in Bombay and Calcutta.

Rivers are the major source of drinking water for people in the rural areas. With these rivers increasingly polluted by city wastes, the villagers may be left with nothing but contaminated water. This is already happening in Bihar and UP, according to a state government spokesman.

The International Institute of Applied systems Analysis in Austria has warned that water pollution will be India’s major problem in 25 years unless, sewerage and sanitation facilities are improved. It is said that accumulated human wastes could mix with open water resources resulting in epidemics.

All states except Maharashtra, Orissa and Tamil Nadu have adopted the prevention of water pollution Act, 1974 and protection Act of 1984. They have set up their own prevention and control of water pollution Boards [PCWB] but most of their actions are on paper.

In Kerala, more than 500 million liters of industrial effluents are being dumped daily into the river besides untreated human wastes. Retting coconut husks in brackish waters and stagnant ponds adds to the pollution. Water in Kuttanad, the rice bowl of Kerala, has been severely polluted by massive application of pesticides in paddy fields. In one crop season, 1000 tonnes of pesticides of 46 different formulations are used and they are leached out into the water ways.

Five of the ten major rivers- Chaliyar, Chalakkudy, Periyar, Pampa and Kallada – are affected by pollution. Thus water pollution is a serious problem in India and effective ways have to be chalked out according to the needs of different places.

The main problem now before the world is that of safe drinking water which is fast assuming alarming proportions. The disturbing fact is the increasing susceptibility of drinking water sources to pollution. The technological expansion has brought into the hands of even the smallest farmer, two of the current agricultural best sellers – fertilizers and pesticides. Their increasing use over the years has resulted in the contamination of water sources. The chlorine, bromine, sodium, potassium, phosphorus, nitrogen, etc. present in these pesticides and fertilizers find their way into the waters through the soil rendering it unsuitable for human consumption.

The oils, soaps, detergents from industries and city wastes have disturbed the vegetation and animal life in sea and rivers, etc, because the layers of oil, etc. on the surface water have decreased the quantity of DO. Water is transparent due to which it absorbs sunlight which is being taken up by plants to make food. If water will be colored, it will check the vegetation and which will finally end the animal world under water as they take plants as food for their survival. Unfortunately, the numbers of these pollutants are growing so rapidly that it has not been possible to identify them as fast as they are produced and the development of analytical methods for determining their concentrations and assessing their toxicities is inadequate.

The principal objective of water pollution abatement are to safe guard the health of the people, to prevent fish kills, to prevent odour nuisances, and to remove unsightly flood banks and floating materials.

Of late, measures have been initiated for conservation and management of the available water resources in the country. At a micro level, rain water harvesting is also being taken up. Some state governments have already amended building bye-laws to make rainwater harvesting mandatory for new buildings. To some extent, waste water is also recycled for use.

1.7 SOURCES OF WATER POLLUTION

Most of the pollution problems are caused by human activities. For agriculture man uses chemical fertilizers, pesticides and insecticides which create great problem to the ecology and environment. Industrial effluent, domestic sewage, infiltration from sewage canal, in urban areas infiltration from leachpits to the domestic wells are all serious problems of environment. The soil gets polluted. The seeds which the trees produce also become polluted. Man eats this polluted matter and gets sick. The ecology is disturbed [**Pervey R, 1982**].

Water pollution adversely changes the quality of water, disturbs and destroys the balance of ecosystems and causes hazards to public health. Water becomes polluted by the presence or addition of inorganic or organic substances or biological agents.

Soil erosion, leaching of minerals from rocks, decaying of organic matter are natural sources of water pollution [**Baven, 1980**].

1.7.1 Sources of Man-made Pollution

They can be classified according to the way in which the pollutants are introduced into the water. When the total or principal flow is conveyed in well defined channels such as municipal or industrial discharges, it is called a point source.

Diffuse or non point sources are difficult to measure. Sprayed fertilizers and pesticides are important examples of diffuse sources.

1.7.1a) Domestic Pollution

This includes discharges from houses, commercial and industrial establishments connected to the public sewage system. The composition of the sewage vary in space and time. Sewage contains human and animal excreta, food residues, cleaning agents, detergents and other wastes. It is always rich in bacteria and other substances. It also contains other biological pollutants. The polluting strength is usually characterized by its BOD.BOD is the amount of oxygen taken up by the micro organisms present in water. A high level of BOD indicates intense level of microbial pollution [**Arora BR, 1985**].

1.7.1b) Industrial Pollution

The composition of the industrial water depends on the nature of the industry and processes of waste water. The trade wastes and effluents [flowing out from sewage tanks] of industries play a significant role in pollution of waters. The types of industries are given below.

1) Paper and pulp
2) Distillery
3) Potassic Fertilizers.
4) Electroplating plant
5) Asbestos
6) Silt
7) Alcohol.
8) Detergents
9) Steel
10) Tanning
11) Cane sugar
12) Oil
13) Pesticides and herbicides.
14) Radioactive wastes.

The chemicals used are alum, resin, chlorine, caustic soda, soda ash, dyes, magnesium bisulphate and sulphuric acid besides clay [**Trivedi PR, 2004**].

The lignin should not be allowed to discharge as it completely destroys the fauna and flora and impairs the productivity [**Goel PK, 2003**].

Heavy suspended materials should be brought to minimum level through settling tanks which reduce BOD. The taste and odour producing substances can be removed by treating waste water with activated carbon [**Kudesia VP, 1980**].

1.7.1c) Agricultural Pollution

Today India is passing through ‘Agricultural Revolution’ or ‘Green Revolution’. During the past few years, there has been a considerable increase in agricultural production due to high yielding varieties of seeds, chemical fertilizers and insecticides.

According to Central Food Technological Institute, Mysore, as much as 50% of our food is lost due to pests and insects. The first synthetic insecticide came to use only 30 -35 years old was DDT which was discovered first in Switzerland in 1930. All the chemical compounds which kill insects, harm them, interfere in their reproduction and normal living are called pesticides.

A portion of the fertilizers are taken up by the plants. The rest get accumulated in the soil. The insecticides / pesticides also get accumulated in the soil. By rain water and irrigation water, they are carried to the nearby streams, from there to the rivers and ultimately reach the sea. From surface water sources, they enter ground water sources. This is harmful to domestic wells and public water supply schemes.

Fertilizers comprise one or more of major plant nutrients, mainly N, P and K. They increase algal growth in lakes and ponds, algal blooms are formed. When these algae decay after some time, micro organisms need oxygen for the purpose. Hence the water body gets deoxygenated which make it unfit to support aquatic life. Due to the lack of DO in water, animals like fishes die. This is called eutrophication. When all the oxygen of the water body is thus used up, nitrate-reducing bacteria will release oxygen from nitrate ions. Ammonia is formed. Then sulphate reducing bacteria will release H_2S from sulphate ions. Metal sulphides are formed, foul smell occurs. When methane is formed by the reduction of organic matter, anaerobic condition result. Organisms which can survive in such conditions will increase. Biodiversity is destroyed. Shift in ecological balance takes place.

Pesticides include insecticides, pesticides, fungicides, nematicides, rodenticides, herbicides and soil fumigants. They cover a wide range of formulations and chlorinated hydrocarbons, organo phosphates, metallic salts, carbonates, thiocarbamates, acetic acid derivatives, etc. Many pesticides are biodegradable and their residues have a longer life. The most persistent ones are organo chlorine compounds. They pass through food chains and accumulate mainly in fatty tissues. By mode of action of pesticides means the way in which the chemicals act upon the systems of an insect to cause its death. Chemical poisons affect the normal functions of some specific cells and tissues in the same way as is the case with higher animals. Generally, the chemical processes in insects are affected by abnormal functions of their organisms. Due to widespread use of chemicals the food consumed by man today is contaminated with the chemicals. These poisonous chemicals are stored in the fatty tissues of human body and it is estimated that about 5-27 ppm of DDT compound is found in tissues of persons living in centuries where DDT is widely used. The accumulation of DDT in human body is found to be harmful for health. Some chemicals even damage the liver. Endrin penetrates through the skin and produces toxic effects. The highly toxic organo phosphorus compounds are supposed to breakdown quickly in nature. The pesticides reach our body indirectly through vegetables, eggs, etc. DDT has also been found in the bodies of human beings in different countries.

Pesticides like DDT get accumulated in the liver / kidney tissues of animals. This is termed as bio-accumulation. They are stored in the fatty tissues where they are metabolized or excreted at a slower rate. When they enter the DNA helix, mutation occurs.

Food chain theory states that the residue concentrations of pesticides, heavy metals, radio nuclides, etc. was found to increase from plankton to the fish eating birds. This is called biological magnification. Pesticide concentration in the 4th trophic level organisms will be 6.25 times greater than the 1st trophic level organism. DDT has been blamed responsible for the cause of reproductive failure among fishes and birds. In birds like Falcon, DDT accumulation resulted in thinning of the eggs which adversely affects the breeding. DDT has been banned in India and Europe.

In fishes, DDT accumulation resulted in fish mortality. A vide variety of animals have developed tolerance to the insecticides. With time the pesticides may (1) break down (2) be redistributed within the application site (3) move offsite. Offsite movement includes movement to ground water, surface water and the atmosphere. Break down and movement occur simultaneously. How long pesticide lasts or persists in the environment is determined by resistance to breakdown. All pesticides react in the environment in the presence of sunlight. In soil and sediments, micro organisms are primarily responsible for pesticide breakdown. Some pesticides may enter plant roots and foliage and breakdown through plant metabolism. In water, breakdown is usually by hydrolysis, often mediated by pH. In aquatic systems pesticide breakdown by microorganisms may also be important. Metabolic reactions are catalyzed by enzymes. The complete breakdown of pesticides and other organic substances is called mineralization.

Transfer from water or a plant surface to air is called volatilization. They can move into the air as particles, adsorbed into dust, or as droplets or aerosols during application.

Plant uptake can be important to pesticide movement. Pesticides that are taken up by plants are not available for movement into ground or surface water sources. If the plants are harvested some pesticides may move from the site with the crop. Many pesticides leave residues in various living systems for prolonged periods of their life span and are presumably responsible for a variety of known and unknown toxic symptoms. Even their minute quantity, their variety, toxicity and persistence have an adverse effect on ecological systems. In tropical conditions, the biological transformation of pesticides is liable to be relatively faster due to heat, light, scanty or heavy rains, delayed or early rains. Broadly the effects include disturbances in the equilibrium existing between insect pests and their parasites, increase diseases substantially, bioaccumulation, development of pesticide tolerance, disturbance in reproductive physiology, behavioral abnormalities in birds, insects, effects on population of birds, wild life, etc, effect on beneficiary insects, contamination of food and human bodies, etc. Sub lethal concentrations of hydrocarbon pesticide residues are now known to be capable of interfering with the calcium metabolism of birds, perhaps through the inhibition of the enzymes carboxic anhydrase. As a result, insufficient calcium is made available during the process of the formation of the egg shell and the egg shells are very thin. The egg shells break when the birds sit on to hatch. This adversely affects the breading.

The delay in egg laying is believed to result from inhibition of liver enzymes by the pesticides with accompanying depression of estrogen levels in the blood.

Chlorinated hydrocarbon pesticide may affect the photosynthesis and growth of plankton. Use of excessive volatile herbicides has often killed or injured vegetation in neighboring areas.

Bio- accumulation has significant impact on the dynamic equilibrium that exists between predators and pray. Both animals and plants have the ability to concentrate many types of pesticides in their body. Pollutants like pesticides ingested within the organisms are not effectively restored or excreted like the remainder of the food biomass. Accumulation of the biocide residues in animals and plants have created great hazards. Residue may persist in the environment for many years, exposing successive generations of animals. In aquatic ecosystems, direct uptake from waters and sediments appears to be the dominant process for many persistent pollutants [**Nelson DM, 1991**].

There are some plants which contain chemical substances like alkaloids and inflavonoids which act as insecticides. Alkaloids such as nicotine from tobacco (Nicotine spp.), rotenone from Derris (Derris elliptical) and pyrethrins and cinerines (Pyrethroids) from pyrethrum [chrisanthemum cinerariacifolium] are good plant insecticides. Most plant insecticides act as contact poisons being absorbed through the cuticle of the insects [**Desh Mukh AM, 2003**].

The plant Millettia pachycarpa contains two insecticidal compounds known as rotenone and sapaivine which act as contact and stomach poisons. Rotenone is not harmful to man. The plants belonging to the “solanacea” or “potato family” are also insecticidal plants. They contains alkaloids called “solanaceous alkaloids” Nicotine, an alkaloid obtained from tobacco acts as a contact insecticide. Nicotine is responsible for killing of many insect pests. Plants like castor [Ricine’s communis], common basil (Ocimum basilium), Caraway (Carum Carve), Anise (Pimpinella Anism) and several others have effective insecticidal properties against many domestic and agricultural pests.

The environment can be saved from agro chemical pollution if organic fertilizers and naturally occurring plant insecticides are used instead of the agrochemicals.

1.7.1d) Thermal Pollution

The main sources are electric power plants and nuclear power station. Water is used as coolant in these units and hot water is released to the original source raising its temperature. Sudden rise in temperature kills fish and other aquatic animals and increases the respiration of algae and other organisms.

1.7.1e) Radioactive Pollution

Radioactive pollution is a special form of physical pollution related to all major life-supporting system- air water and soil, its nature of contamination is different from those of others. Its effects are also of special kinds. Radioactivity is a phenomenon of spontaneous emission of protons, electrons and gamma rays, as a result of disintegration of atomic nucleus of some elements. During the decay of the atom, daughters are formed which may or may not be radio active. Each radio active nuclide has a constant decay rate. Half life is the time needed for half of the atoms to decay. This may vary from a fraction of a second to thousands of years. The nuclide with long life are usually the main sources of environmental concern.

Sources of environmental radiation are natural and man-made. The former comprise cosmic rays that reach the surface of the earth from space and terrestrial radiations from radio-active nuclides such as Ra_{223}, U_{235}, U_{238}, Th_{282}, Rn_{222}, K_{40}, and L_{14}, occur naturally in soil and water.

The first atomic bomb was exploded in Hiroshima followed by Nagasaki. Explosions are controlled chain reactions. These give rise to very large neutron flux conditions that make other materials in the surroundings radioactive. These materials include Sr_{90}, C_{s137}, I_{931} and unused explosive and activation products. The radioactive materials are transformed into gases and fine particles which are thrown high up into the air like a mushroom cloud. Radioactive particles are carried away by the wind and spread to wide areas. They settle down to cause water and soil pollution even in places far away from the site of explosion. When rain drops containing radioactive particles fall on the ground, radioactivity is transferred to the soil particles. From soil radioactive substances enter the food chain affecting different forms of life including man. Water bodies receive radioactivity mainly through soluble products. Thus aquatic organisms absorb and accumulate them through food chain which ultimately includes man.

The main operation of a nuclear power plant includes introduction of the processed nuclear fuel, followed by fission and activation products. These wastes pose a grave public health hazard wherever they are dumped. The radio-active nuclides are sources of radiation especially when they become free and pass into the surroundings in any form. Inert gases and halogen escape as vapours and become potential pollutants of the environment as they settle in land or are washed into surface water.

A large number of radio active isotopes such as ^{14}C, ^{125}I and other compounds are widely used in scientific research.

Waste waters containing radio active materials reach the rivers and lakes through radio active iodine and phosphorus concentrate in slimes, sludges and micro organisms which enter the human food chain through fish and other aquatic life.

Human beings also voluntarily receive radiation from diagnostic x-rays and radiation therapy for cancers, People working in nuclear reactors, fuel processors and power plants are also vulnerable to radiation exposure.

The effects of radiation pollution depends upon

(1) half-life (2) energy releasing capacity (3) rate of diffusion and (4) rate of deposition of the contaminant.

Various atmospheric and climatic conditions such as wind, temperature, rainfall also determine their effects.

Human species is the final victim of radio active pollution as he is at the end of all reactions and interactions. He is beneficiary of a large number of food chains, a user of the largest number of resources and enjoys worldwide distribution. He is the only species that actively plays with radioactive materials.

All organisms are affected from radiation pollution. Some species preferentially accumulate specific nuclides. For eg: oyersters deposit ^{45}Zn, fish accumulate ^{54}Fe, marine animals selectively take up ^{90}Sr. Even dairy milk and its products can become highly contaminated. In high doses, radiation can cause almost instant death. In lower doses, it can affect all organs seriously and impair their functions. This is also true for most plants and animals.

There is hardly any safe dose; slight increase in the background radiation level enhances the risk, long or repeated exposure can cause cancer and leukemia and include mutations. The deleterious genes can persist in human, animal and plant populations and may affect their progeny.

As there is no cure for radiation damage, all efforts should be made to prevent radio active pollution. Leakage from reactors, careless handling, transport and use of radioactive fuels, fission products and radio isotopes have to be totally stopped. The safety measures should be strictly enforced. The waste disposal must be safe. Regular monitoring through frequent sampling and quantitative analysis has to be ensured in the risk areas.

Preventive measures have to be followed so that background radiation level does not rise above the permissible limits. Safety measures against accidents have to be strengthened and appropriate steps need to be taken against occupational exposure.

One of the major concern of using radio active materials is the disposal of wastes. Radio active wastes only with sufficiently low radiation can be discharged into sewage.

1.7.2 Effects of Water Pollutants

The impact of pollutants depends upon its properties and amount. Pollutants bring about physical and chemical changes that make the water in rivers, lakes and ponds unfit for drinking and harmful to aquatic life.

(i) The biological effects of chemical pollutants are varied. Compounds of Hg, As and Pb are poisonous. Some compounds are so corrosive that they may even affect waste treatment plants. Organic sulfur compounds interfere with nitrification.

Inorganic nitrates and phosphates stimulate excessive plant growth in lakes and reservoirs, this is called entrophication. The organochlorines from pesticides are highly persistent and pass through food chains. They mainly accumulate in fatty tissues and affect the nervous system. The broad spectrum of pesticides used currently cause mass destruction of aquatic life through their accidental release or excessive use.

(ii) Change in colour is a very common effect produced by the dyes and inorganic substances like Cr and Fe compounds contained in the discharges.

(iii) Turbidity due to very fine suspended matter or colloidal substances making water unfit for drinking and for industrial uses.

(iv) Impairment of taste caused by industrial effluents containing iron, free chlorine, phenol, manganese, detergents, oil, hydrocarbons and decomposition products. Unpleasant odors due to the presence of free chlorine, phenol, H_2S, ammonia, algae and micro organisms.

(v) Foam formation in waters by soaps, detergents and alkalies.

(vi) Eutrophication is a natural process observed in lakes and tanks where the rich growth of micro organisms consumes much of the DO, tending to deprive other organisms. It is generally found at the bottom layers of the deep lakes. Addition of excess plant nutrients intensifies eutrophication and is harmful to fish and other aquatic life.

(vii) Fluorosis

Fluoride bearing minerals are widely distributed in India and many of the underground and surface waters are contaminated with fluoride ions. High amounts of fluoride are present in drinking water in 13 states in India. Experts have told that the maximum level of fluoride which the human body can tolerate is 1.5 ppm. Water when ingested over a long period of time causes flurosis. It results in various neuro-muscular disorders, gastro intestinal problems, allergies, dental disorders and several skeletal disorders.

It is very important to check the fluoride content of water used for drinking and cooking. Inexpensive defluoridation technology has not yet been developed in India and industrial fluorosis has been reported to affect agriculture and horticulture crops also.

(viii) Sudden elevation of temperature caused by release of hot water from thermal power plants can cause lethal effects on aquatic organisms, particularly fish. Hot water contains less DO and BOD increases. Accelerated microbial activity leads to the death of fishes. Anaerobic decomposition causes development of offensive odors.

1.7.3 Control of Water Pollution

Treatment of sewage is a crucial one. It involves three steps. In the first, the large and suspended particles are removed, in the second, aeration is supplied to promote bacterial decomposition of organic compounds, followed by chlorination to eliminate bacteria; in the third, nitrates and phosphates are removed. The treated water is then released. Sewage treatment is quite expensive and in many developing countries only the first two steps are followed.

Industrial effluents should also be suitably treated to eliminate the pollutants. These involve neutralization of acids and alkalis, removal of toxic chemicals, coagulation of colloidal impurities, precipitation of metallic compounds and reducing the temperature of waste water to decrease thermal pollution [**Hughes, 1985**].

Chemical oxidation can be achieved by chlorination or through reaction with ozone. There are many chemicals which are difficult to eliminate [**Turmer PR, 1991; Underwood L, 2001; Varshney LK, 1983**].

1.8 GROUND WATER POLLUTION

Today human activities are constantly adding industrial, domestic and agricultural wastes to ground water reservoirs at an alarming rate. Ground water contamination is generally irreversible, ie., once it is contaminated, it is difficult to restore the original water quality of the aquifer [**Gilbert J, 1994**]. Excessive mineralization of ground water degrades water quality producing unobjectiable taste, odour and excessive hardness [David, K.W. 1995]. Although the soil mantle through which water passes acts as an absorbent retaining a large part of colloidal and soluble ions, with its cation exchange capacity, but ground water is not completely free from the menace of chronic pollution [**Reghunath HM, 1985**].

1.8.1 Sources of Contamination of Ground Water

Numerous activities including industrial production, agriculture, sewage discharge, commercial and residential activities contaminate ground water sources. The domestic sewage composed of fecal wastes; kitchen and laundry wastes are the major sources of pollution for household wells [**David MN, 1979**].

Sources of Ground Water Contamination

1.8.1(1) Holding Ponds andLagoons

These are shallow excavations that range from a few square feet to many acres in area. They are commonly used to hold municipal sewage, hospital wastes and a variety of wastes including industrial chemicals [**Hocks T, 1981**].

1.8.1(2) Sanitary Land Fills

Sanitary land fills are constructed by placing wastes in excavations and covering the material with soil daily, so that garbage and other materials are not left exposed to produce odors, smoke, vermin and insects. Even though a land fill is covered, leachate almost certainly will be formed by the infiltration of rains [**John CR, 1970**].

1.8.1. (3) Land Disposal Wastes

Another cause of ground water pollution is the disposal of waste material directly on to the land surface. Examples include garbage sludges and domestic wastes. These wastes may occur as individual mounds or they may be spread over the land. If the waste contain soluble products they may be dissolved and infiltrated into the ground water [**Haimes YY**].

1.8.1(4) Septic Tanks, Cesspools and Privies

Another cause of ground water pollution is the effluent from septic tank, cesspools and privies. The close proximity, density of installations can create serious pollution problems, in creviced rock areas effluent may travel from long distances in fracture system and solution channels.

1.7.1(5) Animal Feed Lots

Animal feed lots covers relatively small area but provide huge volume of wastes. Feed wastes pollute ground water with large concentrations of nitrate and bacteria. A variety of water borne diseases like cholera, typhoid fever, bacterial dysentery, gastro enteritis, etc. are attributed to untreated or inadequately treated ground water containing toxic materials and pathogenic forms of bacteria and viruses.

Biological contamination of ground water occur when human or animal wastes enter an aquifer. Standard tests to determine the safety of ground water for drinking purpose involves identifying whether or not bacteria belonging to the coliform group are present. One of the reasons for this test is that these groups of bacteria are easy to recognize. The recent fecal pollution of water sources are indicated by the presence of coliform bacteria ie., Escherichiacoli. The result of coliform test is reported in terms of most probable number (MPN) of coliform group of organisms present in a given volume of water.

Fortunately, ground water, except perhaps from very shallow aquifers, is generally free from pathogenic bacteria and viruses. Microorganisms can be carried by ground water but tend to attach themselves by adsorption to the surface of clay particles. In fine-grained soils, bacteria generally move less than a few meters, but they can migrate much larger distances in coarse-grained soils or discontinuous rocks.

Most cases of contamination result from poor well construction, from over-abstraction, or are associated with aquifers which posses large pores such as gravel deposits, or open discontinuities such as some limestones. Pollution of this type is only important, however, if the water is to be used for potable water supply or food processing.

Pathogenic bacteria can be introduced into the subsurface environment from septic tank systems, seepage from municipal wastes and stabilization ponds. Bacteria may undergo natural die away or they may be retained in the soil or transported to the ground water [**Bitton G and Charles PG, 1983**].

1.9 AIR POLLUTION

Environmental pollution is a serious problem of the industrialized societies. Human activities have played a prominent role in degrading air, water and soil. Pollution of the atmosphere is particularly dangerous because the released pollutants cause widespread damage to life and property in the propulous urban areas. An air pollutant consists of suspended particles and harmful gases, some of which react in the atmosphere to produce extremely toxic substances. The principal atmospheric pollutants contributed by combustion are SO_2, nitrogen oxides, CO, CO_2 and various hydrocarbons. Many products of incomplete combustion undergo photochemical reactions with oxides of nitrogen to generate smog.

The chemical industries produce innumerable harmful compounds containing chlorine, fluorine, (especially chlorofluoro ethane) in addition to SO_2, CO and other gases. Various other industries, blasting and mining activities emit huge quantities of particulate gaseous contaminants.

Air pollution cause respiratory and vascular diseases in human and impede aesthetic perception. They bring about damage to vegetation and livestock and accentuate deterioration of buildings and materials. Atmospheric pollution poses a serious threat in the climatic and atmospheric stability [**Benecka and Weiting, 1988**].

Industrial air pollution can be minimized by separating pollutants from the harmless gases by converting the harmful compounds to innocuous products before discharging them to the atmosphere.

All living things need air. Human activities introduce several harmful substances to air. Such activities pollute the air. Air pollution must be controlled.

Air contains a number of gases, eg. Oxygen, nitrogen and CO_2 . Very small amounts of gases like He, Ne, Ar, Kr, Xe and Rn are also present. Oxygen combines with metals and non-metals to form oxides. Nitrogen is the major constituent of the air. CO_2 gas is given by animals and plants during respiration. Plants use CO_2 to prepare carbohydrate. He, Kr, etc. are inert gases. These are the inactive components of air [**Gupta PK, 2001**].

Air always contain water vapor. It is present in the air as a result of evaporation of water from oceans, rivers, lakes and streams. Water vapor is also given out by plants and animals. The land on warming by sun gives out water vapor. The amount of water vapor in air varies from place to place, day to day and day to night. When the capacity of the air to hold water vapor is exceeded it then condenses into water droplet and forms dew or rain. If the temperature in the area is very low, the water droplet freezes and falls as mist or hail or snow. The content of water vapour in the air is called humidity.

Air contains tiny solid particles. The solid particles of sand and soil are carried into air by strong winds. They remain suspended in air for some time. Solids such as pollen from flowers and high seeds are also introduced into air by plants. Fuels are burnt in homes, factories, power stations and various types of vehicles. The smoke introduces various types of solid particles in air .The amount of solid particles in air is different at different places.

The amount of solid particles and water vapor varies from place to place. The other constituents of air remain nearly the same.

Pollutants are harmful or undesirable substances. These pollutants may be harmful to plants or animal or both. When such pollutants are present in air, it is said to be polluted. Air pollution is largely due to human activity.

The wind carries soil, dust, pollen and other particles, which often causes allergy, sneezing and health problems. Factories and power houses produce large quantities of smoke. The smoke contains particles of coal, ashes and some toxic compounds. Similarly, cement, steel plant and some chemical factories produce large amounts of particles that pollute the air. Cigarette smoking introduces smoke into a room. The smoke goes also into the lungs of non – smokers and affects their health. Burning of firewood and cowdung cakes at home produces smoke which is bothersome and even harmful. By adding a chimney to the stove [Chulka] the smoke can be removed from the house. Vehicles, such as scooters, cars, buses and trucks also produce smoke by burning petrol or diesel, such auto exhaust is a major cause of air pollution.

Other products of burning also cause pollution. All fuels contain carbon. When such a fuel is completely burnt, CO_2 is formed. Most of the time, the fuels do not burn completely. In that case both CO and CO_2 are produced. CO_2 is a poisonous gas. It combines with blood and many proteins of the body and prevents them from doing their duties. In winter, some houses are heated with coal fire, when all the windows and doors are closed, and coal fire is burring, CO_2 gas can accumulate and become very dangerous and even fatal.

Proper ventilation of houses and bed rooms even in winter is essential. Oxides of S and N are also harmful to health. Coal and petrol contain small amounts of S, which on burning gives SO_2, an acidic oxide that affects skin, lungs and other tissues. The oxides of nitrogen formed at the high temperatures that some engines reach are also poisonous.

In refineries and power plants, it is thus important to remove the oxides of S and N before the gases are let out. Otherwise these will be carried in the wind and rain and will produce what is called 'acid rain'. Acid rain will damage cement, steel, marble, bricks and living organisms [**Benecka, 1988**].

In Mathura, north of Agra, a petroleum refinery was being set up and there was the danger that the refinery could produce and let out SO_2, NO_2 and other oxides. If these were carried by the wind towards Agra, the Taj Mahal could be easily damaged. Hence special precautions have been taken in the Matura refinery. One way is to scrap down the exhaust gas with water before it leaves the chimney. This scrubbing dissolves all the toxic gases and prevents their escape into the atmosphere [**Gupta PK, 2001**].

With more industry and progress, the pollution of the air would become a problem. Wisdom lies in anticipating these problems and solving them before they cause damage.

In the past, there were fountains in cities, which had a very important role in controlling air pollution.

CHAPTER II
REVIEW OF LITERATURE

2.1 TRADITIONAL KNOWLEDGE FOR WATER TREATMENT

2.1.1 Introduction

For the past few decades, technology has been advancing at a faster rate and the waste produced by man has also been increased at a larger scale. The waste is nothing but nutrients, which find their way into the nearby water sources. Domestic, industrial and agricultural, waste water and solid waste (mainly domestic) contribute to the pollution of the sources of water. They reach the surface water sources by rain and ultimately reach the ground water sources. Public water supplies and domestic wells are affected. This problem is to be solved urgently, otherwise human civilization will come to an end. It is to be recognized that clean, potable water is a bye-product of biological systems. The entire subject of water must be seen to be a problem of biology rather than engineering. This would recognize that nature has been in the business of water and sewage treatment since the beginning of life, most effectively, and that solutions to the problem of water lies in understanding aquatic biology and dominantly limnology. It must be understood that water systems are affected by terrestrial processes, than the scientific basis for the management of water resources. The definition of ecology is the study of interactions of organisms and the environment. Applying this concept to the provision of potable water suggest that water is ultimately a product of aquatic organisms and as these organisms require specific environmental conditions to survive and prosper, the conditions of terrestrial and aquatic systems be preserved or managed to maintain the survival and success of the essential organisms which produce potable water [**Dinges R, 1982**].

The world of water and sewage treatment is dominated by the subject of waste. There are no wastes, only matter in various states. Most of that named waste is better described as nutrients. We need to learn how to complete the cycle, notably the return stroke, involving the decomposing micro-organisms in water and soil and their symbionts. These micro organisms are the creatures who have been thoughtlessly engaged in water treatment for eons and who continue to be indispensable [**David MN, 1979**].

Chemicals can also disturb the aquatic ecosystems or accumulate in aquatic organisms used in human food. It has been noted that the total demand for water may double every twenty years, or in some countries the doubling may take place in 10 years. The frightening and exponential growth of population and industry not only increases demand for the water quality, but also puts high requirements on water quality [**Stanley M, 1975**]. The surface water gets polluted due to the discharge of waste water. Since the ground water resources are limited, there is a tendency to use more surface water as a source of community water supply and for other uses. New types of wastes are produced, many of which are known to adversely affect the natural and man- made systems of water purification, some of the pollutants cannot be efficiently removed by conventional treatment processes.

Many systems of water purification used today are costly and cause bye products which are unfavorable to the environment. Conventional methods like chlorination can eliminate bacteria but cannot remove harmful industrial chemicals. Chlorination of water converts harmless chemicals into hazardous ones. Chlorination may destroy some of the useful bacteria. Chlorination of water may result in the generation of trihalomethanes which are reported to be carcinogenic. Although conventional water treatment methods like chlorination can eliminate water borne disease bacteria that cause typhoid, dysentery, cholera, they do little or nothing to detect or remove the new industrial chemicals. Green plants and biological systems have the capacity to detoxify dangerous synthetic chemicals in industrial wastes that vegetation can capture nutrients and be harvested directly as food for man and domestic animals and used for paper manufacturing or composting River water in Germany is treated for municipal water supplies with a system that relies on artificial aquifer recharge through bulrushes. Women of Sudan, in an ancient ritual, purifies their drinking water by adding leaves, seeds or pieces of bark and root from selected plants to clay pots containing water they have collected from the Nile. All of the systems described use the sun as their principal energy source. Although these systems can be used for highly toxic industrial effluents, there are still situations where biological systems alone would fail because the effluents itself is toxic to plants. In such situations higher plants would have to be part of systems utilizing conventional techniques. Although biological systems may be ideal for rural areas and under developed countries, where land may be readily available, these systems would probably be unsuitable for many highly urbanized areas where land is scarce. Biological systems can never be a substitute for designing industrial processes which prevent pollutants from entering streams and rivers in the first place. In most situations industrial waste should be separated from domestic wastes no matter what treatment method is used and finally streams and rivers should continue to be identified and protected from contamination [**James GV, 1971; Mark JH, 1973**].

In spite of these cautions, the emergence of these biological systems may prove to be one of the most important in the field of water pollution control in many years. Biological systems are capable of broad range of water quality improvement activities. Certain plant and associated micro organism activities most promising for municipal activities are the following.

(i) Removal of inorganic substances (nitrates, phosphates; Na, K, Ca, etc) from waste water

(ii) Degradation of highly toxic organic substances like phenol

(iii) Improvement of the quality of water polluted by food processing water

(iv) Neutralisation of alkaline and acid waste water

(v) Aeration of water through photo synthesis

(vi) Aeration by plants of water by taking oxygen into their upper stalks and giving it off through their submerged lower stalks

(vii) Provision of habitat for other living things

(viii) Reduction of the volume of waste water (by transpiration) by taking water into their stalks and releasing it as a gas to the atmosphere

(ix) Mechanical filtration of suspended solids and through plant structures

(x) Attenuation of pathogenic systems

The fact that biological systems are inexpensive compared to conventional systems means they will probably present fewer profit opportunities for treatment plant designers [**David MN, 1979**].

2.1.2 Role of Fauna in Waste Water Treatment

Crustaceans like Daphnia can be utilized for water treatment. They remove suspended matter, metal and bacteria from water. (**Kaur Kamaldeep et al., 1992**). Moina and Brachionus also can be employed in water treatment [**Dinges, Ray; Loeldorff CE, 1964; Duffer WR, 1974**].

There are a number of fish species which are employed in waste water treatment, eg. Cyprinids [Carps-minnows], cichilids [Tilapia] and Poecilids [mollies]. Filter feeding fishes like Silver carp, Big head carp, Java tilapia, Blue tilapia, etc. can remove bacteria from water [**Duffer WR, 1974**]. The Chinese grass carp and zill's tilapia feed upon macrophytes. The common carp [Cyprinus carpio] and buffalo fish are bottom feeding omnivores. Mosquito fish [Gumbusia affinis] and green sail fin mollies [Poecitia tantripinna] are top minnows which feed upon insects and attached algae respectively. Other species that are found useful are the Indian species Mrigal, Rohu and Catla. Golden shiner minnows and mullets have been grown in waste waters [**Donassey ME, 1974**]. Chinese grass carp is the most effective plant eating species in the world. This species has high potential for use in integrated waste water treatment systems for the controlled cropping of submerged vegetation and duckweed. In Kerala, the fish Channa was used by people to treat their domestic wells. Channa feeds upon insects, earthworms, etc. The fingerlings of the fish removes bacteria from water [**Eichhaum W, 1976; Eusehin JA et al., 1976**].

Pollutants like pesticides, heavy metals, etc. get accumulated in the liver / kidney tissues of animals. It is known as biological accumulation or bio – accumulation. They are stored in the fatty tissues where they are metabolized or excreted at a slower rate [**Cuanu EAR, 1983**]. When higher organisms prey upon lower organisms, the pollutants get accumulated on a larger scale. This is called biological magnification or bio –magnification [**Daniel WS, 1993**] Pollutant concentrations in aquatic organisms are several orders of magnitude greater in larger organisms of aquatic food chain [**Buck H, 1970**].

When fishes are employed in waste water treatment fish disease arise. They can be employed in case of moderate pollution successfully [**Anderson, 1944**].

2.1.3 Use of flora in waste water treatment

Aquatic plants are the primary producers and functions in a similar manner as terrestrial plants. They may be algae, mosses, ferns or flowering plants and they perform various functions. For example, they may act as shelter for fish and invertebrates. They may be substances on which such organisms live; they are a food source and they also enrich the aquatic ecosystems by fixing carbon thus increasing those foods necessary for energy expenditure. They also produce free oxygen, a requirement of all aerobic organisms. The fixation of carbon and the production of oxygen is done by the process of photosynthesis [**Des WC, 1982**].

In the growth of aquatic plants, various nutrients such as N, P, C and many trace elements are removed from the water. The research of many workers has shown that various aquatic plants require varying concentrations of these chemicals for optimum growth. Furthermore, they can accumulate more of these nutrients than they need for growth [**Grady C, 1980**].

The luxury consumption allows plants to maintain optimum or near optimum growth for a period of time after the chemicals, i.e. phosphorus become limiting in the external medium. It also results in plants having a more significant effect on improving water quality in organically enriched water.

The algae, particularly, and some of the higher plants such as Spartina, are known to give off into the water many chemicals which they take up as simple forms of N and P and secrete into the water as complex organic molecules. These complex organic molecules become food for bacteria and larval stages of many organisms and so the nutrients are cycled. There is one fundamental difference in the effects of algae and other aquatic plants in the bodies of water when compared to bacteria. Bacteria by their action on easily decomposed organic matter produce simpler forms of chemicals which then are immediately used to promote growth of organisms particularly algae. As a result algal blooms quickly develop after bacterial action. In contrast, the detritus produced by algae and other aquatic plants is more decomposed and usually does not produce such a severe impact on the aquatic ecosystem.

Aquatic plants may serve one or more function. Shelter is mainly performed by aquatic plants other than algae. Floating and rooted plants are used by fish so that predators cannot reach them so easily. The submerged and emergent aquatic plants may act as a substrate for the growth of other species. Many algae grow attached to the stems of rooted or floating aquatic higher plants. Many types of animals will eat the tips of these submerged plants in order to get the small epiphytes or diatoms and microscopic invertebrates that are attached to them. Floating aquatic plants such as Anacharis, Utricularia, or Mariophyllam often furnish habitats for various microscopic invertebrates like caddis flies, damsel-flies, black fly larvae, and many different kinds of chironomids. The higher plants such as many of the rooted aquatics are eaten by some of the snails.

The emergent aquatics are food sources for both terrestrial and aquatic organisms. The accumulation of heavy metals by aquatic plants may be many thousands of times the amount in the surrounding body of water. This accumulation up to a given amount does not seem to interfere with the normal functioning of many species. As a result these aquatic plants will remove from the water significant amounts of heavy metals and accumulate them with in their tissues. They are usually released when the plant decays. Of course, they may be transferred through the ecosystem by other organisms preying upon them. Often they are removed from the river ecosystem by terrestrial animals or transferred to the ocean by migrating fish.

The plants reoxygenate the water by the process of photosynthesis and they form an important food base for the whole ecosystem. In the process of performing their function with in the aquatic ecosystem, they assimilate during the growing season, large amounts of nutrients and also they may assimilate considerable amounts of trace metals which may be concentrated within the cells. It is also well known that they excrete various soluble organic compounds which return elements such as N and P to the aquatic ecosystem. These then become food for various kinds of organisms. The amounts of N and P returned in this way is usually small compared to the amount removed.

As a result the immediate effect on water quality is the removal of considerable amounts of nutrients and in some cases, trace metals which are not known to be nutrients. These trace metals and nutrients are than locked up within the protoplasm of these plants. In the case of emergent vegetation these nutrients are dispersed in the terrestrial ecosystem as well as being returned to the aquatic ecosystem in the form of detritus or as food. The decay of the detritus and the release of nutrients from them by fungal and bacterial activity is usually a slower process than the breakdown of simple chemical compounds often occurring in waters. As a result, the impact is not as sudden. It is the assimilative capacity of marshland plants and sediments of algae and aquatic plants in the open system that is of particular value in improving water quality.

Controlled culture of aquatic macrophysics is a promising means of cleansing waste waters. Floating, submersed and emergent aquatic plant may be employed in waste water treatment. Floating plants utilize atmospheric oxygen and CO_2. Almost all the remainder of their sustenance must be obtained from the soluble nutrients in the water in which they are growing, eg. Pistia, Eichhornia, Salvinia, etc. Controlled culture of submersed vegetation for the improvement of water quality of treated waste water effluent is in the early experimental stages. Submerged plants require anaerobic environment, i.e. water clarity must be sufficient to permit higher penetration to the bottom of the culture basin. Submerged vegetation will not allow vegetation to penetrate in the water body. Most of the carbonaceous material and suspended matter must be removed from waste water introduced into the submerged vegetation culture basins. Hydrilla, Gabamba, etc. are examples of submersed vegetation.

Studies on the utilization of emergent plants grown in artificial environment for the treatment of waste waters commenced in the early 1950’s at the Max Planck Institute of Germany [**Seidel K, 1978**]. Only a few plant species have been chosen for culture. Kathe Seidel et al. evaluated over 200 species and selected only two plant species to be used in artificial marsh systems. These were the Schoenoplectus Lacustris and Phragmites communis. Nature offers an abundance of plant species; man produces many types of sewage. How plants will react to new chemical waste produced by man, which latent qualities will emerge enabling them to survive, what rearrangement will have to be made to light their way into an encumbered future are questions of vital importance. Plants themselves change when confronted with new environments, ie. plants have latent qualities of which we are unaware because they have not been challenged so far.

Sewage contains bacteria, pathogens, etc which can be easily transmitted from surface to ground water and are serious threat to public health. In conventional water treatment plants, such bacteria are eliminated by heavy chlorination. But chlorination can create carcinogenic compounds as shown by Environmental Protection Agency in New Orleans. It has been shown that the root excretions of Mentha Aquatica, Acorus Calamus, Juncus Effuses, Phragmites Communis and the root bulb of Alums Glutinosa can either partially or completely kill bacteria in contaminated water. Benign bacteria are left intact.

Excretions from plant roots protect them from decay caused by certain bacteria and fungi, maintaining the plant in a healthy condition especially during the winter months. A root tent (rhizosphere) provides a protective space for benign bacteria in times when contaminants such as acids, phenols, cyanides, or mercury threaten to destroy them. After such contaminants have passed by, surrounding bacteria can recolonize sites outside their tent and continue their vital work.

In conventional sewage works the protection for benign bacteria does not exist. They are often destroyed by poison or acids and must either be introduced artificially through bacterial sludge or reestablish themselves naturally. This can take six to eight weeks and during this period sewage passes through the system without the essential bacterial breakdown of organic forms. If acid or alkaline sewage passes through the roots of Schoenoplectus Lacustris, for e.g., the water is neutralized [ie, altered to P^H, 7]. This results in optimum bacterial and chemical reactions which in turn optimizes the quality of lake, river and ground waters. Thus the use of expensive and chemical remedies can be discarded [**Seidel et al**]. The root bulb of Alnus glutinosa and the root excretions of Acorus Calamus, Mentha Aquatica can either partially or completely destroy pathogens including viruses [**Seidel K, 1978**].

The effect of aquatic plants on p^H is dependent upon the buffering capacity of the water and plant productivity. Algae remove CO_2 from water as a result of photosynthesis. This process shifts the equilibrium between the carbonic acid and less soluble bicarbonates and mono carbonates and consumes hydrogen ions. These changes affect the total hardness and p^H of water. During maximum photosynthesis, when CO_2 is removed, the p^H increases. When the respiratory ion exceeds photosynthesis, carbonic acid increases and p^H decreases. The majority of aquatic plants are suited for a P^H of approximately 7, but some grow rapidly in water having other P^H values [**Won Chang Wung et al, 1997**].

Conventional sewage treatment plants have not only high operating costs, but also high maintenance and energy costs. The sun is still the most economic and the most reliable source of energy we have. The green plant is an age - old model that we cannot respect and value too highly. Gravity can be used in the transport and aeration of liquid wastes through the design of slopping trenches arranged in sequence on various levels.

CHAPTER III

MATERIALS METHODS AND EQUIPMENT

An initial approach to define a problem in aquatic environmental sciences necessitates the use of analytical methods and procedures in the field and laboratory that have been proved to yield reliable results. Once the problem is solved, then only satisfactory solution can be sought out. Numerous analytical methods have been developed to obtain the factual information required to find out a solution of problems as well as to have constant suspension to maintain economical and satisfactory performance of the treatment facilities constructed. Analytical procedures needed to obtain qualitative information are often a mixture of chemical, bio-chemical, biological, bacteriological, bioassay and instrumental methods and interpretation of the data is usually related to the effect on microorganisms or human beings. Also many of the determinations fall under the micro analysis because of the small amounts of contaminants present in the sample [**Manish L and Srivastava, 1975**].

3.1 TOPOGRAPHY OF THE STUDY AREA.

Kerala is blessed with an abundant number of rivers and rainfall. Ground water is the main source of fresh water for major population of the state especially in the rural areas. Groundwater is usually extracted through hand dug shallow wells. Selected places of Kozhikode, Kannur and Kasaragod districts have been taken for the present study. These districts fall under the North Malabar region of Kerala.

Kozhikode is an important business center of Kerala. It is situated in the northern part of Kerala between $11^0\ 11^1$ -$11^0\ 15^1$ north latitude and $75^0\ 45^/$– $75^0\ 50^1$ east longitude. It has a total area of 2344 sq. Km. and a population of 2.62 lakhs, which is about 9% of the State. The relative areas of the different physiographic units in the district are low land, midland and high land. Kozhikode Corporation has an area of 84.2sq.Km. The soil is typically laterite. It is deep red in colour and is observed mainly in the tropics. A part of Kozhikode Corporation in the heart of the City from Nadakkavu to Kallittanada has been selected for the study. The average annual rainfall in the area is 3000mm.

Kannur district lies adjacent to Kozhikode district and is famous for its textile industry. The average annual rainfall is 3438mm and occurs during the periods of South West Monsoon. Due to the presence of hard rock and hard laterite, ground water availability is low in this area. Kannur district has an area of 2966 sq.km. Elayavoor, Cheruthazham and Payyavoor panchayats have been selected for the study.

Kasaragod district is adjacent to the Kannur district and lies at the northern end of Kerala. Due to the presence of hard rock and hard laterite, the availability of ground water resources is very low in this district also. Muliyar panchayat has been selected for the study.

The work that has been done at the above 4 panchayats of Kannur and Kasaragod districts forms part of a project entitled, “Study for assessing the risk to ground water from on site sanitation in rural Kerala”, funded by Modernizing Government Programme (MGP) of the Government of Kerala and the programme was initiated by the Water and Sanitation Programme-South Asia (WSP-SA). Under this project, only microbiological examination of the ground water sources has been conducted.

Water quality studies were conducted at a tribal area of Payyavoor Panchayat of Kannur district of Kerala State. This work forms part of a research project of CWRDM entitled, “Water quality studies and water conservation techniques at a tribal area of Kannur district, Kerala State.” funded by the Western Ghat Cell of Government of Kerala. Two wards of the panchayat, namely Vanchiyam and Kanjirakkolly, where there is tribal colonies, have been selected for the study purpose.

3.2 MATERIALS

3.2.1 Reagents and Chemicals

All the chemicals used were of analytical grade BDH, E Merck, Hi. Media or Qualigens. Standard solutions and reagents for analysis were prepared as follows.

3.2.2 Standard Titrants

1. Sulphuric Acid (0.02N)

Sulphuric Acid solution for total alkalinity determination was prepared by diluting concentrated acid. After *stomdarolisation* with standard sodium carbonate solution (0.02N) the normality was adjusted as required.

2. EDTA Solution (0.01M)

3.725 g of EDTA was dissolved in distilled water and made upto 1 litre. The molarity was checked by titrating against standard calcium solution using murexide as indicator.

3. Silver nitrate solution (0.0282 N)

4.7 g of silver nitrate was dissolved in redistilled water, diluted to one litre and stored in brown bottle. Concentration of the solution was checked titrimetrically with sodium chloride solution (0.0282N) using potassium chromate as indicator.

3.2.3 Stock Solution for SpectrophotometricDetermination

1. Iron Solution

For constructing calibration curve for the estimation of iron, stock solution was prepared by dissoloving 0.864 g hydrated ferric ammonium sulphate in distilled water in the presence of 10 ml of Con. HCl and made upto 1 litre.

1 ml of this solution contains 1mg of iron.

2. Fluoride solution.

Dissolved 221.0mg of anhydrous sodium fluoride in distilled water and diluted to 1000 ml.

1 ml of the solution is equivalent to 100 microgram or 100 ppm fluoride.

3.2.4 Stock Solutions for Flame photometer - Estimation of sodium and potassium

Standard Sodium Solution

Dissolve 12.541 g AR sodium choride in distilled water and made up to 1000 ml.

Standard potassium solution

Dissolved 1.907 g AR potassium Chloride in distilled water of made up to 1000 ml.

3.2.5 Special Reagents

1) Acid Zirconyl SPADNS Reagent

a) SPADNS Solution

Dissolved 958 mg SPADNS (2-Para- Sulpho phenylazo – 1, 8 – dihydroxy, 3-6 naph thalein) also called 4,5 – dihydroxy-3-[parasulpho phenylazo]-2-7- naphthalein disulphonic acid trisodium salt ,in distilled water. and distilled to 500 ml.

b) Zirconyl acid reagent

Dissolved 133 mg.zirconyl chloride octahydrate ($ZrOCl_2 . 8H_2O$) in about 25 ml. distilled water and added 350 ml. Con. HCl, further diluted to 500 ml. with diluted water.

Then mixed equal volumes of SPADNS solution and zirconyl acid reagent for preparing acid Zirconyl SPADNS reagent.

2) Hydroxylamine hydrochloride solution

Dissolved 20g hydroxyl ammine hydrochloride in distilled water and diluted to 100 ml

3) 1, 10- Phenanthroline solution

Dissolved 100 mg of 1, 10 – Phenanthroline in 100 ml of distilled water by stirring and heating to 80 C.

4) Phenanthroline solution for iron estimation.

Dissolved 100mg of 1, 10- phenanthroline in 100ml, distilled water by stirring and heating to 80^0 C.

5) Conditioning reagent for estimation of sulphate

Mixed 50ml, of glycerol with a solution containing 30ml.con.HCl, 300ml. distilled water, 100ml. 95% ethyl alcohol or *isprohyl* alchol and 75g sodium chloride.

6) Standard sulphate solution

Diluted 10.41ml.standard 0.02N sulphuric acid titrant to 100ml. with distilled water.

3.2.6 Buffer solutions

1) Ammonia buffer for estimation of total hardness

Ammonium Chloride (16.92 g) was dissolved in 143ml. concentrated ammonia of specific gravity 0.8 and then 1.25 g of magnesium salt of EDTA was added and diluted to 250 ml with distilled water.

2) Sodium hydroxide 1N to estimate Calcium

Dissolved 40 g sodium hydroxide in distilled water. Cooled and diluted to 1 liter.

3) Ammonium acetate buffer solution

Dissolved 250g ammonium acetate in 750ml distilled water. Added 700ml. concentrated (glacial) acetic acid

3.2.7 Indicators

1. Eriochrome Black. T indicator

0.5 g of the solid indicator was ground with 100 g of AR sodium chloride in a mortar and stored in airtight bottles.

2. Phenolphthalein indicator

Dissolved 1 g phenophthalin in 100 ml of 95% alcohol and added 100 ml of distilled water and then added 0.02 N NaoH until a faint pink colour appears.

3. Methyl Orange indicator

Dissolved 0.5 g of methyl orange in 1 liter of distilled water.

4. Murexide indicator

Mixed solid murexide indicator and AR sodium chloride in the ratio 1:500 by weight in a mortar and ground well and kept the powder in a dry bottle.

5. Potassium Chromate Solution

Dissolved 50g potassium chromate in a little distilled water. Added silver nitrale solution until a definite red precipitate was formed. Allowed the solution to stand for 12 hours. Filtered and diluted the filtrate to one liter with distilled water.

3.2.8 Reagents for Microbiological Examination of water

(a) Buffered Water

Prepared stock phosphate buffer solution by dissolving 34.0g potassium dihydrogon phosphate, in 100ml. distilled water, adjusted to pH 7.2 with IN sodium hydroxide and diluted to 1 litre with distilled water.

Added 1.25ml. stock phosphate buffer solution to 1 litre of distilled water.

(b) Peptone dilution water

Dissolved 15g in 1000ml water.

(c) Brilliant Green Lactose Bile Broth (B G L B)

Dissolved 40g of B G L B in 1000ml. of distilled water.

(d) Azide Dextrose Broth (A D B)

Dissolved 34.7g of ADB in 1000ml of distilled water (single strength)

Double strength – Dissolved 69.4gm in 1000ml.distilled water.

(e) Ethylviolet Azide Broth (EVA)

Dissolved 35.8g of E VA in 1000ml. of distilled water.

(f) Mac Conkey agar

Dissolved 80gm of the agar in 1000ml of distilled water. (Double strength).

Dissolved 40 g of the agar in 1000ml of distilled water.(Single strength).

3.3 INSTRUMENTS

Instruments used in the investigation are.

1. A Systronics digital 335 pH meter was employed for all pH measurements. Standard buffer solutions of pH 4, 7 and 9.2 were used for calibration.

2. E lico CM 180 conductivity meter was used for measuring specific conductivity.

3. A Hitachi model UV – Visible spectrophotometer was used for estimation of iron and fluoride.

4. For determination of sodium and potassium, a Systronics model flame photometer 128 was used. Flame was produced by liquid petroleum gas.

3.4 METHODS

Water sampling and the determination of various physico-chemical and microbiological parameters were carried out following the procedure described in APHA, Standard Methods for the Examination of Water and Waste water (APHA1987).

3.4.1 Sampling

Representative samples of each source were collected after washing and rinsing of containers. Samples from the wells were collected from a few feet below the water surface. Samples from the hand pump operated bore well was taken after thorough flushing. Similar pattern of sampling was used during all the two seasons. Two separate set of samples from each of the wells were collected as follows for the following purposes.

Samples for Chemical analysis

Water samples were collected in plastic containers of two litre capacity. The container after washing with the specific sample were filled directly from the source and then properly stoppered.

Samples for bacteriological analysis

Samples for bactereological examination were collected in 100 ml sterilized plastic containers (already available in the shop). While collecting samples for the bactereological analysis extreme care was exercised to avoid contamination, parts of the bottle coming in contact with the water. Bottles were filled to three quarters of their capacity and samples were collected from the wells.

Samples after collection were transported to the appropriate laboratories for investigation. Whenever required, samples were preseved in refrigerators. Samples for bacteriological analysis were stored at temperatures between 6^0C and 10^0C.

3.4.2 Analysis

(1) pH

The instrument was allowed to warm up for 30 minutes, followed by calibration of the electrode system against standard buffer solutions of known pH 4, 7 and 9.2. The electrode was washed with distilled water having a conductance of less than 2 μmhos/cm. This was then placed in the water sample taken in a 100 ml beaker and the p^H was read directly.

(2) Electrical conductivity

The electrical conductivity of any sample depends upon the electrolytes dissolved in it provided the solution is very dilute, the conductivity is proportional to the amount of such substances dissolved in the water. Conductivity cell was washed with distilled water and placed in potassium chloride solution (0.01N) after rinsing. The reading was adjusted to 1409 (μmhos/cm). This is the standardisation of the EC meter. Then the sample was taken in a 100 ml beaker and specific conductivity was measured after washing the cell with distilled water and rinsing with the sample. The EC meter directly measures the electrical conductivity. The unit is micromhos/cm at 25^0C.

(3) Total Hardness

Total hardness was determined by EDTA titrimetric method. 100 ml of the water sample was titrated against standard EDTA (0.01M) solution using Eriochrome Black T as the indicator at a pH of 10 (ammonia buffer was used). The results are expressed in ppm or mg/l calcium carbonate.

(4) Total Alkalinity

100 ml of the water sample was titrated against sulphuric acid (0.02N) solution using methyl orange as indicator. The results are expressed in mg/L of calcium carbonate. Phenolphthalein alkalinity in the samples were found to be zero.

(5) Calcium and Magnesium

The total hardness value includes hardness due to calcium and magnesium ions. The titration was repeated using murexide as indicator at a p^H of 12 – 13 with 1N sodium hydroxide solution. The titer value corresponds to the amount of Ca in the sample. The difference between the titer value for total hardness and calcium has been used to calculate the concentration of magnesium in the sample. The results are expressed in ppm.

(6) Sodium and potassium

Sodium and potassium are estimated by using flame photometer, which is most rapid, sensitive and generally the most accurate method. Standard sodium and potassium solutions were prepared and the flame photometer was calibrated. The samples were then analysed and results were read directly and expressed in ppm or mg/L.

(7) Chloride

Since the pH of all the samples were around 7, argentometric method was employed for the determination of chloride. 100 ml of the sample was titrated against standard silver nitrate solution (0.0282 N) using potassium chromate as indicator. The results are expressed in ppm.

(8) Sulphate

Sulphate was estimated using turbidity meter.

(9) Fluoride

Fluoride concentration in the water samples were determined spectrophotometrically by SPADNS method. 50 ml of the sample was treated with 10 ml of acid Zirconyl SPADNS reagent and mixed well. The absorbance of the resulting solutions were measured at 554 nm. A calibration curve was prepared by using different fluoride standards in the range of 1-1.4 ppm by diluting appropriate quantities of standard solution to 50 ml. with distilled water. From the calibration curve, the amount of fluoride was calculated and expressed as ppm of fluoride.

(10) Iron

Total iron content in the water sample were determined using UV-Visible spectrophotometer by phenanthroline method. 50 ml of the sample was taken in a beaker, added 2ml of con. HCl and 1ml hydroxylamine solution. Added few glass beads and heated to boiling. Cooled to room temperature and transferred to 50 ml volumetric flask. Added 10 ml ammonium acetate buffer solution and 2ml phenanthroline solution and diluted to the mark with distilled water. Allowed 10-15 minutes for maximum colour development. The intensity of the colour was measured using a uv-visible spectrophotometer at a wavelength of 510 nm. A calibration curve was also constructed using different concentrations of standard iron solutions. The concentrations of iron are expressed in ppm.

(11) Microbiological analysis water.

The analysis was done following the methods described in APHA and other standard texts. Total coliforms were determined which is expressed as most probable number (MPN index/ 100 ml). *E. coli* and faecal streptococci were also determined.

CHAPTER IV

PHYSICO – CHEMICAL AND MICROBIOLOGICAL CHARACTERISTICS OF WELLS

As a result of chemical and biochemical interactions between ground water and the geological materials through which it flows, and to a lesser extent because of contributions from the atmosphere and surface water bodies, ground water contains a variety of dissolved inorganic chemical constituents in various concentrations. When water comes in contact with minerals dissolution of the minerals begins and continues until equilibrium concentrations are attained in the water or until all the minerals are consumed. Thus depending on the minerals that the water has come into contact with during its flow path, ground water may be only slightly higher in dissolved solids than rainwater or it may become many times more salty than seawater. Ground water can be viewed as an electrolyte solution because all its major and minor dissolved constituents are present in ionic form. In processes like groundwater–mineral interactions, proton transfer denotes the transfer of an H^+ between components and phases [**Yasushi K, 1975; Krauskopf 1967**].

The quality of ground water is described by its physical, chemical and microbiological properties. These characteristics are interlinked. Therefore, interpretation of coefficients between water quality parameters gives good idea about the quality of water and facilitates rapid monitoring methods. Kumar et al. (1994) have studied quality and correlationship among water quality parameters of ground water samples from different parts of India and developed linear regression equations for different water quality parameters. Similar studies were also carried out for Musnur Mandal [**Rao KS, 1994**) and Reddigudem Mandal (**Krishna JSR, 1995**) in Krishna district of Andhra Pradesh. Singh (1996) made a study of correlation among 14 water quality parameters by taking 35 locations in Jhungunu district of Rajasthan and obtained neither perfect positive nor perfect negative correlations. Patil and Khaire (2004) has conducted a statistical analysis of physicochemical parameters of ground water. He tried to correlate 55 pairs of parameters and found that there is positive correlation between 2/3 of the total number of pairs.

Jesiamma Joseph (2005) has evaluated the extent of pollution of ground water and soil in selected areas of Calicut district and have found out the correlation between different water quality parameters. Kamalakshan Kokkal et al. (2002) have studied the quality of well water near KSRTC bus stand Kasaragod and has reported that those wells are severely bacteriologically contaminated. Nazimuddin et al. (2003) has identified major sources of pollution in different parts of Kerala. In Mavoor a number of open wells around the buried pipelines along 11 km stretch were found to be affected. Another investigation of wells in West Hill revealed that pollutants from sewerage drain took 34 years to reach well which was only 30 m away from the drain [**Nazimuddin et al., 2003**].

Generally the ground water problems in Kerala are due to the presence of excess of salinity, iron, fluoride, hardness and coliforms. Low pH, high iron content, high hardness, high TDS and salinity are common quality problems in coastal areas [**Nazimuddin and Basak 1995**]. Excess chloride concentration has also been reported from the coastal zone (**CWRDM, 1997**).

The concentration of major, minor and trace inorganic constituents in ground water are controlled by the rates of geochemical processes and by the sequence in which the water has come into contact with the various minerals occurring in the geologic materials along the flow path. The concentration of the dissolved inorganic constituents is increasing by man's activities. Hence it is very important to assess the quality of ground water. Generally ground water contains many suspended and dissolved substances like salt, sand, microorganisms, metals etc, originating from natural sources. The addition of these components artificially or the entrance of any new components to the water system deteriorates its water quality, as they affect the biota adversity. For investigating these alternatives mainly three types of tests have been developed. They are

(1) Physical Tests

(2) Chemical Tests

(3) Biological Tests

4.1 PHYSICAL TESTS

The physical tests generally include temperature, color, odour, taste, turbidity, solids, conductivity, etc. The following physical tests have been conducted for the samples.

4.1.1 Colour

If the water sample is coloreded it will not allow the sunlight to enter the water body. Thus aquatic environment will be affected. The colour is measured either by visual method or using a spectrophotometer. The color of a water results from the presence of metallic ions (Iron and manganese), humus and peat materials, plankton, weeds and industrial wastes.

4.1.2 Solids

Total solids include the concentration of suspended and dissolved constituents of a water sample. Water with high solids are of inferior palatability and may induce an unfavorable physiological reaction to the transient consumer.

4.1.3 Odour and taste

Many organic and some inorganic chemicals contribute taste and odour. Odour is recognized as a quality factor affecting water in several ways. Odour and taste are known as the chemical senses since they depend on actual contact of the stimulating substrate with the appropriate human receptor cell.

4.1.4 Conductivity

Conductance yields a measure of a water's capacity to convey an electric current. Conductivity measurements afford an idea of the aliquots which may prove useful for the common chemical determinations. The electrical conductivity of any sample of water depends upon the electrolytes dissolved in it and providing the solution is very dilute, the conductivity is proportional to the amount of such substances dissolved in the water.

4.2 CHEMICAL TESTS

The chemical tests include pH, total hardness, alkalinity, calcium and magnesium, sodium and potassium, fluoride, chloride, sulphate, nitrate, iron etc.

4.2.1 pH

pH is defined as the logarithm of the reciprocal of the hydrogen ion activity or hydrogen ion concentration in moles per liter and it is determined by glass electrode method. The hydrogen gas system is recognised as the primary standard. The glass electrode in combination with the reference potential provided by a saturated calomel electrode is most generally used. The glass electrode system is based on the fact that a change of pH unit produces an electrical change of 59.1mv at 25^0C. The glass electrode is relatively immune to interference from colour, turbidity, colloidal matter, etc

4.2.2 Total Hardness

The hardness of a water sample is a measure of the capacity of the water for precipitating soap. Soap is precipitated chiefly by calcium and magnesium ions commonly present in water, but may also be precipitated by polyvalent ions such as iron, aluminum, silicon and by hydrogen ions. Because all but the first two ions are usually present in insignificant concentrations in natural waters, hardness is defined as a characteristics of water which represents the total concentration of just the calcium and magnesium ions expressed as $CaCO_3$.

The Sawyer's classification of water according to its hardness is as follows. Water with hardness in the range 1ppm – 50ppm are considered as soft. Hardness in the range 50ppm – 100ppm is slightly hard and hardness in the range 100 – 200ppm is moderately hard and above 200ppm is considered as very hard.

4.2.3 Alkalinity

The alkalinity of a natural water is mainly represented by its content of carbonates, bicarbonates and hydroxides. The alkalinity of a water is its capacity to neutralize acids. Bicarbonate represents the major form of alkalinity because they are formed in considerable amounts by the action of CO_2 on basic materials in the soil. For practical purpose, alkalinity due to other materials such as borates, silicates, phosphates, etc, may be ignored. Alkalinity is determined by titration with a standard solution of a strong acid to certain hydrogen ion concentrations, using selected indicators which show definite colour changes at these points.

4.2.4 Calcium and Magnesium

The presence of calcium in water samples results from passage through or over deposits of limestones, dolomite, gypsum and gypsirferrous shale. If a solution containing calcium and magnesium ions is made strongly alkaline (pH about 12) magnesium is selectively precipitated as magnesium hydroxide, although when the amount of Mg is small, no evidence of a precipitate is seen. The dye, murexide is sensitive to calcium ions only and not to magnesium ions and so the hardness due to Ca may be estimated by titrating with E D T A in the presence of murexide or ammonium purpurate.

Magnesium is a common constituent of naturall waters. When the total hardness and calcium hardness have been found,the difference between the two results gives the hardness due to magnesium in terms of $CaCO_3$.

4.2.5 Sodium and Potassium

Sodium is present in most natural waters. The ratio of sodium to total cations [SAR – Sodium absorption ratio] is important in agriculture and human pathology. Potassium ranks seventh among the elements in order of abundance, yet its concentrations in most drinking waters seldom reaches 20ppm. The flame photometric method is most rapid, sensitive and generally more accurate. If the percentage of calcium, magnesium and sodium ions is above 50ppm in irrigation water, sodium takes up exchangeable calcium and magnesium, causing deflocculation and impairment of the silt and permeability of the soils. The sodium hazard is expressed by the sodium absorption ratio SAR

4.2.6 Fluoride

Fluoride concentration of approximately 1ppm effectively prevents dental carries without harmful effect on health. Higher concentrations of fluoride causes fluorosis. Fluoride is estimated by colorimetric method using SPADNS reagent based on the reaction of fluoride and a zirconium dye lake. The fluoride reacts with the dye lake, dissociating a portion of it into a colourless complex anion [Zr F_3^{2-}] and the dye. As the amount of fluoride is increased, the colour produced becomes progressively lighter or different in hue, depending on the reagent used.

4.2.7 Chloride

The quantity of chorine existing as chlorides can be determined in a very simple manner by the use of a standard solution of silver nitrate, using potassium chromate as an indicator. The reaction involved in the first place, is the formation of the white insoluble silver chloride, and when all the chloride is thus precipitated, the excess of silver is thrown down as red silver chromate. When the silver solution is added to the water containing the potassium chromate both silver chloride and silver chromate are precipitated; at first the chromate is rapidly decomposed by the chloride remaining in solution, but as the amount of unprecipitated chloride decreases, the decomposition of the silver chromate becomes slower and slower, indicating the approach of the end of the reaction. An excess of silver nitrate must be used to produce the red colour and this excess varies within certain limits with the amount of potassium chromate added. Whilst deficiency of chromate is to be avoided, an excess is undesirable, as it obscures the delicacy of the reaction. It is important therefore to use a standard amount of chromate.

Chloride is a common constituent of natural waters and is a measure of salination. In ground water sources generally chloride is small but in coastal areas, salt water intrusion is taking place. In surface water sources chloride content is great due to the discharge of domestic wastes. Abnormal concentrations of chloride indicates pollution.

4.2.8 Sulphate

The sources of sulphate in water are sulfide minerals. Pyrite is one of the most common sulphide mineral found in all rocks types. The oxidation and hydrolysis of pyrite produces sulphuric acid and other soluble sulphates. Sodium and magnesium sulphate exerts a cathartic action and should not be present in excess in drinking water.

4.2.9 Nitrate

Nitrates are found in many foods. Higher concentrations in drinking water can cause a disease known as Methenoglobinemia in infants. Nitrite is changed into nitrate in the stomach of small infants.. The nitrate then interferes with the blood’s ability to carry oxygen. Thus blue baby syndrome can occur. Nitrate when present in excess reacts with proteins in the food and produces carcinogens.. Besides minerals the source of these ions is atmosphere. Rainwater contains nitrite and nitrate by dissolving oxides of nitrogen from the atmosphere. These enter the ground water during discharge process. High nitrate levels are associated with over fertilizing in agricultural areas or failing septic systems.

4.2.10 Iron

Iron is one of the most frequent constituents of potable water but fortunately it usually occurs in such minute quantities that its presence in water derives from the stains imparted to laundry and porcelain and also the bitter sweet astringent taste which may be detectable by some persons at levels above 1 to 2 ppm.

The colorimetric determination of iron in water with phenanthroline compounds has become an important method in recent years.

Iron is brought into solution, is reduced to the ferrous state by boiling with acid and hydroxyl amine and treated with 1, 10–phenanthroline at pH 3.2 – 3.3. Three molecules of phenanthroline chelate with each atom of ferrous iron to form an orange red complex. The coloured solution obeys Beer’s law, its intensity is independent of pH from 3 to 9, is stable for at least 6 months.

4.3 BIOLOGICAL TESTS

Biological tests include a wide variety of parameters like Benthos, Plankton, Bacteria, Virus, Fungi, etc. All the parameters are of great significance in evaluating the water and waste water quality. These biological parameters are always affected by the addition of pollutants by which they change their density and composition, eg. water receiving sewage always shows high concentrations of pathogenic and non- pathogenic organisms. Surface water is likely to come in contact with harmful chemicals and microbes than ground water. Safe and clean drinking water is of prime concern for a healthy and sustainable life of human beings. In Kerala, about 6,00,000 people develop some kind of gastrointestinal illness for which they seek medical help. These illnesses may be due to a variety of reasons including contaminated drinking water. The average well density in Kerala is 140 wells / km^2. Sanitation coverage is currently 84% of the population senses. The new toilets constructed are usually a twinpit / pour flush design that is thought to be less likely to cause pollution to the water table. Due to the density of the residential units and the high density of dug wells in the state, several of the wells are subjected to faecal contamination attributed to poor on – site sanitation systems. Some of the preliminary investigations have revealed that the single pit / double pit latrines and septic tanks are not safe enough to prevent contamination of these dug wells. E. coli and Faecal Streptococci are found in the excretary matter of animals and are of very good microbial indicator of faecal contamination. Total coliforms were determined which is expressed as MPN index per 100ml. [MPN/100 ml]. Escherichia Coli and Faecal Streptococci were also determined. These organisms must be absent in potable water.

Total coliforms and faecal coliforms were determined in the laboratory following the methods described in Standard Methods for the Examination of Water and Waste Water and other standard texts.

Traditionally tests for the detection and enumeration of indicator organisms rather than pathogens have been used. The coliform group of bacteria has been the principal indicator of the suitability of a particular water for domestic, dietetic, or other uses, It has become the custom to report the results of the coliform test by the multiple – tube fermentation procedure as a Most Probable Number (MPN) index. This is only an index of the number of coliform bacteria that, more probably than any other number, would give the results shown by the laboratory examination. It is not an actual enumeration of the coliform bacteria.

TREATMENT OF THE WELLS

Introduction

All natural waters contain a variety of organisms both plants and animals as the natural flora and fauna. In water receiving sewage domestic wastes and industrial wastes may contain plenty of pathogenic organisms. One such etiological agent is bacteria. Bacteria seldom travel more than 100km from a point source. Studies have shown that bacteria are removed by filtration.

Although most members die out rapidly in ground water, bacterial population may occur locally in heavily populated areas where numerous septic tanks discharge large quantities of waste. It has been reported that filtration or physical staining of bacteria is the main limitation to its travel through the soil and adsorption of bacteria and hence its retention is more efficient in clayey soils. Climate, nature of the soil and nature of the microorganisms control the retention in bacteria and viruses and their survival rate. Rainfall, pH, composition of soil, moisture holding capacity of soil, soluble organics, cations and flow rate of contaminated water also influence the movement of viruses and bacteria.

The microbiological examination of water enjoys a special status in pollution studies as it is a direct measurement of deleterious effect of pollution on human health. The bacteria causing cholera, typhoid fever and bacillary dysentery may be present in sewage- polluted water.

It is highly essential to examine the presence of pathogenic organisms in potable water. Biological monitoring of water is also essential in water used for swimming and recreation.

The detection and estimation of bacteria is a tedious work because of the presence of very small number and complicated techniques, hence another indicator type of bacteria are routinely monitored to indicate the presence of pathogenic organisms in water. The organisms known as coliform bacteria are discharged from the human intestine and their presence indicate the possibility of the presence of pathogenic organisms. The coliform bacteria include the general Escherichia coli, citra bacter, Entero bacter and Klebsiella. The Eischerichia coli are entirely different and hence the entire coliforms are used as indicator. The routine tests to confirm the water quality of drinking water standards do not report the actual number of coliforms but they are reported as an approximate count that is Most probable Number (MPN).

Water Treatment

The primary objective of any water treatment methods is to render the water safe for human consumption and other uses, eliminating from the raw water, potentially dangerous microorganisms and chemicals. In view of the alarming number of cases of water borne diseases, what assume primary importance during treatment is the effective removal and inactivation of household infectious agents.

Water treatment plays an important role in the wide subject of pollution problems solving and represents today as one of the most important fields of study. Treatment of water by methods such as storage, coagulation, sedimentation, and filtration would render water chemically and aesthetically acceptable with some reduction in bacterial content. However, this does not provide safe water and it is necessary to disinfect the water to destroy all the disease – producing organisms. Minor methods of disinfection include boiling of water, treatment with substances like excess lime, ozone, iodine and bromine, bleaching powder, potassium permanganate, etc. The ultraviolet water purifier consists of a pre – filter to remove large particulate matter. Then the water is passed through an activated carbon chamber which removes the unobjectionable odour, colour, and biological contaminants. Finally a chamber of ultra violet rays removes the remaining bacteria, viruses and protozoa.

Biological Treatment

In the field of water purification, the available technology for water treatment that is suitable for developed countries is often inappropriate for underdeveloped countries particularly for villages and small communities. Urban dwellers in the developing countries are also becoming increasingly aware of the potential dangers of consuming water which is either improperly treated in centralized facilities or becomes contaminated during distribution or storage. The development of simple technologies needs an integrated out look and multidisciplinary approach where the fields like biology and chemistry should intervene with engineering aspects.

The existing treatment methods mainly involve chemical methods where health problems are a matter of concern. The emergence of biological system for wastewater treatment has received much attention since they represent an alternative cost effective and environmental approach for the removal of pollutants. Hence, studies on the biological water treatment techniques are relevant for the improvement of the quality status of water, especially of wells and ponds, which are the main drinking water sources.

Biological purification of water using aquatic organisms is a low – cost method, which needs very little investment, energy requirement and maintenance compared to the existing water treatment processes.

4.4 RESULTS AND DISCUSSION

In Kerala State there is protected water supply in urban and most of the rural areas but in alternate days only and scarce during summer. Hence people depend upon open dug wells for their domestic needs. About 80% of the population relies on ground water for drinking. The ground water quality gets deteriorated due to human activities. The scientific management of ground water resources is one of the key issues to be considered. In the present study the ground water quality of Kozhikode, Kannur and Kasargod districts is discussed. A tribal area of Kannur district also has been selected for study. The treatment of the wells were done at Kozhikode and Kannur districts using indigenous knowledge and was found to be very effective.

4.4.1 Ground Water quality status of Kozhikode Corporation area

A survey has been conducted and 14 wells were identified for the study purpose. Water samples were collected from these wells during pre- monsoon, monsoon and post-monsoon seasons of the year and physico – chemical and microbiological analysis were conducted. The study area consists of a part of Kozhikode Corporation from Nadakkavu to Kallittanada. The map of the study area is given in fig 4.1. Electrical conductivity, pH, total hardness, total alkalinity, calcium, magnesium, sodium, potassium, iron, fluoride, chloride, sulphate, bicarbonate, nitrate, MPN etc. were determined.

The pH of the water samples were found to be within the permissible limit except for well No. 10. Conductivity varies from 40 to 1750 micromhos per cm. Total hardness varies from 35 to 274 ppm. Alkalinity varies from 0 to 240ppm. Chloride concentration varies from 12 to 210ppm. Concentration of sulphate varies from 0 to 200ppm. MPN index varies from 0 to 1100 per 100ml of sample. The well at Jawahar Nagar colony had high concentration of iron and varies from 5 to 230ppm. The bore well at Nadakkavu only was found to be potable during Pre-monsoon, monsoon and post monsoon seasons of 2000. During pre monsoon 1999, MPN value was high. The results of analysis are shown in tables 4.1, 4.2, 4.3 and 4.4.The concentration of fluoride was determined for the samples and was found to be absent in all the samples.

The diagnostic chemical properties of water are presented by various methods, the most common of which are the hydro chemical facies, eg. the Piper diagram [**Piper AM, 1944**]. The results of analysis are plotted in Piper trilinear diagram and are shown in figure. 4.2 [**Chandrasekharan D and Usha Kumari S, 1982; Chandrasekharan et al., 1983**].

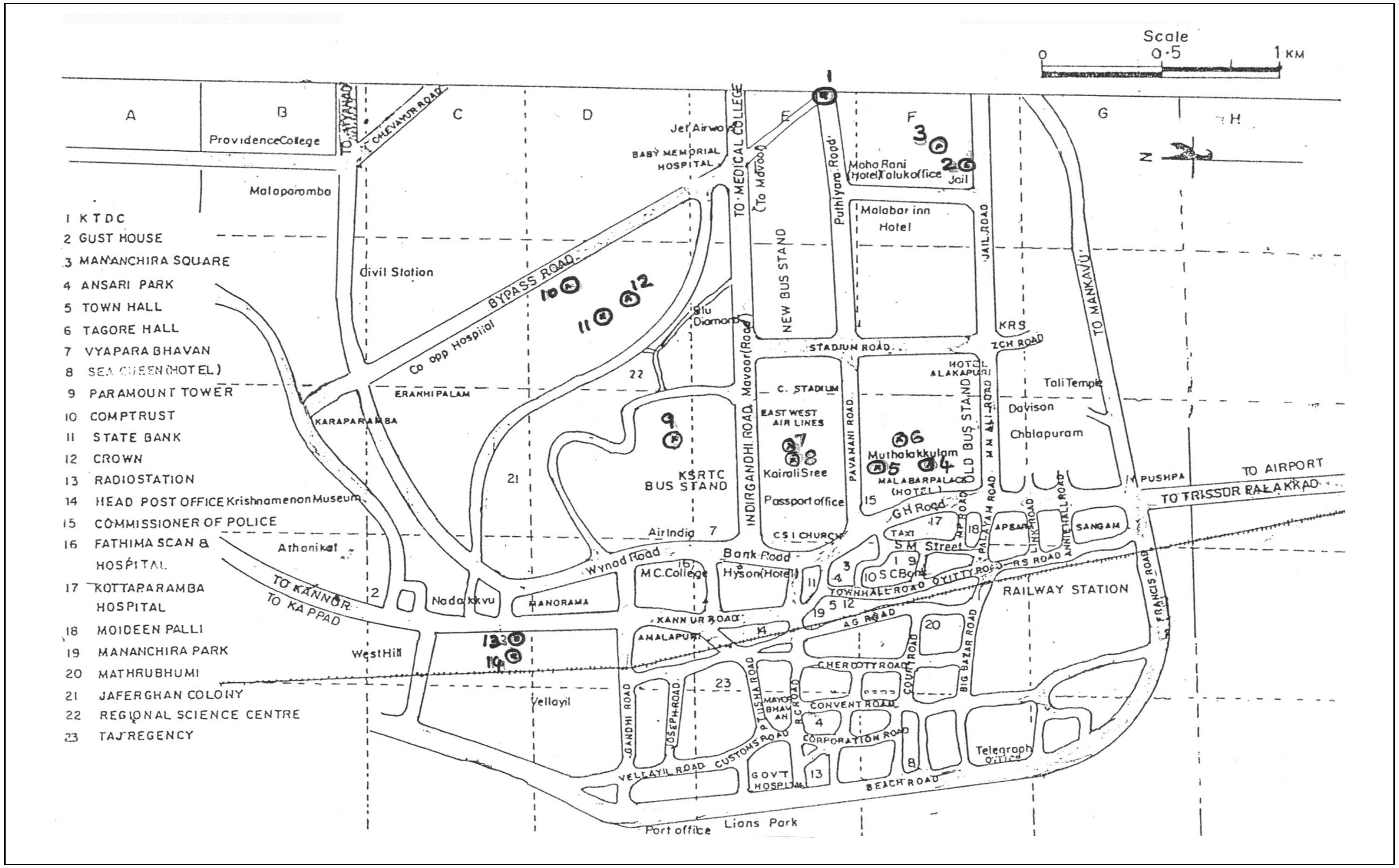


Figure 4.1: Location Map of Calicut Corporation Area

Table 4.1

Water Quality Status of Wells – Pre Monsoon 1999

Well. No	1	2	4	5	6	7	8	9	10	11	12	13	14
P^H	7.0	7.2	7.4	7.6	7.2	7.0	7.4	7.0	5.0	6.8	6.8	6.0	7.0
Electrical conductivity (Micro Mhos/cm)	340	490	175 0	100 0	800	500	420	800	175	190	540	125 0	900
Total Hsrdness (ppm)	64	86	270	174	168	118	90	146	170	82	70	124	124
Total Alkalinity (ppm)	46	44	318	200	168	98	80	130	40	26	12	6	18
Iron (ppm)	0.3	T	T	T	0.1	T	T	T	230	0.6	T	T	T
Bicarbmate (ppm)	46	44	318	200	168	98	80	130	40	26	12	6	18
Chloride (ppm)	26	40	134	90	42	36	28	64	210	50	12	120	64
Sulphate (ppm)	ND	30	40	10	20	ND	ND	20	100	70	60	60	50
MPN	460	110 0	43	23	110 0	240	110 0	110 0	Nil	110 0	110 0	93	240

ND – Not Detected
T – Trace

Table 4.2

Water Quality Status of wells. Pre Monsoon 2000

Well. No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
P^H	7.4	7.6	6.2	7.6	7.6	7.6	7.0	7.0	7.6	4.0	7.6	7.0	7.0	7.6
Electrical conductivity (Micro Mhos/cm)	50	60	230	170	180	120	130	60	140	310	210	90	90	90
Total Hsrdness (ppm)	54	102	156	194	182	150	44	96	156	180	196	84	84	110
Total Alkalinity (ppm)	38	48	8	202	212	152	38	28	134	ND	70	16	26	94
Calcium (ppm)	16.5	31.2	42.4	41.6	34.2	44.0	14.4	25.6	96	48.8	49.6	21.6	21.6	34.4
Magnesium (ppm)	2.9	5.8	12.1	21.9	20.4	9.7	1.9	7.8	17	14.8	35.7	7.3	4.9	7.3
Sodium (ppm)	35	41	106	81	91.4	64	22	41	65	ND	83	1150	187	42
Potassium (ppm)	6	11	57	47	38	21	7	8	19	ND	34	6	157	8
Iron (ppm)	6.2	T	T	0.1	T	0.3	T	T	T	20.0	0.4	0.10.1		0.1
Bicarbmate (ppm)	38	48	8	202	212	152	38	28	134	ND	7.	16	26	94
Chloride (ppm)	32	30	130	66	82	34	12	34	68	164	86	42	42	36
Sulphate (ppm)	ND	20	25.	10	15	ND	5	50	25	10	60	40	40	25

			0											
MPN	460	93	Nil	43	460	110 0	110 0	240	110 0	Nil	43	110 0	43	Nil

Table 4.3

Water Quality Status of wells – Monsoon 2000

Well. No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
P^H	6.6	6.8	7.0	7.6	7.6	7.4	7.0	7.4	7.4	6.8	6.8	6.6	6.0	7.2
Electrical conductivity (Micro Mhos/cm)	140	140	300	920	840	800	530	400	630	1000	430	310	940	650
Total Hsrdness (ppm)	38	96	92	274	192	222	154	102	194	220	94	68	130	130
Total Alkalinity (ppm)	24	36	58	240	194	206	112	90	152	62	24	14	9	56
Calcium (ppm)	4.8	15.1	16	46.7	28	31.2	25.6	16	30.4	31.2	32.0	8.0	19.2	20.8
Magnesium (ppm)	6.3	14.2	12.7	38.4	29.8	35.0	21.9	15.6	28.8	34.6	15.0	11.7	20.0	19.0
Sodium (ppm)	18	20	19	65	78	ND	2	ND	18	ND	28	26	5	50
Potassium (ppm)	2	5	4	25	24	ND	112	ND	2	ND	3	2	4	20
Iron (ppm)	T	T	T	T	T	T	T	T	T	20	T	T	T	T
Bicarbmate (ppm)	24	36	58	24	194	206	112	90	152	62	24	14	9	56
Chloride (ppm)	26	30	28	66	74	52	34	32	46	130	34	36	112	50
Sulphate (ppm)	5	20	3	40	20	20	20	20	50	200	120	40	100	40
MPN	460	1100	1100	1100	240	460	1100	1100	460	Nil	1100	43	1100	Nil

Table 4.4

Water Quality Status of wells. Post Monsoon 2000

Well. No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
P^H	7.4	7.0	7.6	7.6	7.6	7.4	7.6	7.6	7.6	5.0	6.8	7.0	6.0	7.6
Electrical conductivity (Micro Mhos/cm)	40	50	60	210	214	160	100	80	140	270	70	90	110	210
Total Hsrdness (ppm)	60	86	84	252	208	190	144	134	162	186	80	86	102	134
Total Alkalinity (ppm)	46	60	44	44	23	192	104	102	168	Nil	20	12	42	4.0
Calcium (ppm)	18	21	27	25	30	24	31	35	20	50	21	21	27	30
Magnesium (ppm)	3.6	8.1	4	4.6	32.3	3.2	16.1	11.3	22.4	14.8	6.7	8.1	8.4	14.3
Sodium (ppm)	17	26	24	85	ND	8	23	27	44	ND	ND	24	36	78
Potassium (ppm)	10	6	3	36	ND	15	2	2	11	ND	ND	3	2	37
Iron (ppm)	T	T	T	T	T	T	T	T	T	5.0	T	T	T	T
Bicarbmate (ppm)	46	60	44	44	23	192	104	102	168	Nil	20	12	42	4
Chloride (ppm)	32	38	126	44	118	52	44	14	54	158	26	50	44	112
Sulphate (ppm)	10	15	30	30	15	15	20	30	40	120	60	60	40	40
MPN	1100	1100	43	240	93	Nil	240	1100	1100	Nil	1100	400	1100	Nil

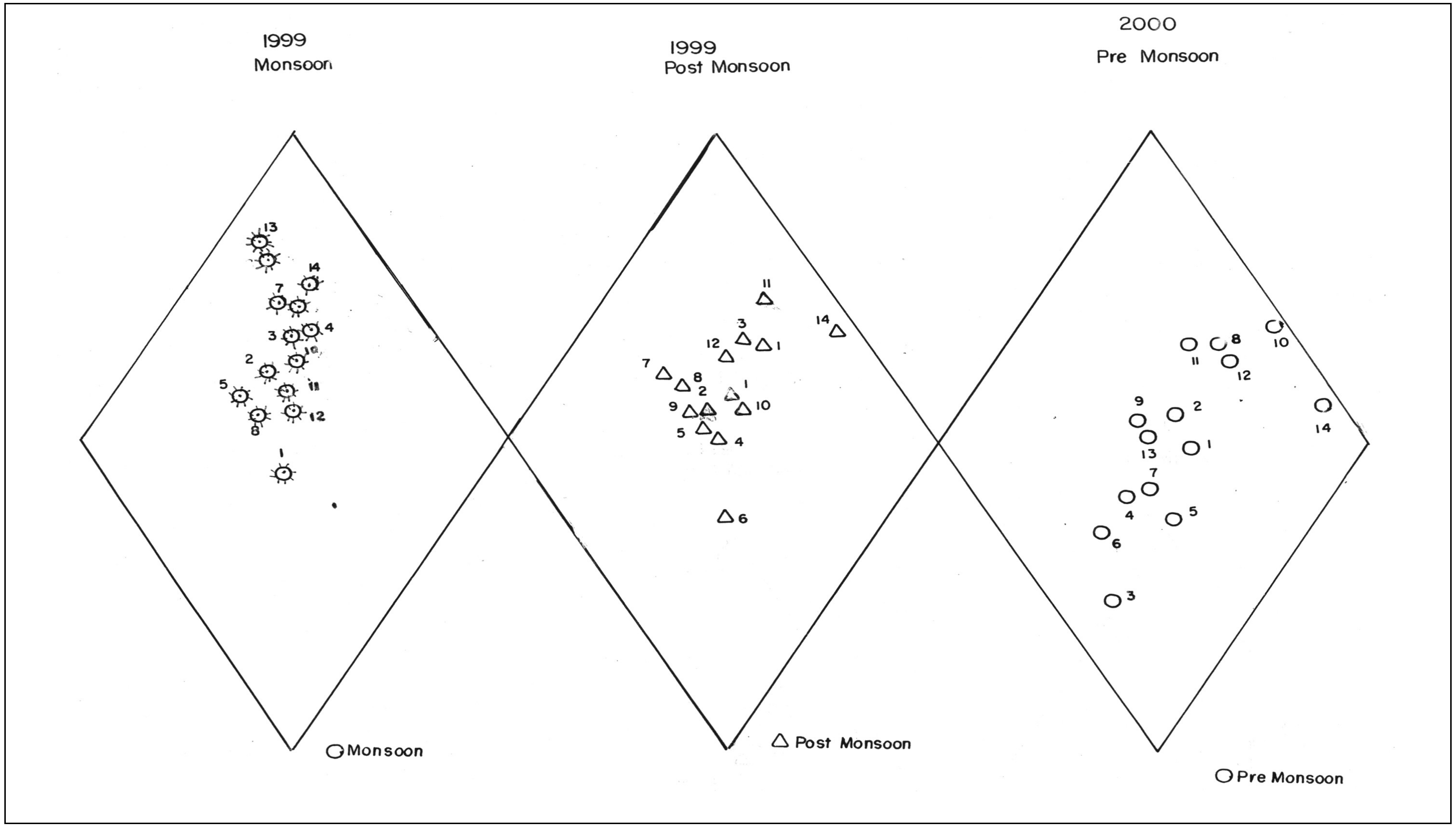


Figure 4.2: Piper Trilinear Diagram for the Wells of Calicut Corporation Area 2000

An examination of the figure demonstrates that two major hydro chemical facies are dominant in the area. They are

(1) (Na+ K) bicarbonate facies

(2) (Na+ K) chloride facies

In the present study we assumed that all the reactions are taking place in the pre-monsoon season. Since chloride, sulphate and bicarbonate are the major anions and the contaminating sources like sewage, seawater are the major sources contributing the former two anions to the aquifer, we used $\frac{Cl^{-1} + SO_4^{2-}}{HCO_3^-}$ ratio to classify the water into chloride and bicarbonate facies. The chemical data of the water samples revealed that the samples contaminated by seawater / sewage has a $\frac{Cl^{-1} + SO_4^{2-}}{HCO_3^-}$ ratio above unity and those which are not has a ratio below unity.

About 80% of the wells are found to be microbiologically contaminated. E. coli was found to be present in one well near the jail, at Puthiyara. The waste water from the jail is passing near the well, thus polluting it.

According to Sawyer's classification, the hardness of the samples can be classified into two categories, namely slightly hard [hardness varying from 50ppm-100ppm] and moderately hard [hardness varying from 101ppm to 200ppm]. The sodium absorption ratio (SAR) values of these samples were found to be below 10, ie. within the permissible limit, which shows that the water can be used to irrigate crops. More than 50% of the wells were found to be contaminated by sewage /leach pit.

Treatment of the wells and Experimental details

Test organisms, plants and materials selected for the treatment are the following:

(1) Lagenadra Toxicaria – aquatic plant found in fresh water

(2) Stychnos potatorum

(3) Fish – Guppy

(4) Fish, Cyprinus Carp

Experiments were conducted using these organisms in the wells in Calicut Corporation area.

During post-monsoon 2000, the wells were treated using strychnos potatorum, plant like Lagenandra, fishes like Carp, Guppy, etc. Some of the wells already had fishes and Lagenandra earlier during our survey. Water samples were collected from the wells after treatment and analysed to find out its physico – chemical and microbiological quality. The results are given in Table 4.5. The results show that strychnos potatorum is very effective in purifying well water. Conductivity, pH, total hardness, alkalinity, calcium, magnesium, sodium, potassium, iron, chloride, sulphate and MPN, were determined [**Dasgupta and Jayakrishnan**].

Table 4.5

Water Quality status of wells- After Treatment 2001

Well. No	1	2	3	4	5	6	7	8	9	10	11	12	13	14
P^H	7.0	7.0	7.6	7.8	7.6	7.6	7.6	7.6	7.6	5.0	7.6	6.8	6.0	7.6
Electrical conductivity (Micro Mhos/cm)	200	50	300	320	80	600	400	300	600	1100	400	300	900	400
Total Hsrdness (ppm)	36	86	104	218	210	172	144	114	204	176	240	72	138	168
Total Alkalinity (ppm)	32	60	82	218	258	226	122	90	190	140	70	20	56	32
Calcium (ppm)	9.0	21	30	37	22	29	35	20	52	39	38	13	35	35
Magnesium (ppm)	4	8.1	7	3	37.5	24	14	16	18	19	36	50.3	13	20
Sodium (ppm)	5.2	26	8.9	19.6	26.5	32	8.1	7.8	27	82	18	19	32	ND
Potassium (ppm)	24	6	40	120	196	153	30	18	13	200	60	28	152	ND
Iron (ppm)	T	T	0.2	T	T	0.4	T	0.1	T	8	0.1	T	T	T
Bicarbmate (ppm)	32	60	82	21.8	258	226	122	90	190	140	70	20	50	32
Chloride (ppm)	24	38	40	72	6	46	40	48	62	156	32	38	106	54
Sulphate (ppm)	5	15	20	20	15	20	20	10	20	16	60	30	30	30
MPN	Nil	1100	Nil	Nil	4	Nil	15	Nil	1100	ND	Nil	Nil	43	Nil

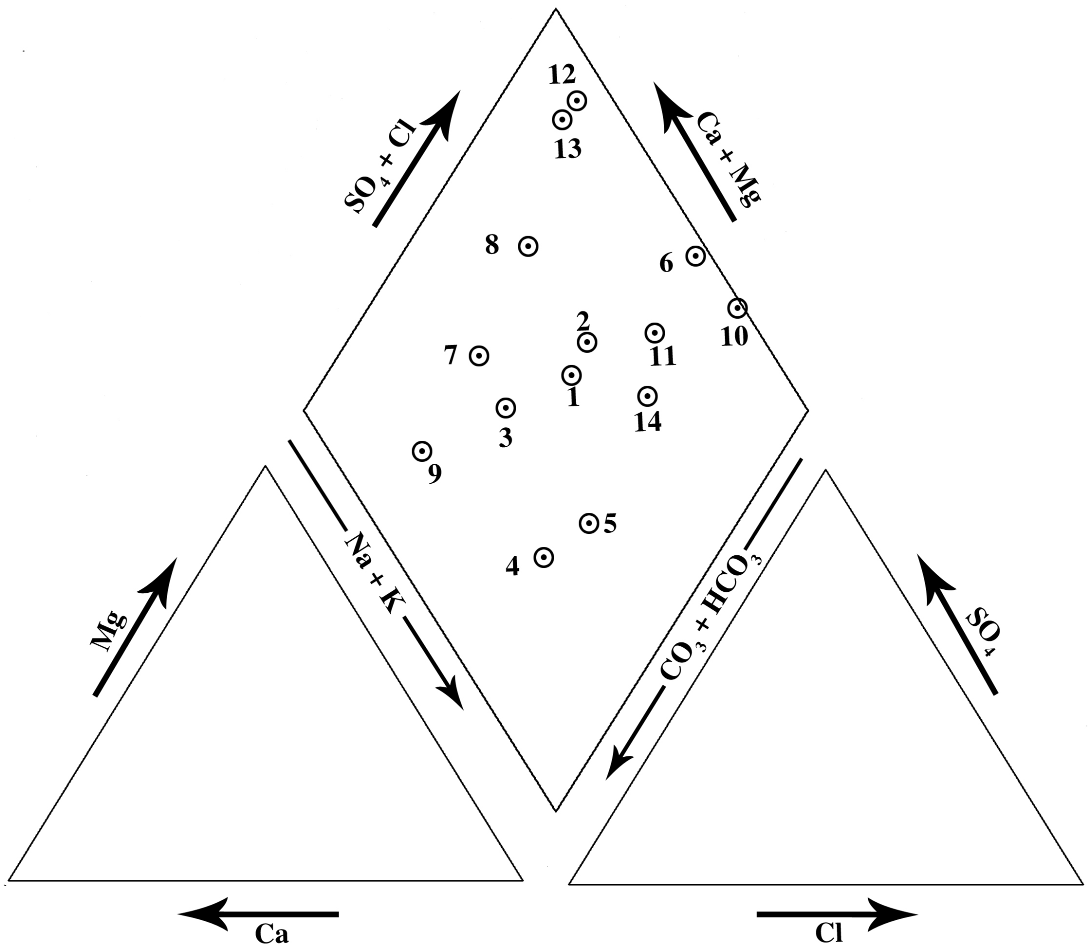


Figure 4.3: Improvement of Water Quality of the Wells of Calicut Corporation Area After Treatment 2001

Table 4.6

Water Quality status of wells 2004 Pre Monsoon, After Treatment

Well. No	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
P^H	7.1	6.8	6.8	7.0	7.2	7.5	7.0	7.4	7.6	7.6	6.8	7.0	6.8	6.9
Electrical conductivity (Micro Mhos/cm)	180	180	240	450	820	500	350	260	500	1250	550	310	800	380
Total Hsrdness (ppm)	35	48	56	120	56	170	150	110	200	240	120	70	132	160
Total Alkalinity (ppm)	30	18	28	10	108	120	50	80	170	210	50	18	76	30
Calcium (ppm)	8	15	15	12	15	30	36	18	50	40	30	10	31	30
Magnesium (ppm)	3.6	2.6	4.5	20	2.7	14.6	15	15.2	18.2	34	18.3	10	13.2	20.7
Iron (ppm)	T	T	T	T	T	T	T	T	T	333.0	T	T	T	T
Bicarbmate (ppm)	30	18	28	10	108	220	50	80	170	210	50	18	76	30
Chloride (ppm)	20	38	58	120	252	40	126	40	50	150	44	35	18	50
Sulphate (ppm)	ND	10	ND	18	ND	20	30	10	20	400	160	28	56	20
MPN	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

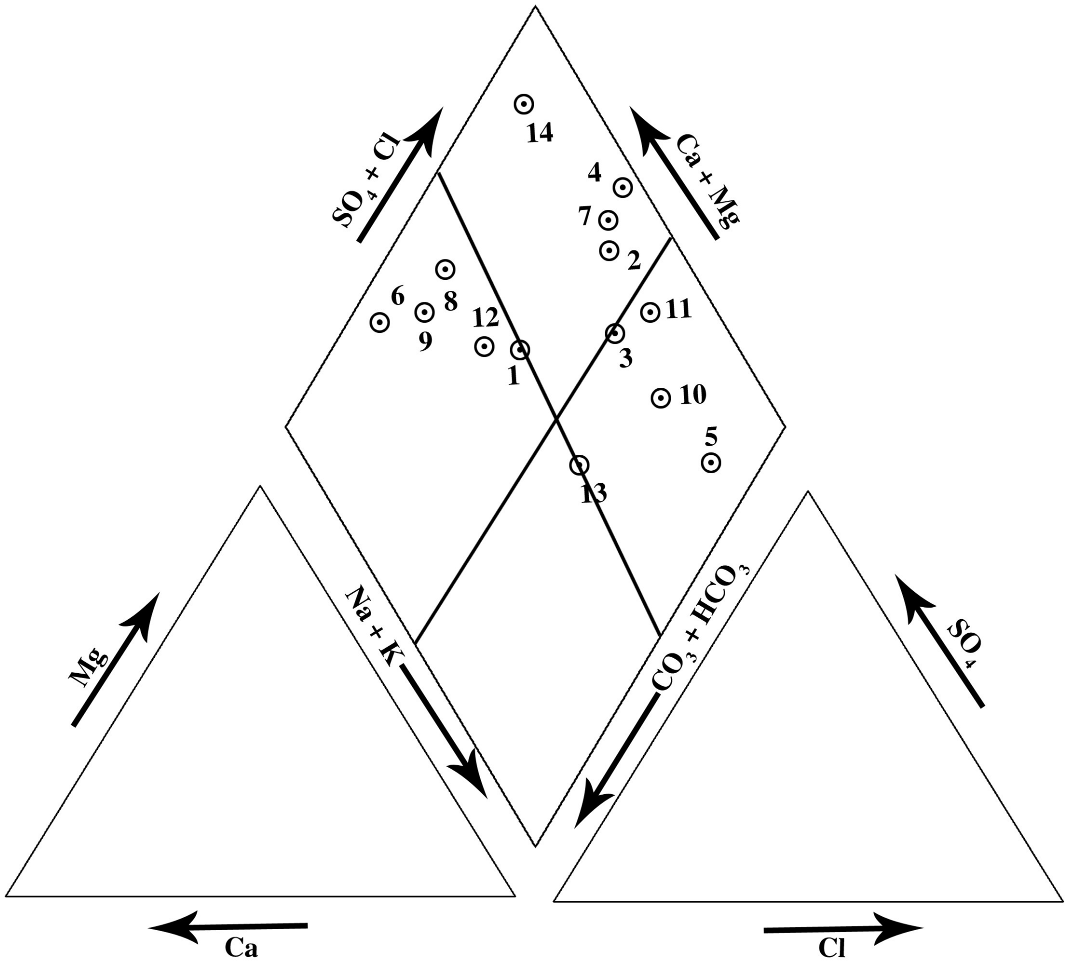


Figure 4.4: Improvement of Water Quality of the Wells of Calicut Corporation Area After Treatment 2004

The results are plotted in the Piper trilinear diagram and it is shown in fig 4.3. It is seen that no dominant facies has been identified which also shows the improvement of water quality. After treatment the following improvement in water quality are noticed.

(a) The pH has been changed to neutral

(b) There was reduction in the concentration of inorganic constituents like hardness, alkalinity, chloride, iron, total solids, etc.

(c) There was reduction in the value of MPN index. When Strychnos potatorum was used for treatment, the wells were found to be free of bacteria [**James GV, 1971; Jenkins SH, 1981**].

All the wells were again treated with Strychnos potatorum and the improvement in water quality was determined. The results are shown in Table 4.6. Piper trilinear diagram has been constructed for the same as shown in fig 4.4. The results show that no dominant facies are present. The variation of EC, hardness, bicarbonate, chloride and MPN are given in figure 4.5 to 4.9.

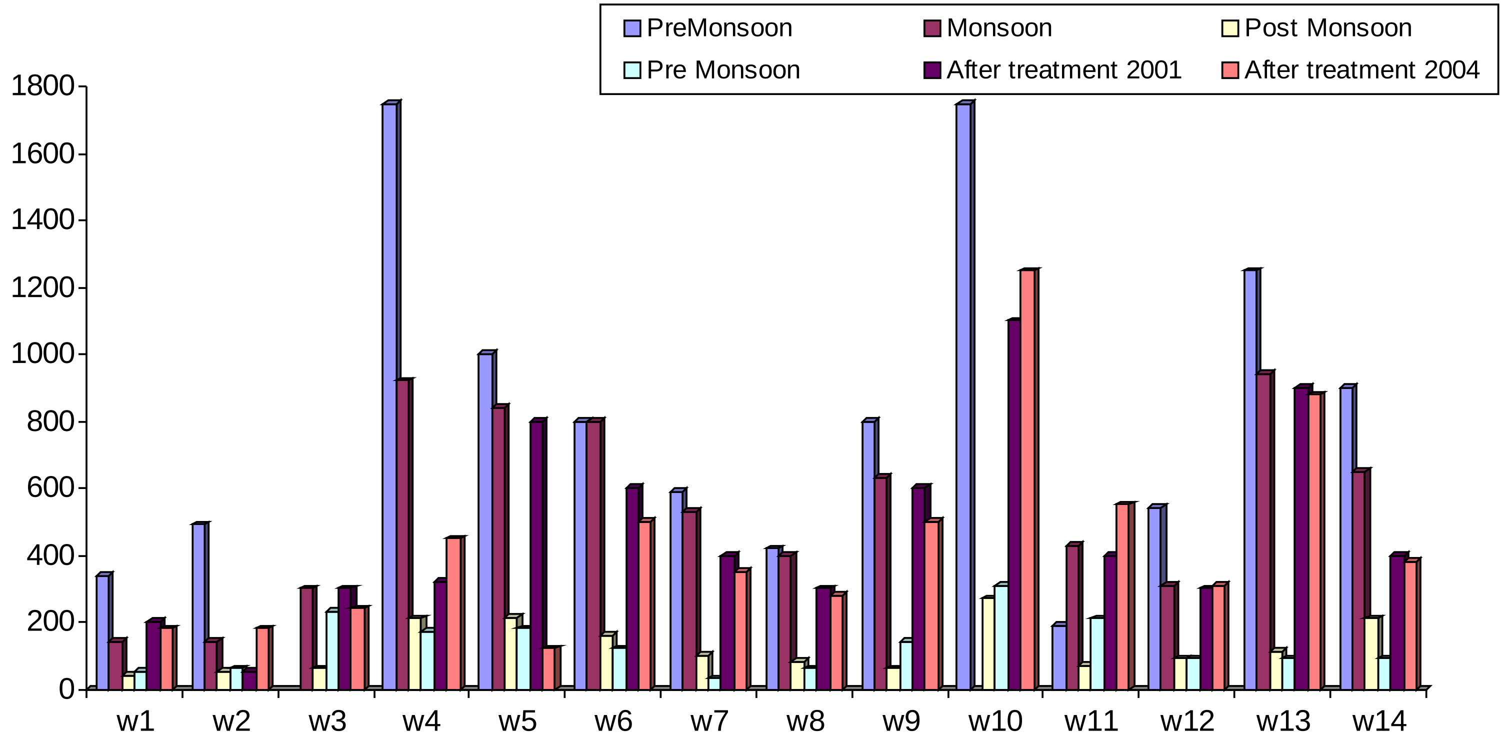


Figure 4.5: Variation of EC of Wells of Calicut Corporation Area

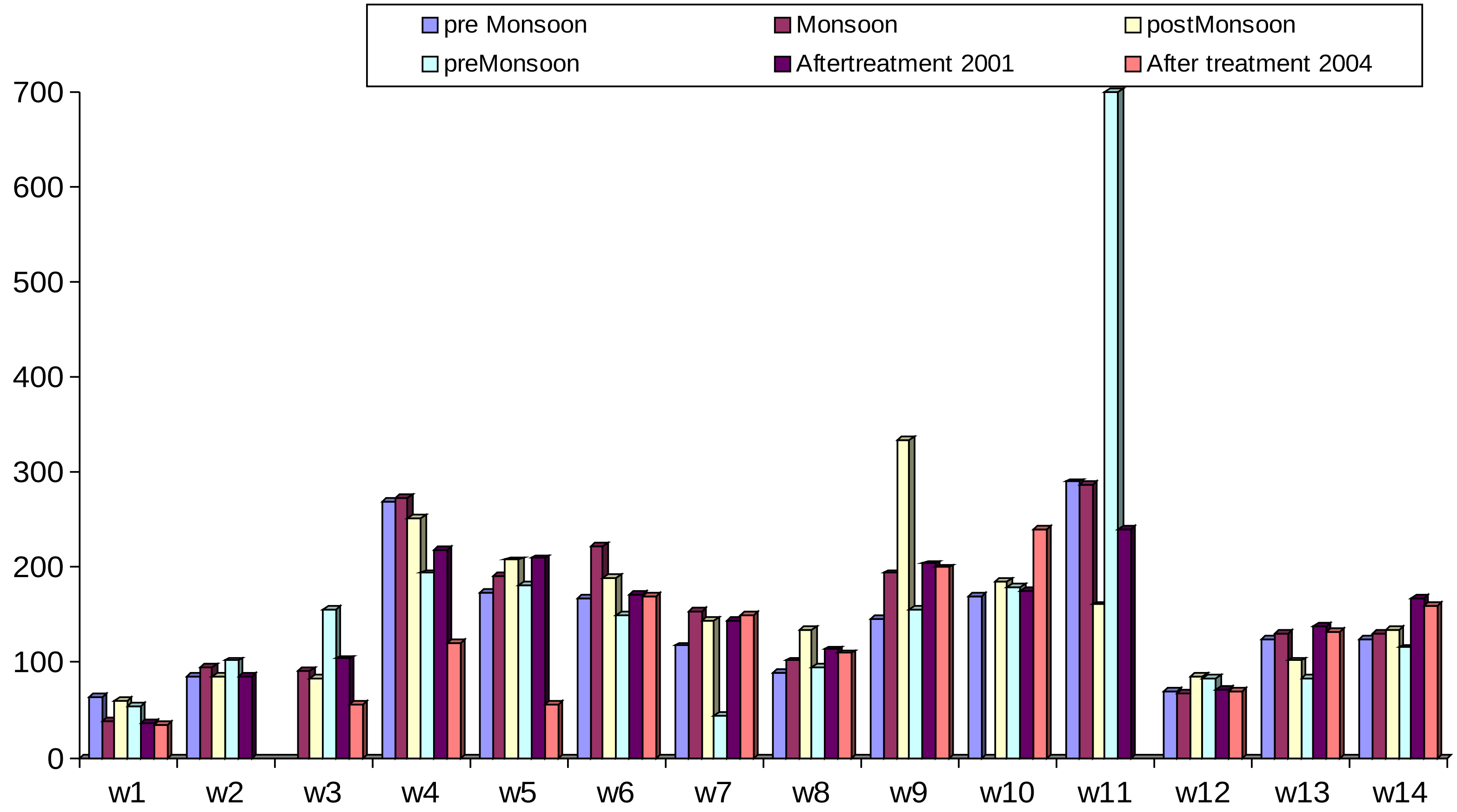


Figure 4.6: Variation of Hardness of Wells of Calicut Corporation Area

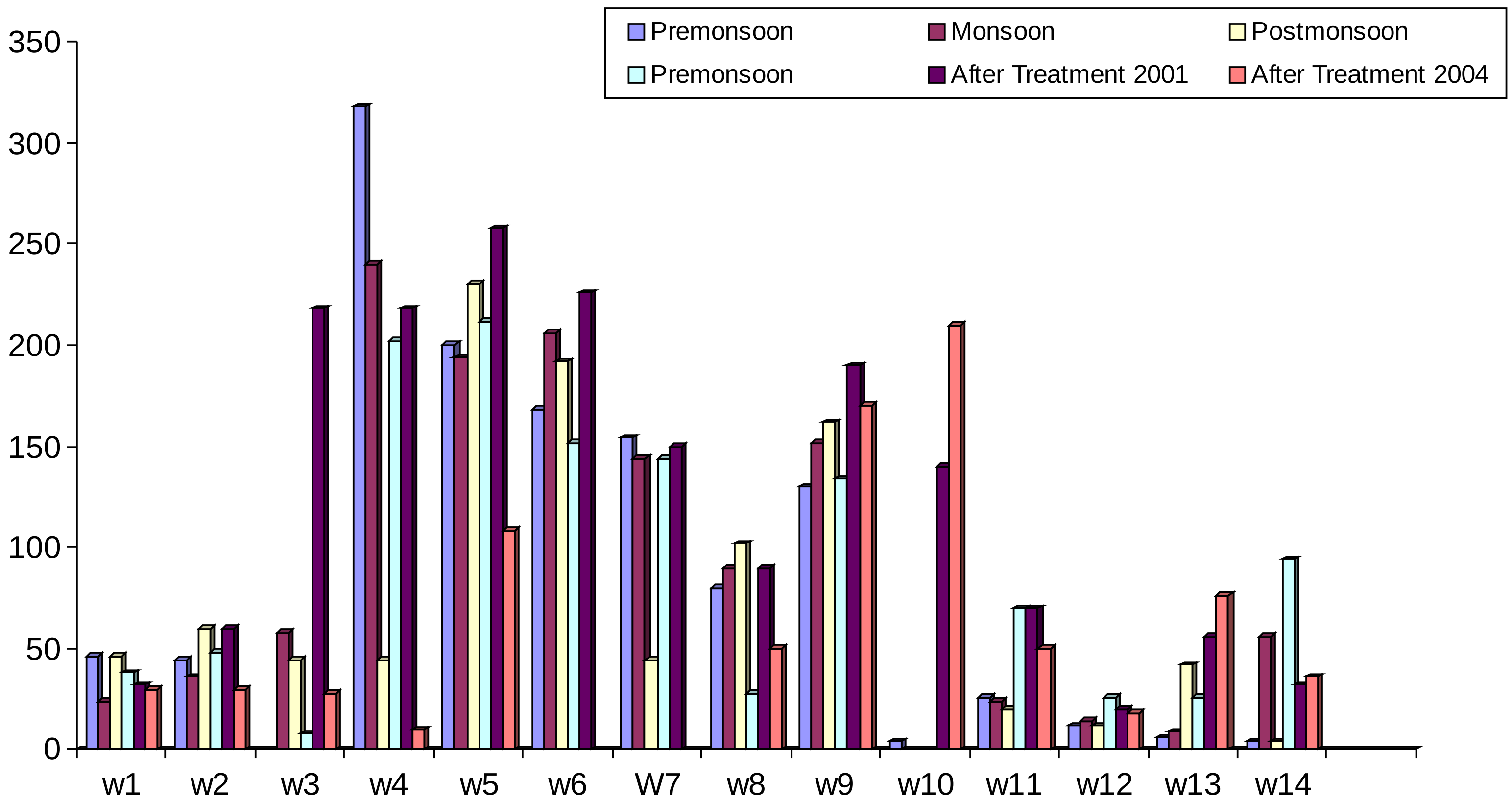


Figure 4.7: Variation of Bicarbonate of Wells of Calicut Corporation Area

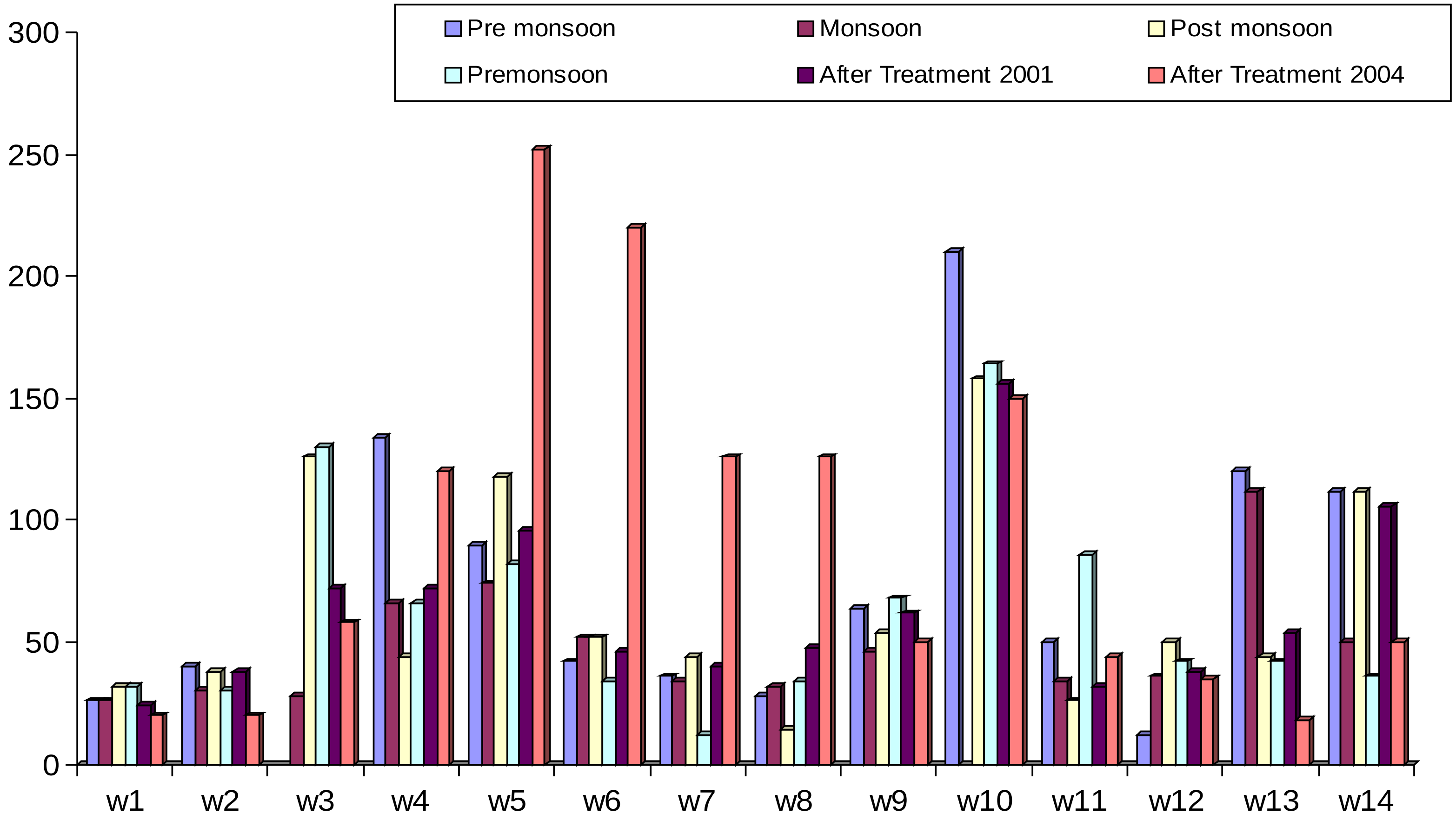


Figure 4.8: Variation of Chloride of Wells of Calicut Corporation Area

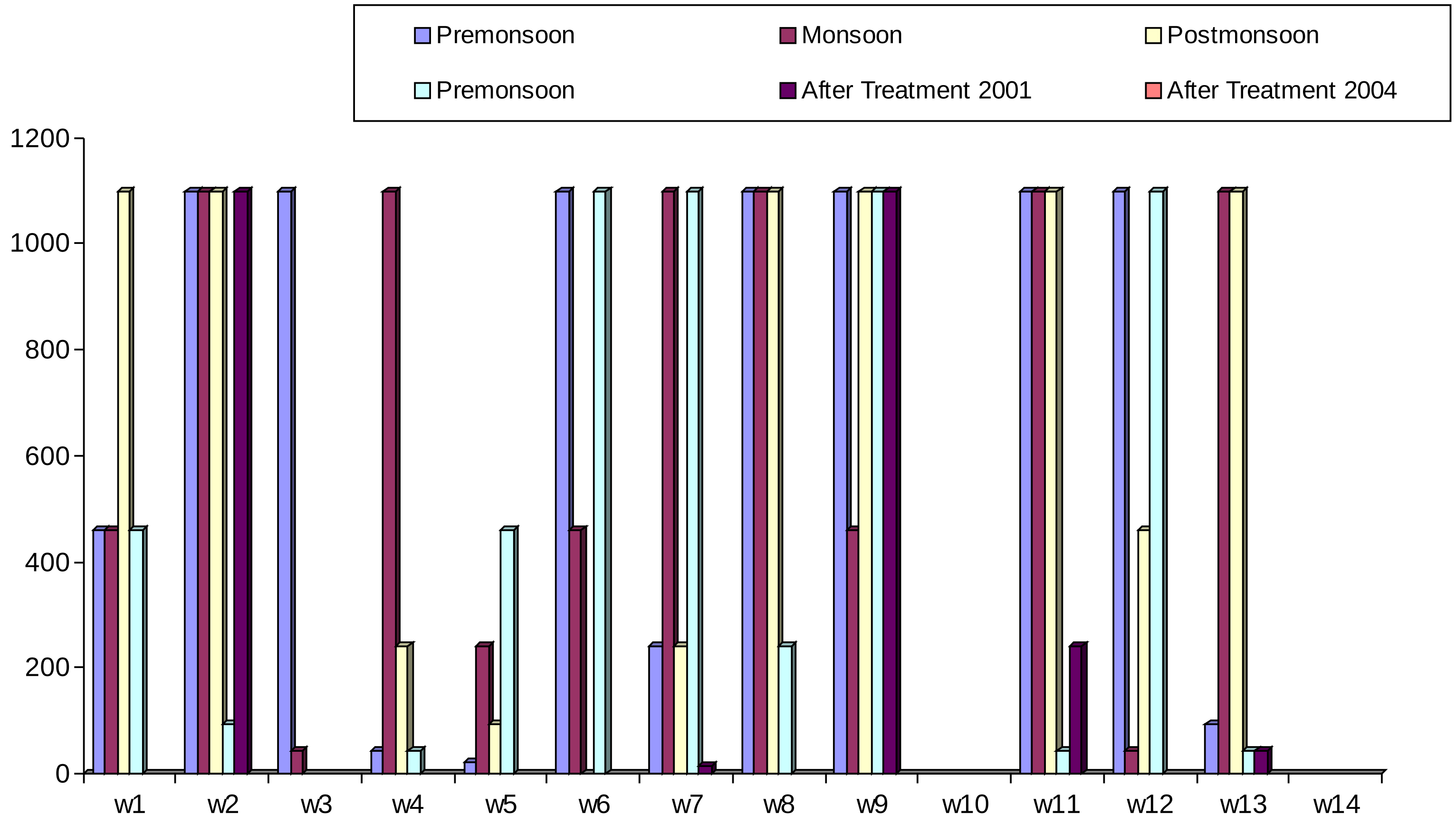


Figure 4.9: Variation of MPN of Wells of Calicut Corporation Area

Correlation between Parameters

When all the wells are considered, there is significant positive correlation between E C and TDS, total hardness and chloride during pre monsoon and post monsoon seasons also.

Another positive correlation found between total hardness and alkalinity, chloride and TDS; correlation between chloride, EC, TDS and total hardness is also significant.

As far as bacterial contamination is concerned there is no regular trend in variation with respect to seasons or wells. There are abrupt changes in MPN values from well to well. No significant correlation with any parameter was found. The results are shown in Tables 4.7 to 4.12.

Table 4.7

Matrix of Correlations Calicut Corporation Pre Monsoon 1999

Descriptive Statistics

	Mean	Std. Deviation	N
pH	6.8769	.68575	13
EC	583.0769	342.03154	13
Total_solids	381.7692	336.73534	13
Total_hardness	129.6923	56.89667	13
Total_alkalinity	91.2308	91.68983	13
Chloride	70.4615	55.50468	13
Nitrate	.4000	.26458	5
MPN	641.5833	491.59082	12

Correlations

		pH	EC	Total_solids	Total_ hardness	Total_ alkalinity	Chloride	Nitrate	MPN
pH	Pearson Correlation	1	.101	-.773**	.026	.496	-.667*	-.664	.055
	Sig. (2-tailed)	.	.744	.002	.932	.085	.013	.221	.865
	N	13	13	13	13	13	13	5	12
EC	Pearson Correlation	.101	1	-.216	-.001	-.094	-.076	.518	-.304
	Sig. (2-tailed)	.744	.	.479	.998	.759	.805	.371	.337
	N	13	13	13	13	13	13	5	12
Total_solids	Pearson Correlation	-.773**	-.216	1	.500	.048	.936**	.694	-.588*
	Sig. (2-tailed)	.002	.479	.	.082	.877	.000	.193	.044
	N	13	13	13	13	13	13	5	12
Total_hardness	Pearson Correlation	.026	-.001	.500	1	.835**	.654*	.265	-.483
	Sig. (2-tailed)	.932	.998	.082	.	.000	.015	.666	.111
	N	13	13	13	13	13	13	5	12
Total_alkalinity	Pearson Correlation	.496	-.094	.048	.835**	1	.211	-.010	-.316
	Sig. (2-tailed)	.085	.759	.877	.000	.	.490	.987	.317
	N	13	13	13	13	13	13	5	12
Chloride	Pearson Correlation	-.667*	-.076	.936**	.654*	.211	1	.834	-.674*
	Sig. (2-tailed)	.013	.805	.000	.015	.490	.	.079	.016
	N	13	13	13	13	13	13	5	12
Nitrate	Pearson Correlation	-.664	.518	.694	.265	-.010	.834	1	-.360
	Sig. (2-tailed)	.221	.371	.193	.666	.987	.079	.	.552
	N	5	5	5	5	5	5	5	5
MPN	Pearson Correlation	.055	-.304	-.588*	-.483	-.316	-.674*	-.360	1
	Sig. (2-tailed)	.865	.337	.044	.111	.317	.016	.552	.
	N	12	12	12	12	12	12	5	12

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.8

Matrix of Correlations Calicut Corporation Pre Monsoon 2000

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.0571	.97169	14
EC	137.8571	75.05676	14
Total_solids	401.0714	203.34868	14
Total_hardness	127.7143	51.94587	14
Total_alkalinity	82.0000	70.77193	13
Chloride	61.2857	42.53221	14
Nitrate	3.0000	1.00000	3
MPN	525.6364	479.14158	11

Correlations

		pH	EC	Total_solids	Total_ hardness	Total_ alkalinity	Chloride	Nitrate	MPN
pH	Pearson Correlation	1	-.656*	-.528	-.139	.671*	-.728**	-.569	-.153
	Sig. (2-tailed)	.	.011	.052	.635	.012	.003	.614	.654
	N	14	14	14	14	13	14	3	11
EC	Pearson Correlation	-.656*	1	.851**	.735**	.338	.913**	.999*	-.036
	Sig. (2-tailed)	.011	.	.000	.003	.259	.000	.022	.915
	N	14	14	14	14	13	14	3	11
Total_solids	Pearson Correlation	-.528	.851**	1	.819**	.537	.810**	.500	-.271
	Sig. (2-tailed)	.052	.000	.	.000	.058	.000	.667	.420
	N	14	14	14	14	13	14	3	11
Total_hardness	Pearson Correlation	-.139	.735**	.819**	1	.677*	.700**	.866	-.250
	Sig. (2-tailed)	.635	.003	.000	.	.011	.005	.333	.459
	N	14	14	14	14	13	14	3	11
Total_alkalinity	Pearson Correlation	.671*	.338	.537	.677*	1	.161	-.148	.018
	Sig. (2-tailed)	.012	.259	.058	.011	.	.599	.906	.959
	N	13	13	13	13	13	13	3	11
Chloride	Pearson Correlation	-.728**	.913**	.810**	.700**	.161	1	.986	-.300
	Sig. (2-tailed)	.003	.000	.000	.005	.599	.	.106	.370
	N	14	14	14	14	13	14	3	11
Nitrate	Pearson Correlation	-.569	.999*	.500	.866	-.148	.986	1	1.000**
	Sig. (2-tailed)	.614	.022	.667	.333	.906	.106	.	.
	N	3	3	3	3	3	3	3	2
MPN	Pearson Correlation	-.153	-.036	-.271	-.250	.018	-.300	1.000**	1
	Sig. (2-tailed)	.654	.915	.420	.459	.959	.370	.	.
	N	11	11	11	11	11	11	2	11

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.9

Matrix of Correlations Calicut Corporation Monsoon 2000

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.0143	.45380	14
EC	573.5714	296.17061	14
Total_solids	316.3571	154.50646	14
Total_hardness	143.2857	68.12480	14
Total_alkalinity	91.2143	77.46382	14
Chloride	53.5714	32.11689	14
Nitrate	.5250	.47170	4
MPN	780.2500	411.07047	12

Correlations

		pH	EC	Total_solids	Total_ hardness	Total_ alkalinity	Chloride	Nitrate	MPN
pH	Pearson Correlation	1	.211	.119	.572*	.840**	-.213	-.988*	-.130
	Sig. (2-tailed)	.	.468	.686	.033	.000	.465	.012	.688
	N	14	14	14	14	14	14	4	12
EC	Pearson Correlation	.211	1	.925**	.837**	.518	.840**	.640	-.011
	Sig. (2-tailed)	.468	.	.000	.000	.058	.000	.360	.972
	N	14	14	14	14	14	14	4	12
Total_solids	Pearson Correlation	.119	.925**	1	.786**	.345	.886**	.638	.071
	Sig. (2-tailed)	.686	.000	.	.001	.227	.000	.362	.827
	N	14	14	14	14	14	14	4	12
Total_hardness	Pearson Correlation	.572*	.837**	.786**	1	.826**	.546*	-.205	.006
	Sig. (2-tailed)	.033	.000	.001	.	.000	.043	.795	.985
	N	14	14	14	14	14	14	4	12
Total_alkalinity	Pearson Correlation	.840**	.518	.345	.826**	1	.083	-.788	-.148
	Sig. (2-tailed)	.000	.058	.227	.000	.	.777	.212	.646
	N	14	14	14	14	14	14	4	12
Chloride	Pearson Correlation	-.213	.840**	.886**	.546*	.083	1	.815	.010
	Sig. (2-tailed)	.465	.000	.000	.043	.777	.	.185	.974
	N	14	14	14	14	14	14	4	12
Nitrate	Pearson Correlation	-.988*	.640	.638	-.205	-.788	.815	1	.500
	Sig. (2-tailed)	.012	.360	.362	.795	.212	.185	.	.667
	N	4	4	4	4	4	4	4	3
MPN	Pearson Correlation	-.130	-.011	.071	.006	-.148	.010	.500	1
	Sig. (2-tailed)	.688	.972	.827	.985	.646	.974	.667	.
	N	12	12	12	12	12	12	3	12

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.10

Matrix of Correlations Calicut Corporation Post Monsoon 2000

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.1286	.76704	14
EC	128.8571	72.76819	14
Total_solids	288.2143	161.34873	14
Total_hardness	136.2857	57.22752	14
Total_alkalinity	66.2308	58.96631	13
Chloride	65.1429	43.99800	14
Nitrate	.0400	.	1
MPN	697.8182	473.37571	11

Correlations

		pH	EC	Total_solids	Total_ hardness	Total_ alkalinity	Chloride	Nitrate	MPN
pH	Pearson Correlation	1	-.286	-.482	.062	.267	-.323	.[a]	-.470
	Sig. (2-tailed)	.	.322	.081	.833	.377	.260	.	.145
	N	14	14	14	14	13	14	1	11
EC	Pearson Correlation	-.286	1	.829**	.821**	.018	.636*	.[a]	-.478
	Sig. (2-tailed)	.322	.	.000	.000	.954	.015	.	.137
	N	14	14	14	14	13	14	1	11
Total_solids	Pearson Correlation	-.482	.829**	1	.793**	.126	.511	.[a]	-.444
	Sig. (2-tailed)	.081	.000	.	.001	.683	.062	.	.171
	N	14	14	14	14	13	14	1	11
Total_hardness	Pearson Correlation	.062	.821**	.793**	1	.324	.282	.[a]	-.462
	Sig. (2-tailed)	.833	.000	.001	.	.280	.330	.	.153
	N	14	14	14	14	13	14	1	11
Total_alkalinity	Pearson Correlation	.267	.018	.126	.324	1	-.292	.[a]	.285
	Sig. (2-tailed)	.377	.954	.683	.280	.	.333	.	.395
	N	13	13	13	13	13	13	1	11
Chloride	Pearson Correlation	-.323	.636*	.511	.282	-.292	1	.[a]	-.725*
	Sig. (2-tailed)	.260	.015	.062	.330	.333	.	.	.012
	N	14	14	14	14	13	14	1	11
Nitrate	Pearson Correlation	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]
	Sig. (2-tailed)	.	.	.	.	.	.	.	.
	N	1	1	1	1	1	1	1	1
MPN	Pearson Correlation	-.470	-.478	-.444	-.462	.285	-.725*	.[a]	1
	Sig. (2-tailed)	.145	.137	.171	.153	.395	.012	.	.
	N	11	11	11	11	11	11	1	11

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Table 4.11

Matrix of Correlations Calicut Corporation After Treatment 2001

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.1714	.79172	14
EC	476.4286	290.50638	14
Total_solids	260.3571	111.81138	14
Total_hardness	148.7143	60.42723	14
Total_alkalinity	114.0000	79.76504	14
Chloride	54.4286	37.40159	14
Nitrate	20.0000	.	1
MPN	417.0000	535.97687	6

Correlations

		pH	EC	Total_solids	Total_ hardness	Total_ alkalinity	Chloride	Nitrate	MPN
pH	Pearson Correlation	1	-.591*	-.402	.204	.247	-.784**	.[a]	.108
	Sig. (2-tailed)	.	.026	.154	.485	.395	.001	.	.838
	N	14	14	14	14	14	14	1	6
EC	Pearson Correlation	-.591*	1	.852**	.476	.420	.648*	.[a]	-.548
	Sig. (2-tailed)	.026	.	.000	.086	.135	.012	.	.260
	N	14	14	14	14	14	14	1	6
Total_solids	Pearson Correlation	-.402	.852**	1	.672**	.662**	.625*	.[a]	-.121
	Sig. (2-tailed)	.154	.000	.	.008	.010	.017	.	.819
	N	14	14	14	14	14	14	1	6
Total_hardness	Pearson Correlation	.204	.476	.672**	1	.649*	.180	.[a]	-.265
	Sig. (2-tailed)	.485	.086	.008	.	.012	.538	.	.612
	N	14	14	14	14	14	14	1	6
Total_alkalinity	Pearson Correlation	.247	.420	.662**	.649*	1	.015	.[a]	-.082
	Sig. (2-tailed)	.395	.135	.010	.012	.	.959	.	.877
	N	14	14	14	14	14	14	1	6
Chloride	Pearson Correlation	-.784**	.648*	.625*	.180	.015	1	.[a]	.049
	Sig. (2-tailed)	.001	.012	.017	.538	.959	.	.	.927
	N	14	14	14	14	14	14	1	6
Nitrate	Pearson Correlation	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]	.[a]
	Sig. (2-tailed)	.	.	.	.	.	.	.	.
	N	1	1	1	1	1	1	1	1
MPN	Pearson Correlation	.108	-.548	-.121	-.265	-.082	.049	.[a]	1
	Sig. (2-tailed)	.838	.260	.819	.612	.877	.927	.	.
	N	6	6	6	6	6	6	1	6

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

a. Cannot be computed because at least one of the variables is constant.

Table 4.12

Matrix of Correlations Calicut Corporation Pre Monsoon 2004

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.1071	.30246	14
EC	483.5714	298.60205	14
Total_solids	316.6786	234.32995	14
Total_hardness	119.0714	61.47728	14
Total_alkalinity	71.2857	61.03521	14
Chloride	74.3571	65.49646	14
Nitrate	14.0800	15.12730	5

Correlations

		pH	EC	Total_solids	Total_ hardness	Total_ alkalinity	Chloride	Nitrate
pH	Pearson Correlation	1	.399	.512	.587*	.834**	.234	-.336
	Sig. (2-tailed)	.	.157	.061	.027	.000	.421	.581
	N	14	14	14	14	14	14	5
EC	Pearson Correlation	.399	1	.823**	.597*	.747**	.539*	.319
	Sig. (2-tailed)	.157	.	.000	.024	.002	.047	.600
	N	14	14	14	14	14	14	5
Total_solids	Pearson Correlation	.512	.823**	1	.818**	.699**	.276	.155
	Sig. (2-tailed)	.061	.000	.	.000	.005	.339	.803
	N	14	14	14	14	14	14	5
Total_hardness	Pearson Correlation	.587*	.597*	.818**	1	.719**	.087	.003
	Sig. (2-tailed)	.027	.024	.000	.	.004	.768	.997
	N	14	14	14	14	14	14	5
Total_alkalinity	Pearson Correlation	.834**	.747**	.699**	.719**	1	.329	.003
	Sig. (2-tailed)	.000	.002	.005	.004	.	.250	.996
	N	14	14	14	14	14	14	5
Chloride	Pearson Correlation	.234	.539*	.276	.087	.329	1	-.596
	Sig. (2-tailed)	.421	.047	.339	.768	.250	.	.289
	N	14	14	14	14	14	14	5
Nitrate	Pearson Correlation	-.336	.319	.155	.003	.003	-.596	1
	Sig. (2-tailed)	.581	.600	.803	.997	.996	.289	.
	N	5	5	5	5	5	5	5

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.4.2 Microbiological quality of Ground Water at selected Panchayats of Kannur and Kasaragod Districts

The study has been aimed to carry out the bacterial contamination of ground water resources at Kannur and Kasaragod districts. This work forms part of a study conducted by CWRDM under the project entitled. “Study for assessing the risk to ground water from on site sanitation in rural Kerala”, with funding from MGP [Modernising Government Programme] of the Government of Kerala and the programme was initiated by the Water and Sanitation Programme – South Asia [WSP – SA]. The study conducted at three Panchayats of Kannur namely Elayavoor, Cheruthazham and Payyavoor and Muliyar panchayat, of Kasaragoid district is discussed here.

A survey has been conducted to identify the sites and wells were selected for the study purpose. About 32 samples were taken from Elayavoor Panchayat. From Cheruthazham Panchayat 8 samples were taken; 15 samples were taken from Payyavur Panchayat; 14 samples were taken from Muliyar Panchayat. The samples were collected during pre – monsoon, monsoon and post–monsoon seasons in the year 2005 – 06. Water quality monitoring was undertaken with special reference on the bacterial contamination by examining the indicator organisms namely Escherichia Coli [E Coli] and Faecal Streptococci. Bacterial contamination levels in the observation wells were examined in terms of Most Probable Number [MPN] index of the Faecal coliforms and Faecal Streptococci. In situ measurements were taken for water temperature and pH using portable meters. Turbidity was measured in the laboratory. Besides household surveys were also conducted during each visit to understand the influence of environmental factors like rainfall during the period of observation. Sample size and combination were determined based on the dominant site features like type of wells, type of latrine and distance between well and latrine. The site features were grouped into three well types, three latrine types and four categories of well – latrine distance leading to a total set of 30 unique site types A total of 90 wells were finally selected for periodic sampling and data collection. From among 90 sites, 22 sites were monitored once in every month. The remaining sites were monitored three times during the year, ie pre–monsoon, monsoon and post–monsoon seasons of the year. Results of analysis of 68 samples collected during the 3 seasons is discussed here. The results of analysis are given in Tables. 4.13 to 4.24. The map of the study area is given in fig.4.5 and fig 4.6.

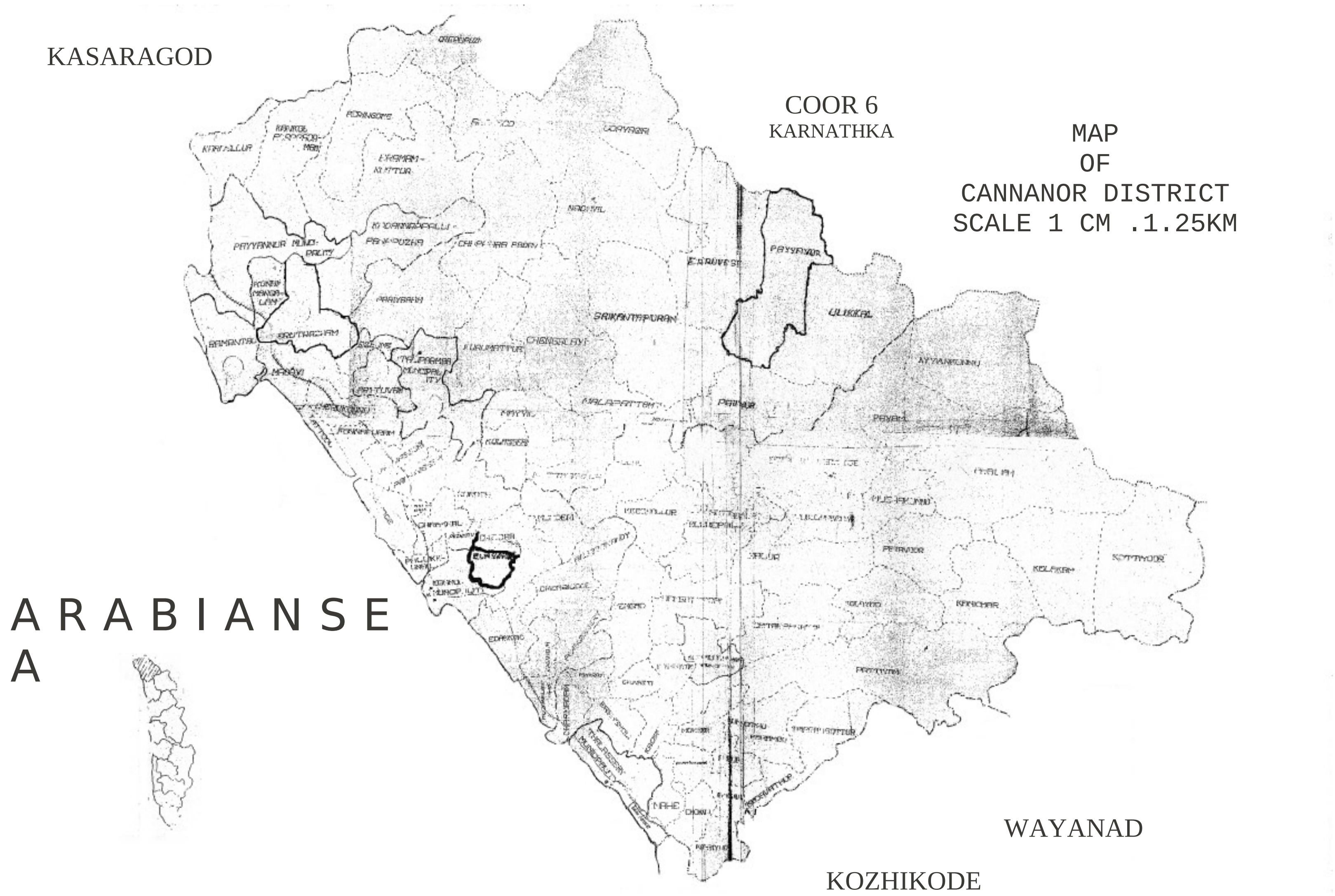
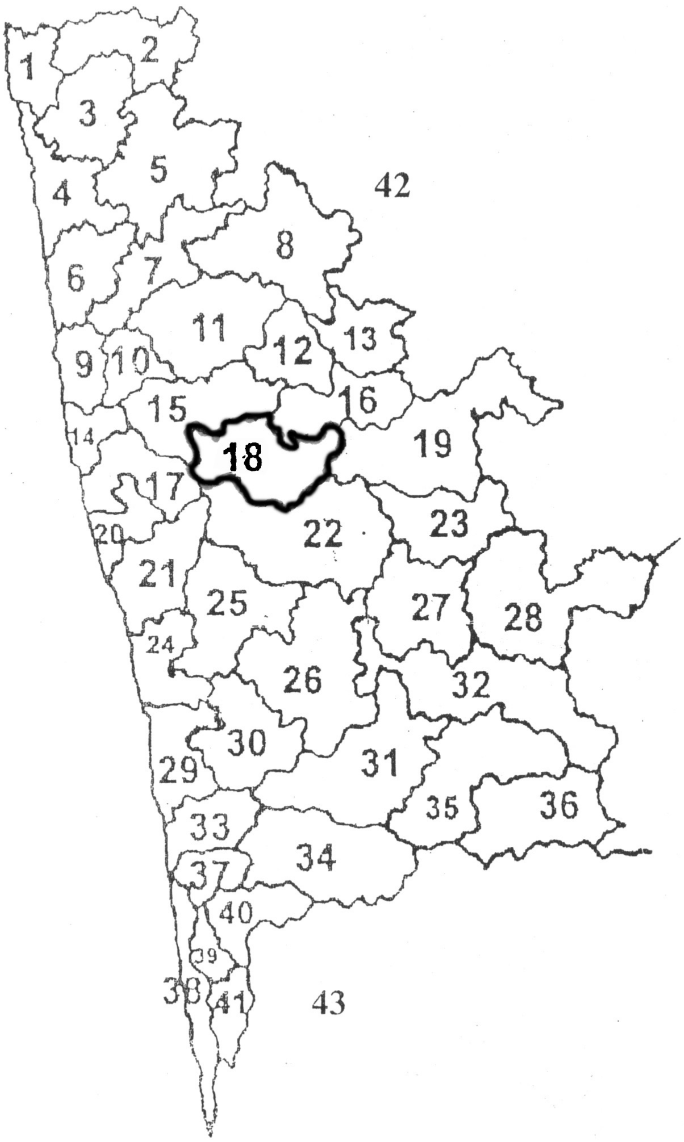


Fig. 4.10: Location Map of Kannur District



1. മഞ്ചേശ്വരം
2. വോർക്കാടി
3. മീഞ്ച
4. മംഗൽപ്പാടി
5. പൈവളികെ
6. കുമ്പള
7. പുത്തിഗെ
8. എൺമകജെ
9. മൊഗ്രാൽ പുത്തൂർ
10. മധൂർ
11. ബദിയഡുക്ക
12. കുംബഡാജെ
13. ബെള്ളൂർ
14. കാസറഗോഡ് മുനിസിപ്പാലിറ്റി
15. ചെങ്കള
16. കാറഡുക്ക
17. ചെമ്മനാട്
18. **മുളിയാർ**
19. ദേലംപാടി
20. ഉദുമ
21. പള്ളിക്കര
22. ബേഡഡുക്ക
23. കുറ്റിക്കോൽ
24. അജാനൂർ
25. പുല്ലൂർ പെരിയ
26. കോടോം ബേളൂർ
27. കള്ളാർ
28. പനത്തടി
29. കാഞ്ഞങ്ങാട് മുനിസിപ്പാലിറ്റി
30. മടിക്കൈ
31. കിനാനൂർ കരിന്തളം
32. ബളാൽ
33. നീലേശ്വരം
34. ചീമേനി
35. വെസ്റ്റ് എളേരി
36. ഈസ്റ്റ് എളേരി
37. ചെറുവത്തൂർ
38. വലിയ പറമ്പ
39. പടന്ന
40. പിലിക്കോട്
41. തൃക്കരിപ്പൂർ
42. ദക്ഷിണ കർണ്ണാടക ജില്ല
43. കണ്ണൂർ ജില്ല

Fig. 4.11: Location Map of Kasaragod District

Water samples for microbiological examination were collected in 100ml pre – sterilized sealed bottles. Samples, after collection were immediately taken to the laboratory for examination. If the processing was not possible within an hour, the samples were transported in ice – box to the laboratory. The samples were preserved at 4^0C up to 6 hours, but in no case not more than 24 hours.

The results of rapid survey revealed that twin pit latrines are less common. Parameters like pH, electrical conductivity, turbidity, MPN, E. Coli and Faecal Streptococci were determined. High values of MPN index, greater than 100 was observed for 74.9% of the samples. E.Coli, a member of the faecal coliform bacteria is one of the best microbial indicator of faecal contamination in water. As E. Coli are universally present in large numbers in the feces of human and warm blooded animals and are readily detectable in the present study, the presence of E. Coli was tested as a quantitative parameter to know the contamination in the observation wells. Most of the samples showed E.Coli positive. Faecal Streptococci was found to be present in all the samples. Presence of E.Coli indicates that the contamination is recent one since, the die off period for faceal coliforms is more than that for E.Coli. Contamination levels were found to be higher during monsoon season, than in the pre – monsoon and post monsoon periods indicating the spread of microbes during rainy period. The level of faecal coliforms and faecal streptococci ranged from 1 to 240000. MPN / 100ml in the water sample tested. None of the samples were found to be potable. Open dug wells without any parapet wall and platform were observed to contain high levels of faecal coliforms than others. Faecal coliforms levels were found to be higher, where the distance is closer between well and latrine. Septic tanks exihibit some reduction in contamination in near by wells. Wells near single pit latrines have high level of contamination compared to wells near double pit latrine and septic tanks.

Table 4.13

Water Quality Status of the wells of Elayavoor Panchayth Monsoon 2005

Sample No.	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17
p^H	6.5	7.2	7.4	7.8	7.8	7.9	5.5	6.9	6.3	6.8	6.0	5.5	7.8	8.3	9.3	8.8	7.8
EC	160	20	90	Nd	60	60	140	50	50	50	30	40	240	240	310	260	50
Turbidity (NTU)	0.08	0.08	0.20	0.10	0.36	0.36	0.36	0.36	0.48	0.20	0.48	0.36	0.68	0.24	0.28	0.44	0
Temperature (oC)	26.8	26.6	26.0	27.2	26.8	26.8	26.4	26.6	26.0	27.2	26.6	26.8	27.0	27.2	26.8	26.0	26.6
MPN/100ml	1100	2400	210	1100	1100	210	1100	1100	2400	460	2400	1100	210	460	1100	1100	7500
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	440	150	460	440	75	20	460	1100	210	43	46	240	75	210	460	28	75

Table 4.13 Contd…

Sample No.	E18	E19	E20	E21	E22	E23	E24	E25	E26	E27	E28	E29	E30	E31	E32
p^H	8.4	7.1	6.7	7.2	5.4	6.3	7.5	8.6	7.9	6.8	5.9	7.6	8.5	7.6	8.06
EC	50	50	40	100	70	40	30	50	50	40	70	0	60	40	170
Turbidity (NTU)	0.36	0.4	0.24	0.52	0.24	0.20	0.16	0.32	0.44	0.12	0.52	0.29	0	0.16	0.68
Temperature (oC)	26.4	26.4	26.2	25.8	26.8	26.6	26.4	26.2	25.8	26.4	25.6	26.0	26.2	26.0	26.2
MPN/100ml	2400	460	2400	2400	460	240	2400	460	1100	2400	93	1100	1100	210	1100
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	43	43	23	23	43.	43	93	210	23	210	28	75	75	23	460

Nd - Not Determined

Table 4.14

Water Quality Status of the wells of Elayavoor Panchayth Post Monsoon 2005

Well No.	**E1**	**E2**	**E3**	**E4**	**E5**	**E6**	**E7**	**E8**	**E9**	**E10**	**E11**	**E12**	**E13**	**E14**	**E15**	**E16**	**E17**
p^H	7.3	6.5	7.0	8.4	6.6	7.1	6.9	6.7	7.1	7.1	6.7	6.9	7.1	8.9	8.8	7.5	7.6
EC	40	10	40	Nd	Nd	Nd	20	40	Nd	40	Nd	Nd	Nd	300	540	390	40
Turbidity (NTU)	0.24	0.2	0.0	0.12	0.04	0.0	0.08	0.12	0.2	0.64	0.04	0.2	0.44	1.76	0.1	0.29	0.12
Temperature (oC)	26.0	26.8	26.4	27.2	26.0	25.2	24.0	25.0	26.0	26.0	26.8	26.4	26.0	27.0	27.0	28.0	26.0
MPN/100ml	210	24000	1100	23	210	150	240000	460	240000	460	240000	240000	210	150	460	240000	240000
E.coli	A	P	P	A	A	A	P	P	P	P	P	A	P	P	P	A	A
FS/100ml	20	150	75	120	28	20	1100	11000	210	28	1100	28	23	15	1100	2400	4

Table 4.14 Contd…

Well No.	**E18**	**E19**	**E20**	**E21**	**E22**	**E23**	**E24**	**E25**	**E26**	**E27**	**E28**	**E29**	**E30**	**E31**	**E32**
p^H	7.5	8.1	8.7	7.0	7.3	7.4	7.2	6.4	7.8	7.1	6.9	7.3	7.5	7.4	7.7
EC	30	100	180	50	50	30	42	40	30	22	40	40	50	80	
Turbidity (NTU)	0.15	0.08	0.29	0.12	1.04	0.08	0.0	0.12	0.24	0.08	0.08	0.0	0.16	0.12	0.32
Temperature (oC)	26.2	26.0	25.2	25.0	26.0	25.2	25.4	25.2	26.2	26.0	26.0	26.2	26.0	26.6	26.8
MPN/100ml	110000	210	43	24000	1100	460	24000	460	240	240000	75	240000	210	93	90
E.coli	P	P	A	P	P	P	P	P	P	P	P	P	A	A	P
FS/100ml	1100	120	210	240	20	15	9	28	28	240	43	21	28	11	150

Table 4.15

Water Quality Status of the wells of Elayavoor Panchayth Pre Monsoon 2006

Well No.	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17
p^H	7.6	7.8	7.8	8.0	8.1	8.2	7.6	7.6	7.7	8.6	8.6	8.4	8.4	8.4	8.5	8.0	8.4
EC	40	80	50	Nd	30	Nd	40	40	Nd	40	Nd	Nd	Nd	280	20	410	40
Turbidity (NTU)	0.28	0.04	0.0	0.08	0.44	0.0	0.28	0.0	0.04	0.16	0.16	0.64	0.2	0.6	0.84	0.52	0.0
Temperature (oC)	25.8	26.6	26.4	27.4	26.2	25.0	25.8	25.2	26.4	26.2	25.4	25.6	25.6	25.0	25.4	25.4	25.0
MPN/100ml	460	7500	1100	1100	460	460	460	1100	11000	2400	4600	1100	1100	240	1100	15000	4600
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	240	93	210	2400	93	75	240	75	1100	93	1100	150	210	240	1100	460	43

Table 4.15 Contd…

Well No.	E18	E19	E20	E21	E22	E23	E24	E25	E26	E27	E28	E29	E30	E31	E32
p^H	8.3	8.2	9.3	9.6	7.7	7.6	7.9	7.9	7.9	7.8	7.5	7.7	7.7	9.2	8.8
EC	40	10	310	40	40	30	40	30	30	210	40	30	50	80	360
Turbidity (NTU)	6.0	0.20	0.60	0.16	0.0	0.0	0.20	0.12	0.28	0.04	0.04	0.12	0.08	0.0	0.0
Temperature (oC)	25.8	26.6	25.0	25.0	26.2	25.4	25.0	25.0	26.6	25.8	26.0	26.4	26.2	26.2	26.6
MPN/100ml	1100	1100	460	15000	2400	460	2400	1100	1100	15000	24000	7500	1100	460	1100
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	460	210	210	460	150	150	75	460	43	216	75	150	93	75	460

Table 4.16

Water Quality Status of the Wells of Cheruthazham Panchyath Monsoon 2005

Well No.	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
p^H EC	7.6	6.7	8.1	7.9	8	7.7	8.7	8.1
Micromhos/cm	Nd	0	20	0	0	0	160	200
Turbidity (NTU)	0.52	0.32	1	0.36	0.44	0.44	0.25	1
Temperature (oC)	26.8	27	28	27	27.8	28	27.2	28
MPN/100ml	11000	1100	110000	240	2400	11000	4600	11000
E.coli	P(+Ve)	P	P	A	P	P	P	P
FS/100ml	43	93	1100	15	9	93	1100	1100

P - Present
A - Absent

Table 4.17

Water Quality Status of the Wells of Cheruthazham Panchyath Post Monsoon 2005

Well No.	C1	C2	C3	C4	C5	C6	C7	C8
p^H EC	8.1	7.7	8.6	8.2	8.2	8.4	9.1	8.9
Micromhos/cm	0	0	80	10	0	0	210	260
Turbidity (NTU)	0.14	0.16	0.32	0.08	0.44	0.24	0	0.12
Temperature (oC)	27.6	28	27	27	28	28.6	27.4	27.4
MPN/100ml	110000	210	110000	460	1100	11000	15000	21000
E.coli	P(+Ve)	A(-Ve)	P	A	P	P	P	P
FS/100ml	7500	28	75	9	28	20	20	1100

Table 4.18

Water Quality Status of the Wells of Cheruthazham Panchyath Pre Monsoon 2006

Well No.	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
p^H EC	8.4	8.6	8.3	8.1	8.6	8.6	8.7	8.3
Micromhos/cm	30	0	40	50	0	60	170	220
Turbidity (NTU)	0.04	0.24	0.16	0.16	0.2	0.4	0.24	0.68
Temperature (oC)	27.2	27.8	27	27.2	28.2	28.4	27.2	27
MPN/100ml	15000	460	110000	1100	2400	4600	7500	11000
E.coli	P	P	P	P	P	P	P	P
FS/100ml	1100	93	150	43	75	75	150	460

Table 4.19

Water Quality Statos of the Wells of Payyavoor Panchyath Monsoon 2005

Well No.	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**P11**	**P12**	**P13**	**P14**	**P15**
p^H	8.1	9.2	7.9	8	8.3	6.9	6.7	6.7	8.5	6.7	6.8	8.3	8.5	8	8.1
EC	0	60	0	50	0	40	0	40	0	0	0	40	30	0	0
Turbidity (NTU)	0.08	0.48	0.84	0.56	0.52	0.16	0.12	0.24	0.28	0.16	0.16	0.56	0.08	0.32	0.28
Temperature (oC)	25.6	25.8	25.4	25.2	24.8	25.6	25.4	25.2	25	26.2	24.8	25	26	24.6	25.2
MPN/100ml	1100	4600	1100	2400	2400	1100	2400	460	1100	1100	460	1100	210	4600	240
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	75	93	1100	75	460	23	150	460	93	460	460	43	43	240	210

Table4.20

Water Quality Status of the Wells of Payyavoor Panchyath Post Monsoon 2005

Well No.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
p^H	8.4	8.3	7.8	8.0	7.6	7.7	7.5	8.0	8.2	8.6	7.6	8.1	8.3	8.0	7.9
EC	Nd	110	Nd	90	30	Nd	30	50	Nd	Nd	Nd	Nd	Nd	Nd	Nd
Turbidity (NTU)	0.36	0.84	0.68	4.40	0.44	0.24	0.28	0.24	0.24	0.85	0.48	0.48	0.24	0.24	0.32
Temperature (oC)	25.2	25.4	24.8	25.2	25.0	24.6	25.2	24.8	24.2	25.2	25.0	25.2	24.8	24.2	25.2
MPN/100ml	1100	1100	11000	2400	2400	4600	210	1100	4600	150	240	120	120	1400	210
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	23	75	460	15	210	21	15	43	43	210	15	7	28	75	43

Table 4.21

Water Quality Status of the Wells of Payyavoor Panchyath Pre Monsoon 2006

Well No.	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
p^H	8.8	9.3	8.9	8.2	8.4	8.7	8.4	7.7	8.9	8.4	8.6	8.5	8.8	8.5
EC	10	10	40	110	50	30	30	50	80	30	0	0	30	40
Turbidity (NTU)	0.12	0.4	1.92	0.52	0.6	0.28	0.16	1.24	0.48	0.84	0.48	0.08	0.6	0
Temperature (oC)	25	25.2	25	25	25.4	24.2	25	24.4	24	25	24.4	24.6	24.	25.4
MPN/100ml	1100	2400	7500	4600	1100	15000	4600	1100	1100	460	460	460	4600	1100
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	1100	150	460	210	150	150	460	2400	460	1100	210	150	460	1100

Table 4.22

Water Quality Status of the Wells of Muliyar Panchyath Monsoon 2005

Well No.	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
p^H	7.6	6.7	6.2	6.5	7.6	8.6	6.9	6.4	8.0	6.6	8.1	7.3	6.8	6.7
EC	70	Nd	30	Nd	Nd	40	50	50	300	Nd	40	Nd	Nd	Nd
Turbidity	1.12	0.0	0.48	0.08	4.72	0.12	4.32	0.48	0.76	0.08	0.04	0.20	0.08	0.0
Temperature	17.6	27.2	27.0	26.0	26.2	26.8	25.6	26.0	26.0	27.2	27.6	25.8	26.6	26.4
MPN/100ml	1100	460	1100	240	11000	2400	7500	7500	4600	7500	7500	240	7500	4600
E.coli	p	p	p	p	p	p	p	p	p	p	p	p	p	p
FS/100ml	1100	15	93	75	210	43	15	150	1100	75	28	150	460	43

Table 4.23

Water Quality Status of the Wells of Muliyar Panchyath Post Monsoon 2005

Well No.	**M1**	**M2**	**M3**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**	**M12**	**M13**	**M14**
p^H	7.8	6.3	6.2	7.1	7.1	7.2	6.1	8.2	6.6	7.2	6.6	8.3	6.5
EC	70	Nd	30	Nd	30	50	Nd	260	Nd	Nd	Nd	200	Nd
Turbidity	1.16	0.32	0.24	0.32	0.2	2.04	0.44	1.64	0.8	0.44	0.08	0.64	0.24
Temperature	27.0	27.0	26.0	25.0	26.4	27.0	26.2	24.8	25.2	25.4	27.0	26.0	25.2
MPN/100ml	24000	21000	24000	1100	210	24000	15000	46000	2400	210	120	110000	21000
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P
FS/100ml	460	28	93	28	11	150	210	240000	43	75	210	110000	23

Table 4.24

Water Quality Status of the Wells of Muliyar Panchyath Pre Monsoon 2006

Well No.	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M12**	**M13**	**M14**
p^H	9.8	8.7	8.5	8.8	7.6	8.4	9.6	9.4	9.8	9.1	9.3	9.1	9.3
EC	100	Nd	Nd	30	Nd	40	40	Nd	2.30	100	Nd	90	Nd
Turbidity	3.28	1.96	0.68	0.12	0.36	0.24	0.32	2.2	0.64	0.6	0.36	1.4	0.32
Temperature	27.0	27.2	26.2	26.4	25.2	26.4	27.2	26.0	25.0	25.2	27.2	25.8	25.0
MPN/100ml	1100	4600	2400	1000	1100	1100	4600	4000	1100	7500	1100	7500	2400
E.coli	P	P	P	P	P	P	P	P	P	P	P	P	P
FS	240	210	460	460	75	150	460	460	150	1100	460	1100	150

pH and turbidity were also monitored in the well water samples as these parameters have significant influence on the movement of microbes and their attenuation in the environment. Acidic soils tend to increase absorption of bacteria and viruses and that limit transport in some soils. Turbidity in ground water is associated with the presence of suspended matter such as clay, silt and fine particles of organic and inorganic matter, plankton and other microscopic organisms. Higher turbidity levels are often associated with higher levels of disease – causing microorganisms such as viruses, parasites and some bacteria. In the present study higher values of turbidity and pH appear to increase the levels of contamination. Open wells without any platform and parapet wall were observed to contain higher levels of faecal coliforms than others. The level of contamination of faecal coliforms is higher when the distance between well and latrine is less. Single pit latrine are associated with higher level of contamination than double pit and septic tanks. Sanitary survey results indicate that areas with inadequate drainage, responsible for water stagnation near a well, contribute significantly to level of contamination. The latrine close to the well, especially single pit latrines were found to have great influence on the higher levels of contamination Wells near the water logged areas showed more contamination. Hence, necessary steps must be taken to prevent contamination and the wells must be treated and the treatment method must preferably be eco-friendly [**AWWA, 1971**].

The indigenous knowledge prevalent in Northern Kerala is to treat well water using a mixture of Amala, Vertiver, Muthanga, Thettamparal, Kudangal and Amaranthus seeds (**Sreekumar et al., 2006**). These are powdered and taken in equal quantity, wrapped in a cloth bag and put in the well. The studies conducted in the laboratory revealed that this mixture has the capacity to destroy the bacteria, [E. Coli and faecal streptococci] at a faster rate. This mixture can be employed for the treatment of the wells. The treatment can be done through panchayats. In the Kannur and Kasaragod districts, there is hard rock and hard laterite present. The concentrations of dissolved ions is very low. Almost all the water samples are found to be very soft. Hence Strychnos potatorum cannot be employed here and treatment of the wells by the mixture will be appropriate for such types of samples [**Hamsen J, 1986; Gorden L and Russel LC, 1974; Haimes YY**].

Correlation between paramenters

There is positive correlation between MPN or faecal streptococci with turbidity and pH (Table 4.33). There is negative correlation between pH and faecal streptococci during pre monsoon season, where as there is negative correlation between total hardness and faecal streptococci during monsoon 2005 [**Patil NM and Khare PG, 2004**]. The correlation tables are given below (table 4.25 to 4.36) [**Singh SK, 1996**].

Table 4.25

Matrix of correlation Elayvoor panchayth Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.2862	1.00918	32
Ec	86.7742	78.84107	31
INTU	.2934	.18085	32
Temp	26.4438	.42422	32
MPN	1355.4063	1383.80744	32
faceal	185.8438	230.50479	32

Correlations

		pH	Ec	INTU	Temp	MPN	faceal
pH	Pearson Correlation	1	.409*	-.078	-.015	.033	-.026
	Sig. (2-tailed)	.	.022	.671	.937	.856	.889
	N	32	31	32	32	32	32
Ec	Pearson Correlation	.409*	1	.312	.249	-.211	.199
	Sig. (2-tailed)	.022	.	.087	.177	.253	.283
	N	31	31	31	31	31	31
INTU	Pearson Correlation	-.078	.312	1	-.285	-.266	-.010
	Sig. (2-tailed)	.671	.087	.	.113	.141	.959
	N	32	31	32	32	32	32
Temp	Pearson Correlation	-.015	.249	-.285	1	-.045	.124
	Sig. (2-tailed)	.937	.177	.113	.	.808	.497
	N	32	31	32	32	32	32
MPN	Pearson Correlation	.033	-.211	-.266	-.045	1	-.094
	Sig. (2-tailed)	.856	.253	.141	.808	.	.608
	N	32	31	32	32	32	32
faceal	Pearson Correlation	-.026	.199	-.010	.124	-.094	1
	Sig. (2-tailed)	.889	.283	.959	.497	.608	.
	N	32	31	32	32	32	32

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.26

Matrix of correlation Elayvoor Panchayth Post Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.2862	1.00918	32
Ec	86.7742	78.84107	31
INTU	.2934	.18085	32
Temp	26.4438	.42422	32
MPN	1355.4063	1383.80744	32
faceal	185.8438	230.50479	32

Correlations

		pH	Ec	INTU	Temp	MPN	faceal
pH	Pearson Correlation	1	.685**	.544**	.340	-.215	-.161
	Sig. (2-tailed)	.	.000	.001	.057	.237	.378
	N	32	24	32	32	32	32
Ec	Pearson Correlation	.685**	1	.580**	.568**	-.002	.063
	Sig. (2-tailed)	.000	.	.003	.004	.993	.771
	N	24	24	24	24	24	24
INTU	Pearson Correlation	.544**	.580**	1	.322	-.236	-.061
	Sig. (2-tailed)	.001	.003	.	.072	.194	.741
	N	32	24	32	32	32	32
Temp	Pearson Correlation	.340	.568**	.322	1	.087	-.153
	Sig. (2-tailed)	.057	.004	.072	.	.635	.402
	N	32	24	32	32	32	32
MPN	Pearson Correlation	-.215	-.002	-.236	.087	1	.010
	Sig. (2-tailed)	.237	.993	.194	.635	.	.956
	N	32	24	32	32	32	32
faceal	Pearson Correlation	-.161	.063	-.061	-.153	.010	1
	Sig. (2-tailed)	.378	.771	.741	.402	.956	.
	N	32	24	32	32	32	32

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.27

Matrix of correlation Elayvoor Panchayth Pre Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	8.1500	.53280	32
Ec	92.6923	115.18881	26
INTU	.3787	1.05017	32
Temp	25.8188	.63725	32
MPN	4001.8750	5813.44018	32
Faceal	350.2813	477.69515	32

Correlations

		pH	Ec	INTU	Temp	MPN	Faceal
pH	Pearson Correlation	1	.309	.109	-.261	-.101	.074
	Sig. (2-tailed)	.	.124	.551	.149	.582	.687
	N	32	26	32	32	32	32
Ec	Pearson Correlation	.309	1	-.031	-.155	.173	.177
	Sig. (2-tailed)	.124	.	.880	.451	.398	.386
	N	26	26	26	26	26	26
INTU	Pearson Correlation	.109	-.031	1	-.069	-.123	.060
	Sig. (2-tailed)	.551	.880	.	.708	.501	.746
	N	32	26	32	32	32	32
Temp	Pearson Correlation	-.261	-.155	-.069	1	-.015	.305
	Sig. (2-tailed)	.149	.451	.708	.	.936	.090
	N	32	26	32	32	32	32
MPN	Pearson Correlation	-.101	.173	-.123	-.015	1	.011
	Sig. (2-tailed)	.582	.398	.501	.936	.	.953
	N	32	26	32	32	32	32
Faceal	Pearson Correlation	.074	.177	.060	.305	.011	1
	Sig. (2-tailed)	.687	.386	.746	.090	.953	.
	N	32	26	32	32	32	32

Table 4.28

Matrix of correlation Cheruthazham Panchayth Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.8500	.57071	8
EC	54.2857	86.95921	7
NTU	.5413	.29483	8
Temp	27.5500	.48697	8
MPN	31292.50	48750.71157	8
Faecal	444.1250	543.99014	8

Correlations

		pH	EC	NTU	Temp	MPN	Faecal
pH	Pearson Correlation	1	.561	.197	.370	.275	.624
	Sig. (2-tailed)	.	.191	.639	.367	.509	.098
	N	8	7	8	8	8	8
EC	Pearson Correlation	.561	1	.320	.011	.441	.777*
	Sig. (2-tailed)	.191	.	.484	.982	.322	.040
	N	7	7	7	7	7	7
NTU	Pearson Correlation	.197	.320	1	.570	.971**	.583
	Sig. (2-tailed)	.639	.484	.	.140	.000	.129
	N	8	7	8	8	8	8
Temp	Pearson Correlation	.370	.011	.570	1	.566	.305
	Sig. (2-tailed)	.367	.982	.140	.	.143	.462
	N	8	7	8	8	8	8
MPN	Pearson Correlation	.275	.441	.971**	.566	1	.741*
	Sig. (2-tailed)	.509	.322	.000	.143	.	.036
	N	8	7	8	8	8	8
Faecal	Pearson Correlation	.624	.777*	.583	.305	.741*	1
	Sig. (2-tailed)	.098	.040	.129	.462	.036	.
	N	8	7	8	8	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.29

Matrix of correlation Cheruthazham Panchayth Post Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	8.4000	.45356	8
Ec	70.0000	106.23424	8
NTU	.1875	.14059	8
Tmp	27.6250	.54968	8
MPN	33596.25	47747.55280	8
FS	1097.5000	2614.02875	8

Correlations

		pH	Ec	NTU	Tmp	MPN	FS
pH	Pearson Correlation	1	.863**	-.300	-.344	.063	-.205
	Sig. (2-tailed)	.	.006	.470	.404	.882	.627
	N	8	8	8	8	8	8
Ec	Pearson Correlation	.863**	1	-.453	-.396	-.039	-.164
	Sig. (2-tailed)	.006	.	.259	.331	.926	.698
	N	8	8	8	8	8	8
NTU	Pearson Correlation	-.300	-.453	1	.330	.126	-.162
	Sig. (2-tailed)	.470	.259	.	.425	.766	.701
	N	8	8	8	8	8	8
Tmp	Pearson Correlation	-.344	-.396	.330	1	-.374	-.045
	Sig. (2-tailed)	.404	.331	.425	.	.362	.916
	N	8	8	8	8	8	8
MPN	Pearson Correlation	.063	-.039	.126	-.374	1	.643
	Sig. (2-tailed)	.882	.926	.766	.362	.	.085
	N	8	8	8	8	8	8
FS	Pearson Correlation	-.205	-.164	-.162	-.045	.643	1
	Sig. (2-tailed)	.627	.698	.701	.916	.085	.
	N	8	8	8	8	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.30

Matrix of correlation Cheruthazham Panchayth Pre Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	8.4500	.20702	8
EC	71.2500	80.43409	8
NTU	.2650	.19589	8
Temp	27.5000	.55549	8
MPN	19007.50	37110.47436	8
Faecal	268.2500	361.08636	8

Correlations

		pH	EC	NTU	Temp	MPN	Faecal
pH	Pearson Correlation	1	-.056	.007	.596	-.303	-.167
	Sig. (2-tailed)	.	.896	.987	.119	.466	.692
	N	8	8	8	8	8	8
EC	Pearson Correlation	-.056	1	.716*	-.483	-.094	.096
	Sig. (2-tailed)	.896	.	.046	.226	.825	.822
	N	8	8	8	8	8	8
NTU	Pearson Correlation	.007	.716*	1	.026	-.201	-.157
	Sig. (2-tailed)	.987	.046	.	.951	.634	.711
	N	8	8	8	8	8	8
Temp	Pearson Correlation	.596	-.483	.026	1	-.427	-.388
	Sig. (2-tailed)	.119	.226	.951	.	.291	.342
	N	8	8	8	8	8	8
MPN	Pearson Correlation	-.303	-.094	-.201	-.427	1	-.011
	Sig. (2-tailed)	.466	.825	.634	.291	.	.980
	N	8	8	8	8	8	8
Faecal	Pearson Correlation	-.167	.096	-.157	-.388	-.011	1
	Sig. (2-tailed)	.692	.822	.711	.342	.980	.
	N	8	8	8	8	8	8

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.31

Matrix of correlation Payyavur Panchayth Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.8467	.75201	15
EC	14.6720	22.31430	15
NTU	3.4907	12.31507	15
Temp	25.3200	.45857	15
MPN	1624.6667	1408.94523	15
FS	265.6667	287.19000	15

Correlations

		pH	EC	NTU	Temp	MPN	FS
pH	Pearson Correlation	1	.348	.503	-.080	.306	-.214
	Sig. (2-tailed)	.	.204	.056	.778	.268	.443
	N	15	15	15	15	15	15
EC	Pearson Correlation	.348	1	.561*	.276	.520*	-.438
	Sig. (2-tailed)	.204	.	.030	.319	.047	.103
	N	15	15	15	15	15	15
NTU	Pearson Correlation	.503	.561*	1	.283	.587*	-.157
	Sig. (2-tailed)	.056	.030	.	.306	.021	.577
	N	15	15	15	15	15	15
Temp	Pearson Correlation	-.080	.276	.283	1	-.184	-.097
	Sig. (2-tailed)	.778	.319	.306	.	.513	.732
	N	15	15	15	15	15	15
MPN	Pearson Correlation	.306	.520*	.587*	-.184	1	-.149
	Sig. (2-tailed)	.268	.047	.021	.513	.	.597
	N	15	15	15	15	15	15
FS	Pearson Correlation	-.214	-.438	-.157	-.097	-.149	1
	Sig. (2-tailed)	.443	.103	.577	.732	.597	.
	N	15	15	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.32

Matrix of correlation Payyavur Panchayth Post Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	8.0000	.32293	15
EC	62.0000	36.33180	5
Turbidity	.4220	.21248	15
Temp	24.9333	.36775	15
MPN	2050.0000	2898.14719	15
faceal	85.5333	122.28063	15

Correlations

		pH	EC	Turbidity	Temp	MPN	faceal
pH	Pearson Correlation	1	.909*	.339	.096	-.224	-.045
	Sig. (2-tailed)	.	.033	.216	.733	.422	.874
	N	15	5	15	15	15	15
EC	Pearson Correlation	.909*	1	.739	.628	.169	-.313
	Sig. (2-tailed)	.033	.	.154	.257	.786	.608
	N	5	5	5	5	5	5
Turbidity	Pearson Correlation	.339	.739	1	.534*	.128	.546*
	Sig. (2-tailed)	.216	.154	.	.040	.650	.035
	N	15	5	15	15	15	15
Temp	Pearson Correlation	.096	.628	.534*	1	-.386	-.049
	Sig. (2-tailed)	.733	.257	.040	.	.156	.862
	N	15	5	15	15	15	15
MPN	Pearson Correlation	-.224	.169	.128	-.386	1	.721**
	Sig. (2-tailed)	.422	.786	.650	.156	.	.002
	N	15	5	15	15	15	15
faceal	Pearson Correlation	-.045	-.313	.546*	-.049	.721**	1
	Sig. (2-tailed)	.874	.608	.035	.862	.002	.
	N	15	5	15	15	15	15

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.33

Matrix of correlation Payyavur Panchayth Pre Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	8.5786	.37862	14
EC	36.4286	30.28255	14
NTU	.5514	.51205	14
Temp	24.7571	.48471	14
MPN	3255.7143	4007.48668	14
FS	611.4286	631.28510	14

Correlations

		pH	EC	NTU	Temp	MPN	FS
pH	Pearson Correlation	1	-.336	-.125	-.022	.185	-.586*
	Sig. (2-tailed)	.	.240	.671	.940	.526	.028
	N	14	14	14	14	14	14
EC	Pearson Correlation	-.336	1	.222	-.011	.103	.063
	Sig. (2-tailed)	.240	.	.445	.970	.726	.831
	N	14	14	14	14	14	14
NTU	Pearson Correlation	-.125	.222	1	-.054	.137	.281
	Sig. (2-tailed)	.671	.445	.	.855	.642	.331
	N	14	14	14	14	14	14
Temp	Pearson Correlation	-.022	-.011	-.054	1	-.253	-.014
	Sig. (2-tailed)	.940	.970	.855	.	.383	.961
	N	14	14	14	14	14	14
MPN	Pearson Correlation	.185	.103	.137	-.253	1	-.310
	Sig. (2-tailed)	.526	.726	.642	.383	.	.280
	N	14	14	14	14	14	14
FS	Pearson Correlation	-.586*	.063	.281	-.014	-.310	1
	Sig. (2-tailed)	.028	.831	.331	.961	.280	.
	N	14	14	14	14	14	14

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.34

Matrix of correlation Muliyar Panchayth Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.1429	.73035	14
EC	82.8571	96.55988	7
Turbidity	.8914	1.57343	14
Temp	25.8571	2.45128	14
MPN	4517.1429	3588.57895	14
Faeceal	254.0714	376.39984	14

Correlations

		pH	EC	NTU	Temp	MPN	FS
pH	Pearson Correlation	1	-.336	-.125	-.022	.185	-.586*
	Sig. (2-tailed)	.	.240	.671	.940	.526	.028
	N	14	14	14	14	14	14
EC	Pearson Correlation	-.336	1	.222	-.011	.103	.063
	Sig. (2-tailed)	.240	.	.445	.970	.726	.831
	N	14	14	14	14	14	14
NTU	Pearson Correlation	-.125	.222	1	-.054	.137	.281
	Sig. (2-tailed)	.671	.445	.	.855	.642	.331
	N	14	14	14	14	14	14
Temp	Pearson Correlation	-.022	-.011	-.054	1	-.253	-.014
	Sig. (2-tailed)	.940	.970	.855	.	.383	.961
	N	14	14	14	14	14	14
MPN	Pearson Correlation	.185	.103	.137	-.253	1	-.310
	Sig. (2-tailed)	.526	.726	.642	.383	.	.280
	N	14	14	14	14	14	14
FS	Pearson Correlation	-.586*	.063	.281	-.014	-.310	1
	Sig. (2-tailed)	.028	.831	.331	.961	.280	.
	N	14	14	14	14	14	14

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.35

Matrix of correlation Muliyar Panchayth Post Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.0154	.72898	13
EC	106.6667	98.52242	6
Turbidity	.6585	.60302	13
Temp	26.0154	.83051	13
MPN	22336.67	31086.32039	12
Faceal	27025.46	70831.64207	13

Correlations

		pH	EC	Turbidity	Temp	MPN	Faceal
pH	Pearson Correlation	1	.814*	.542	-.163	.622*	.687**
	Sig. (2-tailed)	.	.049	.056	.595	.031	.009
	N	13	6	13	13	12	13
EC	Pearson Correlation	.814*	1	.320	-.763	.704	.963**
	Sig. (2-tailed)	.049	.	.536	.078	.118	.002
	N	6	6	6	6	6	6
Turbidity	Pearson Correlation	.542	.320	1	.042	.277	.456
	Sig. (2-tailed)	.056	.536	.	.892	.384	.117
	N	13	6	13	13	12	13
Temp	Pearson Correlation	-.163	-.763	.042	1	-.030	-.415
	Sig. (2-tailed)	.595	.078	.892	.	.926	.159
	N	13	6	13	13	12	13
MPN	Pearson Correlation	.622*	.704	.277	-.030	1	.609*
	Sig. (2-tailed)	.031	.118	.384	.926	.	.035
	N	12	6	12	12	12	12
Faceal	Pearson Correlation	.687**	.963**	.456	-.415	.609*	1
	Sig. (2-tailed)	.009	.002	.117	.159	.035	.
	N	13	6	13	13	12	13

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.36

Matrix of correlation Muliyar Panchayth Pre Monsoon 2005

Descriptive Statistics

	Mean	Std. Deviation	N
pH	9.0308	.62501	13
EC	57.4714	38.91130	7
Turbidity	.9600	.96554	13
Temp	26.1385	.85395	13
MPN	3038.4615	2404.34969	13
FS	421.1538	335.03827	13

Correlations

		pH	EC	Turbidity	Temp	MPN	FS
pH	Pearson Correlation	1	.023	.363	.151	.137	.170
	Sig. (2-tailed)	.	.961	.223	.623	.655	.579
	N	13	7	13	13	13	13
EC	Pearson Correlation	.023	1	.624	.092	.588	.632
	Sig. (2-tailed)	.961	.	.134	.844	.165	.128
	N	7	7	7	7	7	7
Turbidity	Pearson Correlation	.363	.624	1	.302	.153	.011
	Sig. (2-tailed)	.223	.134	.	.315	.618	.972
	N	13	7	13	13	13	13
Temp	Pearson Correlation	.151	.092	.302	1	-.104	-.083
	Sig. (2-tailed)	.623	.844	.315	.	.735	.787
	N	13	7	13	13	13	13
MPN	Pearson Correlation	.137	.588	.153	-.104	1	.817**
	Sig. (2-tailed)	.655	.165	.618	.735	.	.001
	N	13	7	13	13	13	13
FS	Pearson Correlation	.170	.632	.011	-.083	.817**	1
	Sig. (2-tailed)	.579	.128	.972	.787	.001	.
	N	13	7	13	13	13	13

**. Correlation is significant at the 0.01 level (2-tailed).

4.4.2 Physico-Chemical and Microbiological quality of ground water resources at a tribal area of Kannur district

Water quality studies have been carried out at a tribal area of Kannur district. Payyavur panchayat has been selected for the study. Kanjirakkolly and Vanchiyam are two wards of the panchayat where there is tribal colonies. Paniya, Mavilan, Karimbalan, etc. are some of the tribes who reside here. There is water scarcity in these wards. This study forms part of a project of C W R D M entitled, ”Water quality studies and water conservation techniques at a tribal area of Kannur district, Kerala state” funded by Western Ghat Cell, Government of Kerala.

Due to the presence of hard rock and hard laterite, ground water availability is low in this area. There are few open dug wells in this area. People depend upon surface water from natural pits, locally caled ‘olys’ for their domestic needs. They are taking water from olys upstream using pipes. They do not have any arrangements to store the water. It is getting wasted after use. Few people have installed a springler irrigation unit to irrigate the crops. During summer some of the olys will become dry. This is the case especially in Kanjirakkolly ward. At Vanchiyam there are open wells. Few people depend upon olys also for their needs. The local people dig a pitch near the streams uphill and use this water using pipes. Water samples were collected from the olys and open wells during pre-monsoon, monsoon and post monsoon 2007 and analysed to find out its quality. During pre-monsoon 2008, the olys and wells were treated using a powdered mixture consisting of Amala, Muthanga, Vertiver, Kudangal, Srychnos potatorum and Amaranths seeds. After 15 days, the water samples were collected and analysed to find out the improvement of its quality. The results of the study are discussed here. The map of the study area is given in fig. 4.7.

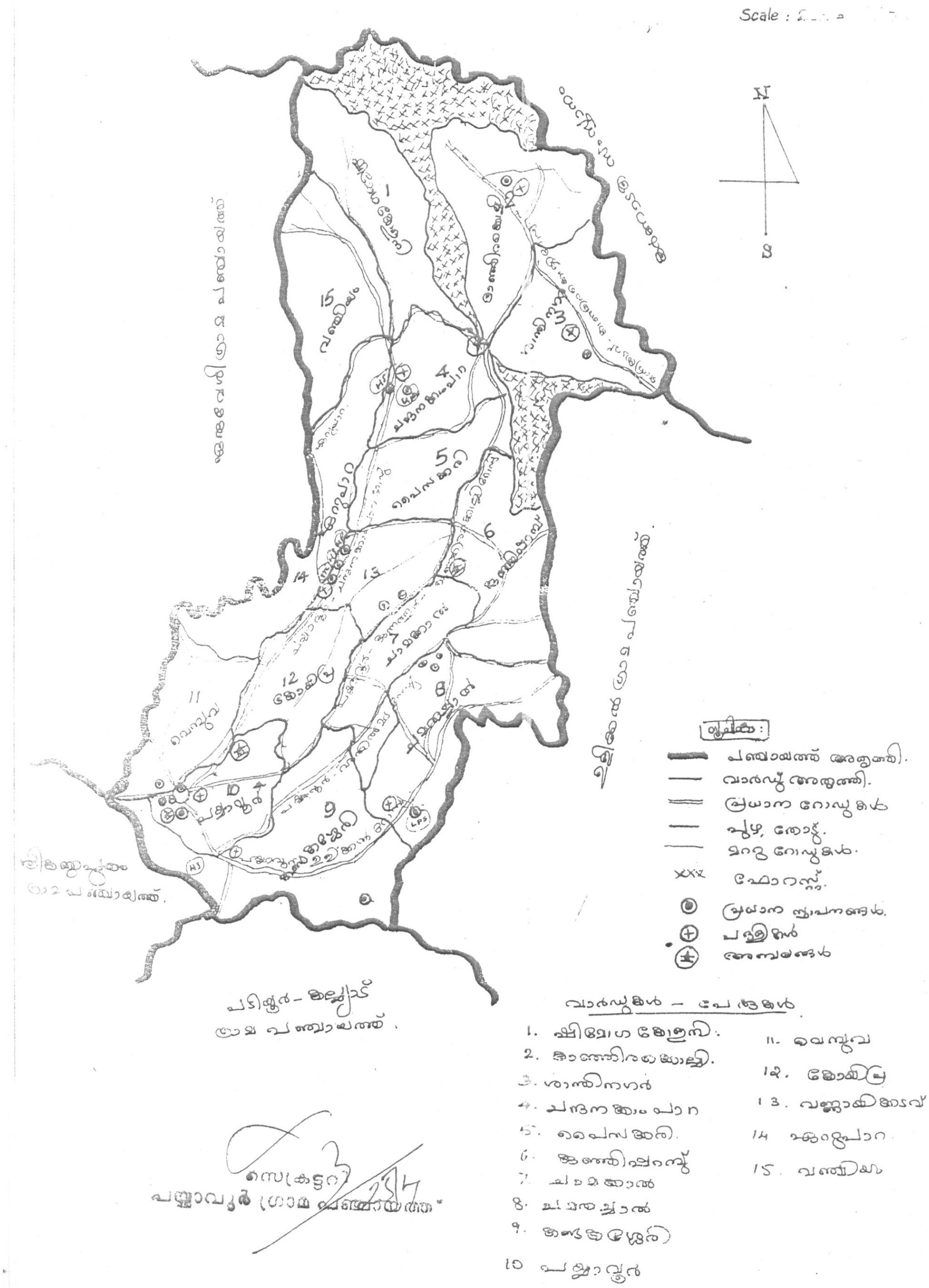


Figure 4.12: Location Map of Payyavur Panchayat

4.4.3 Results and Discussion

(a) Kanjirakkolly ward

Due to the steepness of the place and the presence of hard rock, availability of ground water resources is very low in this area and there is acute water scarcity. Hence the tribes and local people depend upon water from natural pits, commonly called ‘olys’. Local people dig few pits near streams and use it. But the tribes use the water from the natural ‘olys’ only. The panchayat has dug one well for the tribes. But it has not been used because they like water from olys. Water samples were collected from 5 olys and 3 wells during pre monsoon, monsoon and post monsoon 2007 and analysed to find out its quality. The results of analysis are given in Tables4.37 to4.39. The results show that all the samples are found to be very soft, ie. hardness is below 60ppm and are microbiologically contaminated. E coli and faecal streptococci were detected in the samples and it shows faecal contamination. The pH is found to be neutral. The bacterial contamination was found to be high during pre-monsoon season and low during the monsoon and post-monsoon seasons. This is due to the flushing of the water samples during the heavy rains. The value of MPN index varys from 7-1100 during pre- monsoon period, 9-28 during the monsoon period and 4-28 during the post-monsoon period.

(b) Vanchiyam ward

Panchayat has dug open wells for the tribes and the local people have shortage of ground water. They make small pits near streams uphill and use the water from this artificial olys for their needs using pipes. Water samples were collected from the wells and few olys and analysed to find out its physico-chemical and microbiological quality. The results of the study shows that all the samples are soft and microbiologically contaminated. pH was found to be neutral. Hardress was found to be below 50ppm. (ie very soft). The rate of microbiological contamination was found to be high during pre monsoon and monsoon seasons and low during post-monsoon season. The value of M P N index varys from 23-2400 during pre monsoon period, 21-2400 during monsoon season; and 4-120 during post monsoon period. E coli and faecal streptococci were found to be present in the samples which indicates that the contamination is from faecal matter. The results are given in tables 4.40 to 4.42.

Table 4.37

Water Quality Status of wells of Kanjirakkolly ward Pre Monsoon 2007

Sample Code	**K_1**	**K_2**	**K_4**	**K_5**	**K_6**	**K_7**	**K_8**
P^H	7.4	7.1	7.5	7.4	7.3	7.9	7.6
Electrical Conductivity	30	30	30	60	30	90	30
Total Hardness (ppm)	7	10	14	14	17	4	8
Calcium(,,)	3	5	4	4	3	4	3
Magnesium(,,)	0.7	0.6	0.3	0.9	1.7	0.8	0.4
Bicarbonates(,,)	5	10	8	10	3.7	10	10
Chloride (,,)	5	10	8	10	7	10	10
MPN /100ml	15	20	9	20	11	20	28/
E coli	-	-	-	+	+	-	-
Fs/ 100ml	4	75	75	75	4	460	64

Table 4.38

Water Quality Status of wells of Kanjirakkolly ward Monsoon 2007

Sample Code	K_1	K_2	K_4	K_5	K_6	K_7	K_8
P^H	7.6	7.1	7.1	7.5	7.2	7.4	7.5
Electrical Conductivity	20	20	20	30	30	20	20
Total Hardness (ppm)	19	18	17	20	17	12	17
Calcium(,,)	4.8	4.0	3.2	2.8	4.0	2.4	2.2
Magnesium(,,)	1.7	1.9	2.1	3.1	1.7	1.8	2.7
Bicarbonates(,,)	25	26	20	26	26	12	25
Chloride (,,)	9	8	8	11	8	10	11
MPN /100ml	240	43	43	7	460	9	240
E coli	P	P	P	P	P	P	P
Fs/ 100ml	93	460	9	93	43	15	150

Table 4.39

Water Quality Status of wells Kanjirakkolly ward Post Monsoon 2007

Sample code	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
PH	8.0	8.1	7.9	8.0	7.6	7.7	8.0	8.0
EC	40	30	40	40	40	40	30	30
Total Hardness	25	7	9	3	3	4	9	7
Total alkalinity	15	13	12	11	21	21	10	13
Calcium	4	2	3	1	1	1	2	2
Magnesium	3.5	0.5	0.3	0.1	0	0.25	P	0.5
Iron	P	P	P	P	P	P	10	P
Bicarbonate	15	13	12	11	21	21	20	13
Chloride	10	18	15	11	20	18	20	20
MPN	4	4	9	9	28	9	-	9
Ecoli	-	+	-	-	-	+	20	-
Streptococci	23	23	9	43	23	4		15

Table 4.40

Water Quality Status of Vanchiyam Ward Pre – Monsoon 2007

Sample Code	**V_1**	**V_2**	**V_3**	**V_4**	**V_5**	**V_6**	**V_7**	**V_8**	**V_9**	**V_{10}**	**V_{11}**	**V_{12}**	**V_{13}**	**V_{14}**	**V_{15}**	**V_{16}**	**V_{17}**	**V_{18}**
P^H	7.9	7.6	7.5	7.5	7.7	7.1	7.5	7.1	7.5	7.5	8.5	7.8	7.5	7.5	7.7	7.5	8.5	7.8
Electrical Conductivity (Micro mho/cm)	60	40	30	30	30	40	40	40	20	40	140	30	30	40	40	40	40	30
Total Hardness (ppm)	9	16	7	10	8	9	15	10	14	8	13	12	9	10	10	11	20	7
Calcium(,,)	5	6	8	6	4	6	3	7	4	4	2	5	6	6	5	6	4	3
Magnesium(,,)	0.8	0.2	3.1	1.9	1.4	1.4	1.8	1.8	0.4	0.4	1.9	0.7	1.5	1.2	0.6	0.9	2.4	0.8
Bicarbonate (,,)	5	15	5	7	5	10	5	16	4	5	7	5	10	15	5	10	7	11
Chloride (,,)	21	4	6	6	10	7	9	7	7	8	6	7	7	7	7	9	7	3
MPN / 100ml	204	2400	28	150	150	1100	28	210	93	115	2400	2400	23	2400	1100	210	2400	150
E coli	-	-	-	-	-	+	+	-	+	+	+	-	-	-	-	-	-	-
Fs/ 100ml	14	150	7	1100	75	75	93	460	93	150	120	43	123	39	23	39	39	28

Table 4.41

Water quality status of Vanchiyam ward Monsoon 2007

	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}
pH	7.1	7.4	7.9	7.7	7.4	7.2	7.1	6.9	6.9	7.1	7.0	7.0	7.2	7.2	7.2	7.0	7.1
Electrical Conductivity (Micro mho/cm)	20	30	60	40	20	20	70	20	20	20	20	20	20	20	30	20	30
Total Hardness (ppm)	16	24	47	35	22	17	14	15	20	27	15	15	17	15	23	14	21
Calcium(,,)	2.4	3.2	1.2	6.0	3.2	3.2	2.8	3.6	2.8	2.8	2.4	2.4	3.2	2	4	2	3.2
Magnesium(,,)	2.1	3.8	9.1	4.8	2.6	3.8	0.4	4.9	2.1	4.8	4.1	2.1	2.1	1.3	4.4	1.5	2.8
Bicarbonate(,,)	16	24	47	35	22	17	14	15	20	37	23	33	22	21	21	11	34
Chloride(,,)	10	7	9	8	10	15	9	9	8	9	12	10	11	9	8	7	8
MPN /100ml	460	2400	2400	460	240	2400	23	2400	93	460	1100	1100	1100	460	21	21	240
E coli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Fs/100 ml	1100	2400	150	460	20	210	460	20	240	1100	25	23	43	43	210	93	1100

Table 4.42

Water Quality Status of Wells Vanchiyam ward Post – Monsoon 2007

Sample code	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}
pH	8.1	8	7.1	8.1	7.9	7.7	8.0	7.6	7.7	7.7	7.6	8.1	8.0	7.8	7.7	7.6	8.0	7.8
Ec	40	70	40	50	50	70	40	40	70	40	40	40	70	50	50	40	40	40
Total Hardness	9	23	13	21	12	12	21	29	16	11	25	22	10	10	20	29	16	12
Total alkalinity	10	21	24	32	17	12	11	48	22	21	39	39	11	17	31	34	20	18
Calcium	2	8	4	6	4	4	6	8	9	10	7	9	3	5	7	6	6	3
Magnesium	0.3	1.0	1.0	1.4	0.1	0.4	1.4	2.1	1.5	2.4	1.8	0.7	0.6	0.6	0.6	3.4	0.2	1.09
Iron	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Bicarbonate	10	21	24	32	17	12	11	48	22	21	39	39	11	17	31	34	20	18
Chloride	26	17	16	20	15	19	14	11	17	20	20	20	14	16	15	20	15	17
MPN	4	4	7	7	4	7	11	11	4	4	4	4	41	39	7	150	20	7
Ecoli	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	+	-
Streptococci	28	4	9	4	4	23	7	11	4	4	7	4	7	7	4	11	4	4

(c) Treatment of the water samples

The surface and ground water samples of Kanjirakkolly and Vanchiyam wards are microbiologically contaminated and none of the samples are found to be potable. Hence treatment of the samples is very essential before drinking. The indigenous knowledge prevalent among the people of North Malabar for treating well water is to put a powdered mixture containing Muthanga, Amala, Vertiver, Kudangal, Strychnos Potatorum and Amaranthus seeds, wrapped in a clothbag. These were powdered well and taken in equal quantities, wrapped in a cloth bag, sterilised and put in the well during pre-monsoon 2008. After 15days, water samples were collected and analysed to find out its physico-chemical and microbiological quality. The results of the study shows that there is improvement in the water quality. The results are given in table 4.43 and 4.44. The salient findings are given below.

Table 4.43

Water Quality Status of wells Kanjirakkolly Ward After Treatment 2008

Sample code	K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8
pH	7.9	7.7	7.6	7.8	7.6	7.6	7.8	7.9
Ec	30	30	40	40	30	40	40	30
Total Hardness	12	11	13	16	7	11	15	11
Total alkalinity	15	25	16	22	19	21	15	21
Calcium	4	3	5	6	2	4	6	4
Magnesium	0.5	0.1	0.1	0.2	0.5	0.2	0	0.2
Iron	P	A	A	A	A	A	A	P
Bicarbonate	12	11	13	16	7	11	15	11
Chloride	7	8	12	11	6	8	6	11
MPN	150	210	75	210	1100	150	28	28
Ecoli	+	+	-	-	-	-	-	-
Streptococci	20	20	4	4	15	150	20	11

Table 4.44

Water Quality Status of wells Vanchiyam Ward After Treatment 2008

Sample code	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	V_{14}	V_{15}	V_{16}	V_{17}	V_{18}
P^H	8.1	8.0	7.8	8.1	7.9	7.7	8.0	7.6	7.4	7.4	7.6	7.1	7.4	7.8	7.7	7.7	6.7	7.1
Ec	60	40	50	40	60	40	50	50	50	50	60	60	50	50	80	70	30	60
Total Hardness	9	23	13	21	12	12	21	29	20	25	19	25	17	24	26	17	8	24
Total alkalinity	10	21	24	32	17	12	11	48	21	16	10	20	17	30	30	25	11	20
Calcium	3	10	6	6	5	4	6	8	7	8	6	5	5	5	8	4	2	5
Magnesium	0.3	0.4	0.4	1.4	0.1	.4	1.4	2.1	1.5	1.1	1.0	1.8	1.1	1.75	1.2	1.75	0.7	2.1
Iron	P	P	P	P	P	P	P	P	P	P	P	A	P	P	P	P	A	A
Bicarbonate	10	21	24	32	17	12	11	48	21	16	10	20	17	30	30	25	11	20
Chloride	26	17	16	20	15	19	14	11	10	12	11	20	9	10	10	13	10	20
MPN	4	4	7	7	4	7	11	11	28	75	28	20	93	21	28	93	23	75
Ecoli	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
Streptococci	28	4	9	4	4	23	7	11	9	75	9	15	4	24	20	15	20	28

(i) M P N index was found to be reduced

(ii) E coli has not been detected in most of the samples

(iii) Faecal streptococci has been found to be reduced in number.

In Kanjirakkolly, M P N index was found to vary from 28 to 1100. E coli was not detected in 6 samples out of 8. The value of faecal streptococci was found to be reduced and varies from 4 to 150. At Vanchiyam, MPN index varies from 23 to 93. E coli was detected only in two samples out of 18. The value of facial streptococci was found to be reduced and varies from 4 to 75.

The results of the study shows that there is considerable improvement in water quality after treatment.

About 50gms of the powdered mixture has been used for treatment. The panchayat well at Vanchiyam was treated using 100gms of the mixture. If the quantity of the mixture have been increased the total coliforms and faecal coliforms might have been destroyed completely. K_6, K_7 and K_8 are the only wells of Kanjirakkolly ward. Regarding K_6, there is hard rock inside the well. When the powdered mixture was put inside the well in cloth bag, there was water above the level of rock. As the water level went down, the cloth bag got stuck on the surface of the rock and did not have any contact with water when the sample was taken.

Hence the water quality has not improved very much compared to the rest of the samples.

Correlation between parameters

Increase in pH tend to increase contamination level. There is positive correlation between pH, faecal streptococci and MPN. A correlation between MPN and magnesium is found. The correlation table is given below (Table 4.45 to 4.50). The correlation after treatment has not been calculated.

Table 4.45

Matrix of correlations Kanjirakklly ward Pre Monsoon 2007

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.3429	.20702	7
EC	22.8571	4.87950	7
Total_hard	17.1429	2.54484	7
calcium	3.3429	.95718	7
magnesium	2.1429	.54729	7
Bicarbonates	22.8571	5.24177	7
Chloride	9.2857	1.38013	7
MPN	148.8571	171.03550	7
Fs	123.2857	156.60855	7

Correlations

		pH	EC	Total_hard	calcium	magnesium	Bicarbonates	Chloride	MPN	Fs
pH	Pearson Correlation	1	.024	.145	-.137	.349	.037	.767*	.068	-.293
	Sig. (2-tailed)	.	.960	.757	.770	.443	.937	.044	.885	.523
	N	7	7	7	7	7	7	7	7	7
EC	Pearson Correlation	.024	1	.364	.041	.321	.410	.106	.338	-.241
	Sig. (2-tailed)	.960	.	.422	.931	.483	.361	.821	.458	.602
	N	7	7	7	7	7	7	7	7	7
Total_hard	Pearson Correlation	.145	.364	1	.455	.414	.889**	-.014	.134	.304
	Sig. (2-tailed)	.757	.422	.	.304	.356	.007	.977	.774	.508
	N	7	7	7	7	7	7	7	7	7
calcium	Pearson Correlation	-.137	.041	.455	1	-.612	.457	-.692	.395	.254
	Sig. (2-tailed)	.770	.931	.304	.	.144	.303	.085	.381	.582
	N	7	7	7	7	7	7	7	7	7
magnesium	Pearson Correlation	.349	.321	.414	-.612	1	.287	.753	-.329	-.010
	Sig. (2-tailed)	.443	.483	.356	.144	.	.532	.051	.471	.984
	N	7	7	7	7	7	7	7	7	7
Bicarbonates	Pearson Correlation	.037	.410	.889**	.457	.287	1	-.086	.448	.448
	Sig. (2-tailed)	.937	.361	.007	.303	.532	.	.855	.313	.314
	N	7	7	7	7	7	7	7	7	7
Chloride	Pearson Correlation	.767*	.106	-.014	-.692	.753	-.086	1	-.241	-.199
	Sig. (2-tailed)	.044	.821	.977	.085	.051	.855	.	.603	.669
	N	7	7	7	7	7	7	7	7	7
MPN	Pearson Correlation	.068	.338	.134	.395	-.329	.448	-.241	1	-.183
	Sig. (2-tailed)	.885	.458	.774	.381	.471	.313	.603	.	.695
	N	7	7	7	7	7	7	7	7	7
Fs	Pearson Correlation	-.293	-.241	.304	.254	-.010	.448	-.199	-.183	1
	Sig. (2-tailed)	.523	.602	.508	.582	.984	.314	.669	.695	.
	N	7	7	7	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.46

Matrix of correlations Kanjirakklly ward Monsoon 2007

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.4571	.25071	7
EC	42.8571	23.60387	7
Total_hard	10.5714	4.61364	7
calcium	3.7143	.75593	7
magnesium	.7714	.46085	7
Bicarbonates	8.1000	2.69011	7
Chloride	8.5714	1.98806	7
MPN	17.5714	6.45128	7
Fs	108.1429	158.50282	7

Correlations

		pH	EC	Total_hard	calcium	magnesium	Bicarbonates	Chloride	MPN	Fs
pH	Pearson Correlation	1	.700	-.566	-.251	-.214	.294	.225	.244	.772*
	Sig. (2-tailed)	.	.080	.185	.587	.644	.522	.628	.597	.042
	N	7	7	7	7	7	7	7	7	7
EC	Pearson Correlation	.700	1	-.446	.240	.085	.449	.457	.239	.896**
	Sig. (2-tailed)	.080	.	.316	.604	.856	.312	.303	.605	.006
	N	7	7	7	7	7	7	7	7	7
Total_hard	Pearson Correlation	-.566	-.446	1	-.041	.464	-.396	-.151	-.550	-.616
	Sig. (2-tailed)	.185	.316	.	.931	.295	.379	.747	.200	.140
	N	7	7	7	7	7	7	7	7	7
calcium	Pearson Correlation	-.251	.240	-.041	1	-.314	.615	.570	.039	.305
	Sig. (2-tailed)	.587	.604	.931	.	.492	.142	.181	.934	.506
	N	7	7	7	7	7	7	7	7	7
magnesium	Pearson Correlation	-.214	.085	.464	-.314	1	-.612	-.270	-.324	-.104
	Sig. (2-tailed)	.644	.856	.295	.492	.	.144	.558	.478	.824
	N	7	7	7	7	7	7	7	7	7
Bicarbonates	Pearson Correlation	.294	.449	-.396	.615	-.612	1	.901**	.686	.486
	Sig. (2-tailed)	.522	.312	.379	.142	.144	.	.006	.089	.269
	N	7	7	7	7	7	7	7	7	7
Chloride	Pearson Correlation	.225	.457	-.151	.570	-.270	.901**	1	.646	.476
	Sig. (2-tailed)	.628	.303	.747	.181	.558	.006	.	.117	.281
	N	7	7	7	7	7	7	7	7	7
MPN	Pearson Correlation	.244	.239	-.550	.039	-.324	.686	.646	1	.240
	Sig. (2-tailed)	.597	.605	.200	.934	.478	.089	.117	.	.605
	N	7	7	7	7	7	7	7	7	7
Fs	Pearson Correlation	.772*	.896**	-.616	.305	-.104	.486	.476	.240	1
	Sig. (2-tailed)	.042	.006	.140	.506	.824	.269	.281	.605	.
	N	7	7	7	7	7	7	7	7	7

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.47

Matrix of correlations Kanjirakklly ward Post Monsoon 2007

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.9125	.17269	8
Total_hard	8.3750	7.15017	8
alkalinity	14.5000	4.27618	8
calcium	3.6250	.51755	8
magnesium	1.0750	1.13358	8
Chloride	14.9125	5.59373	8
MPN	11.5000	8.29802	8
streptococci	20.0000	11.69860	8

Correlations

		pH	Total_hard	alkalinity	calcium	magnesium	Chloride	MPN	streptococci
pH	Pearson Correlation	1	.377	-.861**	.220	-.064	-.581	-.633	.354
	Sig. (2-tailed)	.	.357	.006	.601	.881	.131	.092	.390
	N	8	8	8	8	8	8	8	8
Total_hard	Pearson Correlation	.377	1	-.171	.236	.715*	-.329	-.413	-.041
	Sig. (2-tailed)	.357	.	.686	.573	.046	.427	.309	.923
	N	8	8	8	8	8	8	8	8
alkalinity	Pearson Correlation	-.861**	-.171	1	-.161	.295	.287	.318	-.380
	Sig. (2-tailed)	.006	.686	.	.703	.479	.491	.443	.353
	N	8	8	8	8	8	8	8	8
calcium	Pearson Correlation	.220	.236	-.161	1	.444	.219	-.216	.118
	Sig. (2-tailed)	.601	.573	.703	.	.270	.602	.607	.781
	N	8	8	8	8	8	8	8	8
magnesium	Pearson Correlation	-.064	.715*	.295	.444	1	-.219	-.286	.159
	Sig. (2-tailed)	.881	.046	.479	.270	.	.602	.493	.706
	N	8	8	8	8	8	8	8	8
Chloride	Pearson Correlation	-.581	-.329	.287	.219	-.219	1	.693	-.424
	Sig. (2-tailed)	.131	.427	.491	.602	.602	.	.057	.295
	N	8	8	8	8	8	8	8	8
MPN	Pearson Correlation	-.633	-.413	.318	-.216	-.286	.693	1	.040
	Sig. (2-tailed)	.092	.309	.443	.607	.493	.057	.	.926
	N	8	8	8	8	8	8	8	8
streptococci	Pearson Correlation	.354	-.041	-.380	.118	.159	-.424	.040	1
	Sig. (2-tailed)	.390	.923	.353	.781	.706	.295	.926	.
	N	8	8	8	8	8	8	8	8

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.48

Matrix of correlations Vanchiyam ward Pre Monsoon 2007

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.6500	.37140	18
Ec	42.2222	25.79456	18
Total_hard	11.0000	3.44708	18
calcium	5.0000	1.53393	18
Magnesium	1.2889	.76994	18
Alkalinity	8.1667	3.94447	18
Chloride	7.6667	3.71008	18
MPN	864.5000	1028.67140	18
Fs	148.3889	258.53664	18

Correlations

		pH	Ec	Total_hard	calcium	Magnesium	Alkalinity	Chloride	MPN	Fs
pH	Pearson Correlation	1	.577*	.469*	-.609**	.150	-.327	.081	.505*	-.241
	Sig. (2-tailed)	.	.012	.050	.007	.552	.185	.749	.033	.334
	N	18	18	18	18	18	18	18	18	18
Ec	Pearson Correlation	.577*	1	.152	-.446	.155	-.021	.113	.396	-.082
	Sig. (2-tailed)	.012	.	.547	.064	.538	.933	.656	.104	.747
	N	18	18	18	18	18	18	18	18	18
Total_hard	Pearson Correlation	.469*	.152	1	-.300	.035	.009	-.129	.550*	-.055
	Sig. (2-tailed)	.050	.547	.	.226	.889	.973	.611	.018	.830
	N	18	18	18	18	18	18	18	18	18
calcium	Pearson Correlation	-.609**	-.446	-.300	1	.224	.389	-.021	-.131	.224
	Sig. (2-tailed)	.007	.064	.226	.	.371	.111	.935	.603	.372
	N	18	18	18	18	18	18	18	18	18
Magnesium	Pearson Correlation	.150	.155	.035	.224	1	-.075	-.102	-.067	.197
	Sig. (2-tailed)	.552	.538	.889	.371	.	.768	.686	.793	.433
	N	18	18	18	18	18	18	18	18	18
Alkalinity	Pearson Correlation	-.327	-.021	.009	.389	-.075	1	-.346	.267	.131
	Sig. (2-tailed)	.185	.933	.973	.111	.768	.	.160	.284	.605
	N	18	18	18	18	18	18	18	18	18
Chloride	Pearson Correlation	.081	.113	-.129	-.021	-.102	-.346	1	-.260	-.168
	Sig. (2-tailed)	.749	.656	.611	.935	.686	.160	.	.298	.506
	N	18	18	18	18	18	18	18	18	18
MPN	Pearson Correlation	.505*	.396	.550*	-.131	-.067	.267	-.260	1	-.209
	Sig. (2-tailed)	.033	.104	.018	.603	.793	.284	.298	.	.406
	N	18	18	18	18	18	18	18	18	18
Fs	Pearson Correlation	-.241	-.082	-.055	.224	.197	.131	-.168	-.209	1
	Sig. (2-tailed)	.334	.747	.830	.372	.433	.605	.506	.406	.
	N	18	18	18	18	18	18	18	18	18

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.49

Matrix of correlations Vanchiyam ward Monsoon 2007

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.2000	.26926	17
Ec	24.7059	11.24591	17
Total_hard	21.0000	8.73928	17
calcium	2.9647	1.03013	17
Magnesium	3.3353	2.01834	17
Alkalinity	24.2353	9.69877	17
Chloride	9.3529	1.96663	17
MPN	904.5882	926.38080	17
Fs	452.7647	637.91021	17

Correlations

		pH	Ec	Total_hard	calcium	Magnesium	Alkalinity	Chloride	MPN	Fs
pH	Pearson Correlation	1	.826**	.863**	.162	.621**	.613**	-.094	.283	.123
	Sig. (2-tailed)	.	.000	.000	.534	.008	.009	.718	.272	.639
	N	17	17	17	17	17	17	17	17	17
Ec	Pearson Correlation	.826**	1	.916**	.037	.824**	.740**	-.249	.355	.100
	Sig. (2-tailed)	.000	.	.000	.888	.000	.001	.334	.162	.703
	N	17	17	17	17	17	17	17	17	17
Total_hard	Pearson Correlation	.863**	.916**	1	.114	.820**	.802**	-.244	.247	.149
	Sig. (2-tailed)	.000	.000	.	.663	.000	.000	.346	.339	.568
	N	17	17	17	17	17	17	17	17	17
calcium	Pearson Correlation	.162	.037	.114	1	.034	-.004	-.105	-.121	.112
	Sig. (2-tailed)	.534	.888	.663	.	.896	.987	.690	.643	.670
	N	17	17	17	17	17	17	17	17	17
Magnesium	Pearson Correlation	.621**	.824**	.820**	.034	1	.664**	.022	.578*	.033
	Sig. (2-tailed)	.008	.000	.000	.896	.	.004	.934	.015	.899
	N	17	17	17	17	17	17	17	17	17
Alkalinity	Pearson Correlation	.613**	.740**	.802**	-.004	.664**	1	-.129	.186	.142
	Sig. (2-tailed)	.009	.001	.000	.987	.004	.	.621	.475	.586
	N	17	17	17	17	17	17	17	17	17
Chloride	Pearson Correlation	-.094	-.249	-.244	-.105	.022	-.129	1	.364	-.356
	Sig. (2-tailed)	.718	.334	.346	.690	.934	.621	.	.151	.161
	N	17	17	17	17	17	17	17	17	17
MPN	Pearson Correlation	.283	.355	.247	-.121	.578*	.186	.364	1	.144
	Sig. (2-tailed)	.272	.162	.339	.643	.015	.475	.151	.	.582
	N	17	17	17	17	17	17	17	17	17
Fs	Pearson Correlation	.123	.100	.149	.112	.033	.142	-.356	.144	1
	Sig. (2-tailed)	.639	.703	.568	.670	.899	.586	.161	.582	.
	N	17	17	17	17	17	17	17	17	17

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.50

Matrix of correlations Vanchiyam ward Post Monsoon 2007

Descriptive Statistics

	Mean	Std. Deviation	N
pH	7.8444	.18222	18
Total_hard	17.2778	6.61376	18
Total_alk	23.7222	11.08155	18
calcium	6.3333	2.35147	18
magnesium	1.1328	1.00647	18
Chloride	17.3333	3.39550	18
MPN	16.5556	34.38745	18
Streptococci	8.1111	6.82460	18

Correlations

		pH	Total_hard	Total_alk	calcium	magnesium	Chloride	MPN	Streptococci
pH	Pearson Correlation	1	-.270	-.384	-.146	-.547*	.203	-.336	-.009
	Sig. (2-tailed)	.	.279	.116	.562	.019	.420	.173	.972
	N	18	18	18	18	18	18	18	18
Total_hard	Pearson Correlation	-.270	1	.793**	.501*	.452	-.159	.393	-.216
	Sig. (2-tailed)	.279	.	.000	.034	.059	.529	.107	.390
	N	18	18	18	18	18	18	18	18
Total_alk	Pearson Correlation	-.384	.793**	1	.539*	.429	-.101	.198	-.280
	Sig. (2-tailed)	.116	.000	.	.021	.076	.691	.431	.261
	N	18	18	18	18	18	18	18	18
calcium	Pearson Correlation	-.146	.501*	.539*	1	.369	-.059	-.079	-.475*
	Sig. (2-tailed)	.562	.034	.021	.	.132	.816	.756	.046
	N	18	18	18	18	18	18	18	18
magnesium	Pearson Correlation	-.547*	.452	.429	.369	1	.127	.511*	-.131
	Sig. (2-tailed)	.019	.059	.076	.132	.	.614	.030	.604
	N	18	18	18	18	18	18	18	18
Chloride	Pearson Correlation	.203	-.159	-.101	-.059	.127	1	.120	.486*
	Sig. (2-tailed)	.420	.529	.691	.816	.614	.	.635	.041
	N	18	18	18	18	18	18	18	18
MPN	Pearson Correlation	-.336	.393	.198	-.079	.511*	.120	1	.085
	Sig. (2-tailed)	.173	.107	.431	.756	.030	.635	.	.737
	N	18	18	18	18	18	18	18	18
Streptococci	Pearson Correlation	-.009	-.216	-.280	-.475*	-.131	.486*	.085	1
	Sig. (2-tailed)	.972	.390	.261	.046	.604	.041	.737	.
	N	18	18	18	18	18	18	18	18

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

CHAPTER V
WATER QUALITY INDEX

Introduction

Water is essential for the survival of any form of life. Ground water is a replenishable resource and is considered to be the least polluted as compared to other inland water resources.

Environmental monitoring in many countries over the last few years has produced large amount of data on many aspects of pollution of natural water.

One of the effective ways of communicating the available knowledge of the quality of water is to use certain indices which can be easily computed mathematically. The water quality index allows comparison of quality status of two or more water bodies from different localities and also help to evaluate pollution control programme.

The Central Board for the prevention and control of water pollution in India has suggested the use of 52 parameters in monitoring pollution in a water body. Since the use of such a large number of parameter is a difficult task, only few parameters which are relevant to that particular type of aquatic system are usually incorporated into the water quality index. WQI is defined as a rating reflecting the composite influence of different water quality parameters on the overall quality of water. Quality analysis of water gives an idea of its physical and chemical composition represented by some numerical value. Though distortion can occur from combining various environmental parameters into one single value of index score and there can be loss of information on a single variable, WQI is regarded as one of the most effective ways to communicate water quality. The highest score a body of water can receive is 100. In the present work the water quality index has been calculated from the point of view of the suitability of surface and ground waters for human consumption (Water quality centre for environmental studies, 2001).

The quality rating qi corresponding to the individual parameters (V_i) in the polluted water with respect to its standard or permissible value (S_i) has been calculated as follows.

$$q_i W_i = (V_i/S_i)\, W_i \times 100 \text{ except for pH and MPN.}$$

1. For MPN, q_{MPN} is as follows

$$q_{MPN}\left(\frac{\log 10\ V_{MPN} + 1}{\log 10\ S_{MPN} + 1}\right)100$$

Where q_{MPN} = quality rating for the most probable number of coliforms

V_{MPN} = Expected value for most probable no. of coliforms

S = standard value for most probable no. of coliforms

= 1 per 100ml.

2. For pH, q_pH is as follows.

$$qpH = 100\ [(VpH-7.00)/(8.5-7.0)]$$

$$W\ Q\ I = (\varepsilon q_i w_i / \varepsilon w_i)$$

Permissible value for WQI is 100, according to this method

RESULTS AND DISCUSSION

7.1 Kozhikode Corporation Area

The results are given in tables 5.1 to 5.4. Water with a value of WQI below 100 is suitable for human use. In the present study, generally for a higher percentage of wells, except bore well, the WQI values are found to be greater than 100. All these are found to have consistently higher bacteriological load especially coliforms. So they were not found suitable for human use. (Premonsoon 1999, Monsoon 2000, Post Monsoon 2000, Premonsoon 2000) The WQI for well No.10 was found to be below 100, but the iron content was very high and so not potable.

Table 5.1

Water Quality Index (WQI) of study places in Calicut corporation area during Pre Monsoon 1999

Parameter	ICMR std(S1)	Unit Wt(W)	1	2	4	5	6	7	8	9	10	11	12	13	14
pH	7-8.5	0.004	0	0.0533	0.1066	0.16	0.053333	0	0.106667	0	0	0	0	0	0
Total solids	500	0.002	0.0456	0.0844	0.224	0.1624	0.1	0.084	0.0568	0.144	0.5664	0.116	0.072	0.1776	0.152
Total hardness	300	0.0033	0.0704	0.0946	0.297	0.1914	0.1848	0.1298	0.099	0.1606	0.187	0.0902	0.077	0.1364	0.1364
Total alkalinity	120	0.0083	0.3181	0.3040	2.1995	1.383333	0.162	0.677833	0.553333	0.899167	0.276667	0.179833	0.083	0.0415	0.1265
Chloride	250	0.004	0.0416	0.0640	0.2144	0.144	0.0672	0.0576	0.0448	0.1024	0.336	0.08	0.0192	0.192	0.1024
Nitrate	20	0.05	0	0.075	0.125	0	0	0.025	0	0	0	0	0	0.2	0.075
MPN	1 per	0.1	36.6275	40.4139	26.33468	23.61728	40.41393	33.80211	40.41393	40.41393	13.0103	40.41393	40.41393	29.68483	33.80211
qiwi			37.1033	41.0895	29.50125	25.65841	41.98126	34.77635	41.27453	41.27453	14.37637	40.87996	40.66513	30.43233	34.39241
wi		0.1716													
WQI			216.2	239.4	171.9187	149.5245	244.646	202.6594	240.5275	243.1241	83.77836	238.2282	236.9763	177.3446	200.422

Table 5.2

Water Quality Index (WQI) of study places in Calicut corporation area during Pre Monsoon 2000

Parameter	ICMR std(S1)	Unit Wt(W)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pH	7-8.5	0.004	0.106667	0.16	0	0.16	0.16	0.16	0	0	0.16	0	0.16	0	0	0.16
Total solids	500	0.002	0.084	0.122	0.156	0.188	0.2	0.176	0.08	0116	0.196	0.358	0.28	0.08	0.12	0.09
Total hardness	300	0.0033	0.0594	0.1122	0.1716	0.2134	0.2002	0.165	0.0484	0.1056	0.1716	0.198	0.2156	0.0924	0.0924	0.121
Total alkalinity	120	0.0083	0.262833	0.332	0.055333	1.397167	1.466333	0.051333	0.262833	0.193667	0.926833	0	0.484167	0.110667	0.179833	0.650167
Chloride	250	0.004	0.0512	0.048	0.208	0.1056	0.1312	0.0544	0.0192	0.0544	0.1088	0.2624	0.1376	0.0672	0.0672	0.0576
Nitrate	20	0.05	0	0	1	0	0	0	0	0.5	0.75	0	0	0	0	0
MPN	1 per	0.1	36.62758	26.68483	13.0103	26.33468	36.62758	40.41393	40.41393	33.80211	40.41393	13.0103	26.33468	40.41393	26.33468	13.0103
qiwi			37.19168	30.45903	14.60123	28.39885	38.78531	42.02066	40.82436	34.77178	42.72716	13.8287	27.61205	40.76419	26.79412	14.08907
wi		0.1716														
WQI			216.7347	177.5002	80.08877	165.4945	226.0216	244.8756	237.9042	202.6327	248.9928	80.58683	160.9094	237.5536	156.1429	82.10412

Table 5.3

Water Quality Index (WQI) of study places in Calicut corporation area Monsoon 2000

Parameter	ICMR std(S1)	Unit Wt(W)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pH	7-8.5	0.004	0	0	0	0.16	0.16	0.106667	0	0.106667	0.106667	0	0	0	0	0.053333
Total solids	500	0.002	0.0376	0.68	0.0772	0.1888	0.152	0.156	0.102	0.072	0.1284	0.2708	0.1148	0.0736	0.1744	0.156
Total hardness	300	0.0033	0.0418	0.1056	0.1012	0.3014	0.2112	0.2442	0.1694	0.1122	0.2134	0.242	0.1034	0.0748	0.143	0.143
Total alkalinity	120	0.0083	0.166	0.246	0.401167	1.66	1.340833	1.424833	0.774667	0.6225	1.051333	0.428833	0.166	0.096833	0.06225	0.387333
Chloride	250	0.004	0.0416	0.048	0.0448	0.1056	0.1184	0.0832	0.0544	0.0512	0.0736	0.208	0.0544	0.0576	0.1792	0.08
Nitrate	20	0.05	0	0	0	0	0.05	0	0	0.05	0	0	0	0	0.3	0.125
MPN	1 per	0.1	36.62758	40.41393	40.41393	40.41393	33.80211	36.62758	40.41393	40.41393	36.62758	13.0103	40.41393	26.33468	40.41393	13.0103
qiwi			36.91458	40.88453	40.88453	42.82973	35.83555	38.64248	41.51439	41.42849	38.20098	14.15993	40.85253	26.63752	41.27278	13.95497
wi		0.1716														
WQI			215.1199	238.2548	239.1509	249.5905	208.8319	225.1893	241.9254	241.4248	222.6164	82.51709	238.0683	155.2303	240.5173	81.32265

Table 5.4

Water quality status of wells of Calicut corporation area Post Monsoon 2000

Parameter	ICMR std(S1)	Unit Wt(W)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pH	7-8.5	0.004	0.106667	0.16	0	0.16	0.16	0.16	0	0	0.16	0	0.16	0	0	0.16
Total solids	500	0.002	0.084	0.122	0.156	0.188	0.2	0.176	0.08	0116	0.196	0.358	0.28	0.08	0.12	0.09
Total hardness	300	0.0033	0.0594	0.1122	0.1716	0.2134	0.2002	0.165	0.0484	0.1056	0.1716	0.198	0.2156	0.0924	0.0924	0.121
Total alkalinity	120	0.0083	0.262833	0.332	0.055333	1.397167	1.466333	0.051333	0.262833	0.193667	0.926833	0	0.484167	0.110667	0.179833	0.650167
Chloride	250	0.004	0.0512	0.048	0.208	0.1056	0.1312	0.0544	0.0192	0.0544	0.1088	0.2624	0.1376	0.0672	0.0672	0.0576
Nitrate	20	0.05	0	0	1	0	0	0	0	0.5	0.75	0	0	0	0	0
MPN	1 per	0.1	36.62758	26.68483	13.0103	26.33468	36.62758	40.41393	40.41393	33.80211	40.41393	13.0103	26.33468	40.41393	26.33468	13.0103
qiwi			37.19168	30.45903	14.60123	28.39885	38.78531	42.02066	40.82436	34.77178	42.72716	13.8287	27.61205	40.76419	26.79412	14.08907
wi		0.1716														
WQI			216.7347	177.5002	80.08877	165.4945	226.0216	244.8756	237.9042	202.6327	248.9928	80.58683	160.9094	237.5536	156.1429	82.10412

All these wells except the bore well were treated with aquatic organisms, plants, etc. in the year 2001 and 2004 and parameters were measured. The results are given in Table 5.5. Details of materials used for the treatment are given in table 5.6 for the year 2001. During 2004, Stychnos potatorum has been employed for treatment. There was appreciable improvement in WQI in 2001 as shown in Table 5.7. The result of 2004 showed that the water quality was still improved.

Table 5.5

Water Quality Index (WQI) of study places in Calicut corporation area After Treatment 2001

Paramet er	ICMR std(S 1)	Unit Wt(W)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pH	7-8.5	0.004	0	0	0.16	0.2133 33	0.16	0.16	0.16	0.16	0.16	0	0.16	0	0	0.16
Total solids	500	0.002	0.032	0.07	0.076	0.128	0.152	0.108	0.092	0.084	0.16	0.192	0.096	0.064	0.14	0.064
Total hardnes s	300	0.003 3	0.0396	0.0946	0.1144	0.2398	0.231	0.1892	0.1584	0.1254	0.2244	0.1936	0.264	0.0792	0.1518	0.1848
Total alkalinity	120	0.008 3	0.2213 33	0.415	0.5671 67	1.5078 33	1.7845	1.5931 67	0.8438 33	0.6225	1.3141 67	0.9683 33	0.4141 67	0.1383 33	0.3873 33	0.2213 33
Chloride	250	0.004	0.0384	0.0608	0.064	0.1152	0.0096	0.0736	0.064	0.0768	0.0992	0.2496	0.0512	0.0608	0.1696	0.0864
Nitrate	20	0.05	0	0	0	0	0	0	0	0	0	0	0	0	5	0
MPN	1 per	0.1	13.010 3	40.413 93	13.010 3	13.010 3	16.020 6	13.010 3	21.760 91	13.010 3	40.413 93	13.010 3	33.802 11	13.010 3	26.334 68	13.010 3
qiwi			13.341 64	40.054 33	13.991 87	15.214 47	18.357 7	15.104 27	23.079 15	14.079	42.371 69	14.613 83	34.857 48	13.352 63	32.183 42	13.726 83
wi		0.171 6														
WQI			77.748 45	239.24 43	81.537 68	88.662 39	106.97 96	88.020 2	134.49 39	82.045 45	246.92 13	85.162 2	203.13 22	77.812 55	187.54 91	79.993 2

Table 5.6

Water Quality Index (WQI) of study places in Calicut corporation area After Treatment 2004

Sl.No.	Well No.	Materials used for treat ment	Before pH	Treatment Total Solids (ppm)	Hardness (ppm)	Chloride (ppm)	Iron (ppm)	MPN	Wqi	After pH	Treatment Total Solids (ppm)	Hardness (ppm)	Chloride (ppm)	Iron (ppm)	MPN	Wqi
1	1	Strychnos Potatorum	7.4	210	54	32	0.2	Nil	216.7	7.0	80	36	24	T	Nil	77.75
2	2	Lagenandra	7.6	305	102	30	T	93	177.5	7.0	166	86	38	T	1100	239.2
3	3	Strychnos Potatorum & Gupplies	6.3	390	156	130	T	Nil	85.1	7.6	100	104	72	T	Nil	81.5
4	4	Lagenandra Carp, Gold fish, etc	7.6	470	194	66	0.1	Nil	165.5	7.8	320	218	72	T	Nil	88.7
5	5	Lagenandra Tilapia present	7.6	500	182	82	T	400	226.6	7.6	380	210	96	T		106.98
6	6	Lagenandra + Cyprinus Crap	7.6	440	150	34	0.3	1100	244.9	7.6	270	172	46	0.4	Nil	88.0
7	7	Lagenandra	7.0	200	44	12	T	1100	237.9	7.6	230	144	40	ND		134.5
8	8	Lagenandra + Cyprinus Carp	7.6	60	290	90	34	240	202.6	7.6	300	210	114	48	Nil	82.0
9	9	Lagenandra	7.6	490	156	68	T	1100	249.0	7.6	40	204	62	Nil	1100	246.92
10	10	Strychnus Potatorum	4.0	895	180	164	20	Nil	80.6	5.0	480	176	156	80	Nil	85.16
11	11	Lagenandra	7.6	700	196	86	0.4	43	160.9	7.6	240	240	32	0.1	240	203.13
12	12	Cyprinus Carp Lagenandra present	7.0	300	84	42	0.1	1100	237.6	6.8	160	72	38	ND	ND	77.81
13	13	Strychnos Potatorum	7.0	300	84	42	0.1	443	156.1	6.0	250	138	50	T	43	187.55
14	14	Bore well No.	7.6	225	116	36	0.1	Nil	82.1	7.6	350	168	106	T	Nil	79.9

		Treatment done														9

Table 5.7

Water Quality Index (WQI) of study places in Calicut corporation area After Treatment 2004

Parameter	ICMR std(S1)	Unit Wt(W)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pH	7-8.5	0.004	0.026667	0	0	0	0.053333	0.133333	0	0.106667	0.16	0.16	0	0	0	0
Total solids	500	0.002	0.028	0.0196	0.0528	0.2024	0.072	0.16	0.1232	0.1	0.16	0.3848	0.121	0.076	0.1936	0.08
Total hardness	300	0.0033	0.0385	0.0528	0.0616	0.132	0.0616	0.187	0.165	0.121	0.22	0.264	0.123	0.077	0.1452	0.176
Total alkalinity	120	0.0083	0.2075	0.1245	0.193667	0.069167	0.747	0.83	0.345833	0.553333	1.175833	1.4525	0.345833	0.1245	0.525667	0.2075
Chloride	250	0.004	0.032	0.0608	0.0928	0.192	0.4032	0.064	0.2016	0.064	0.08	0.24	0.0704	0.056	0.0288	0.08
Nitrate	20	0.05	0	0.88	0	0	0	0	0.88	0	0	1.98	3.96	0	9.9	0
MPN	1 per	0.1	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103	13.0103
Eqiwi			13.34297	14.148	13.41117	13.60587	14.34743	14.38463	14.72593	13.9553	14.80613	17.4916	17.63953	13.3438	32.80357	13.5538
Ewi		0.1716														
WQI			77.75622	82.44755	78.15365	79.28827	83.60975	83.82653	85.81546	81.32459	86.28283	101.9324	102.7945	77.76107	138.7154	78.98485

Well No. 1: Kallittanada, Near Mims hospital

The water quality index was found to be 216.2 during pre monsoon 1999; 215.1 during monsoon 2000; 238.9 during post monsoon 2000; 216.7 during pre Monsoon 2000; 77.75 during 2001 after treatment using strychnos potatorum77.1 during 2004 after treatment using strychos potatorum. The water quality has been improved during 2001and2004 after treatment using strychnos potatorum.

Well No. 2: Puthiyara, Near Subjail, Kozhikode

The value of water quality index was found to be 239.4 during 1999pre monsoon, 238.25 during monsoon 2000; 239.2 during post monsoon 2000; 177.5 during pre monsoon 2000; 239.2 during 2001 after treatment with Lagennandra;- 239.2 during 2004 after treatment with Strychnos potatorum. The results show that Lagenandra cannot be employed for this well because the area is low lying and during monsoon, the plant was found to be decayed due to the presence of pollutants entering the well. The plant can be employed in the case of moderate pollution only.

Well No. 3: Puthiyara, Near Sub Jail, Kozhikode

The water quality index was found to be 239.2 during monsoon 2000; 158.3 during post monsoon 2000; 85.1 during pre monsoon 2000; 81.5 during 2001 after treatment with Strychnos potatoum and; 78.1 during 2004 after treatment using Strychnos potatoum. This well is near the jail road. The wastewater from the jail pollutes the well. The jail authorities are allowing the wastewater to flow out during alternate days only due to public complaint. After treatment there was improvement in the quality.

Well No. 4: Near Muthalakkulam

The WQI was found to be 171.9 during pre monsoon 1999; 249.6 during monsoon 2000, 202.9 during post monsoon 2000; 165.5 during premonsoon; 88.7 during 2001 after treatment with Lagenandra and fish, Cyprinus Carp.; 78.3 during 2004 after treatment with Strychnos potatorum.

The well water is contaminated due to leach pit and sewage. There was Gold fish and guppies present already in the well. After treatment, the quality has been improved.

Well No. 5: Near Coronation Theatre

The WQI was found to be 149.5 during 1999 pre monsoon; 208.8 during monsoon2000; 178.3 during post monsoon 2000; 226.0 during pre monsoon 2000; 107 during 2001 after treatment with Lagenandra; 83.6 during 2004 after treatment with Strychons potatorun. Fish Tilapia was present in the well. The house owner has put amala wood in the well earlier and the well is near the drainage canal. The quality has been found to be improved after treatment.

Well No. 6: Near Coronation Theatre

The WQI was found to be 202.7 during 1999 pre monsoon; 225.2during monsoon 2000; 86.5 during post monsoon 2000; 244.6 during pre monsoon 2000; 244.9 during 2001 after treatment with Lagenandra and Cyprinus carp; 83.8 during 2004 after treatment with Strychnos potatorum. The water quality is found to be improved.

Well No. 7: Near S.K. Temple

The WQI was found to be 202.7 during pre monsoon 1999; 241.9 during monsoon 2000; 203.9 a during post monsoon; 2000; 237.9 during pre monsoon 2000; 134.5 during 2001 after treatment with Lagenandra and 85.8 during 2004 after treatment with Srychnos potatorum. The water quality is found to be improved after treatment and obtained good results when Strychnos potatorum was used.

Well No. 8: Near S.K.Temple

The WQI was found to be 240.5 during pre monsoon 1999; 247.4 during monsoon 2000; 242.0 during post monsoon 2000; 202.6 during pre monsoon 2000; 82.0 during 2001 after treatment with Lagenandra and Cyprinus Carp and 81.3 during 2004 after treatment with Strychnos potatorum. The water quality has been found to be improved.

Well No. 9: Near KSRTC Bus Stand

The WQI was found to be 243.1 during pre monsoon 1999; 222.6 during monsoon 2000; 245.5 during post monsoon 2000; 248.95 during pre monsoon 2000; 246.98 during 2001 after treatment with Lagenandra and 86.2 during 2004 after treatment with Strychnos potatorun. Strychnos potatorum was found to be very effective.

Well No. 10: Jawahar Nagar Colony

WQI was found to be 83.8 during pre-monsoon 1999; 82.5 during monsoon 2000; 80.1 during post monsoon 2000; 80.6 during pre monsoon 2000; 85.1 during 2000 after treatment with Strychnos potatorum; and 101.9 after treatment with Strychns potatorum. Because of the high iron content, the water is not potable.

Well No. 11: St.Vincent Convent

WQI was found to be 238.2 during pre monsoon 1999; 238.1 during monsoon 2000; 237.5 during post monsoon 2000; 160.91 during pre monsoon 2000; 203.1 during 2001 after treatment with

Lagenandra and 102.8 during 2004 after treatment with Strychnos potatorum. The wastewater from the kitchen was passing near the well and the plastering of the drainage channel was broken in many places. There was a kitchen garden near the well. The waste water is leaching into the well. This may be the reason why there is no appreciable reduction in WQI after treatment.

Well No. 12: Near St. Vincent Convent.

WQI was found to be 236.98 during pre monsoon 1999; 155.2 during monsoon 2000; 215.4 during post monsoon 2000; 237.5; 77.8 during premonsoon 2000; 77.8 during 2001 after treatment with Cyprinus Carp and 77.8 during 2004 after treatment using Strychnos potatorum. Lagenandra was already present in the well. There was improvement in water quality.

Well No 13, Public well, Nadakkavu Konnenat Street

WQI was found to be 177.3 during pre monsoon 1999; 240.5 during monsoon 2000; 239 during post monsoon 2000; 166.1 during pre monsoon 2000; 187.5 during 2001 after treatment; and 138.7 during 2004 after treatment using Strychnos potatorum. There is a pond near the well. The well water tastes salty. Moreover, the well is few kilometers away from the sea.

Well No. 14: Borewell, Nadakkavu, Konnenat Street

WQI was found to be 200.4 during pre monsoon 1999; 81.3 during monsoon 2000; 78.2 during post monsoon 2000; 82.1 during pre monsoon 2000; 79.99 during 2001; and 78.9 during 2004. This is a bore well and no treatment has been done. Few families live in this street. The open well water is salty in this area.

In the present assessment of ground water of Calicut Corporation area, only seven prominent parameters which significantly alter the water quality are selected and their quality function are computed. The parameters are pH, chloride, alkalinity, total hardness, total dissolved salts, nitrate and MPN. The variation in Wq_i before and after treatment are given in Fig. 5.1.

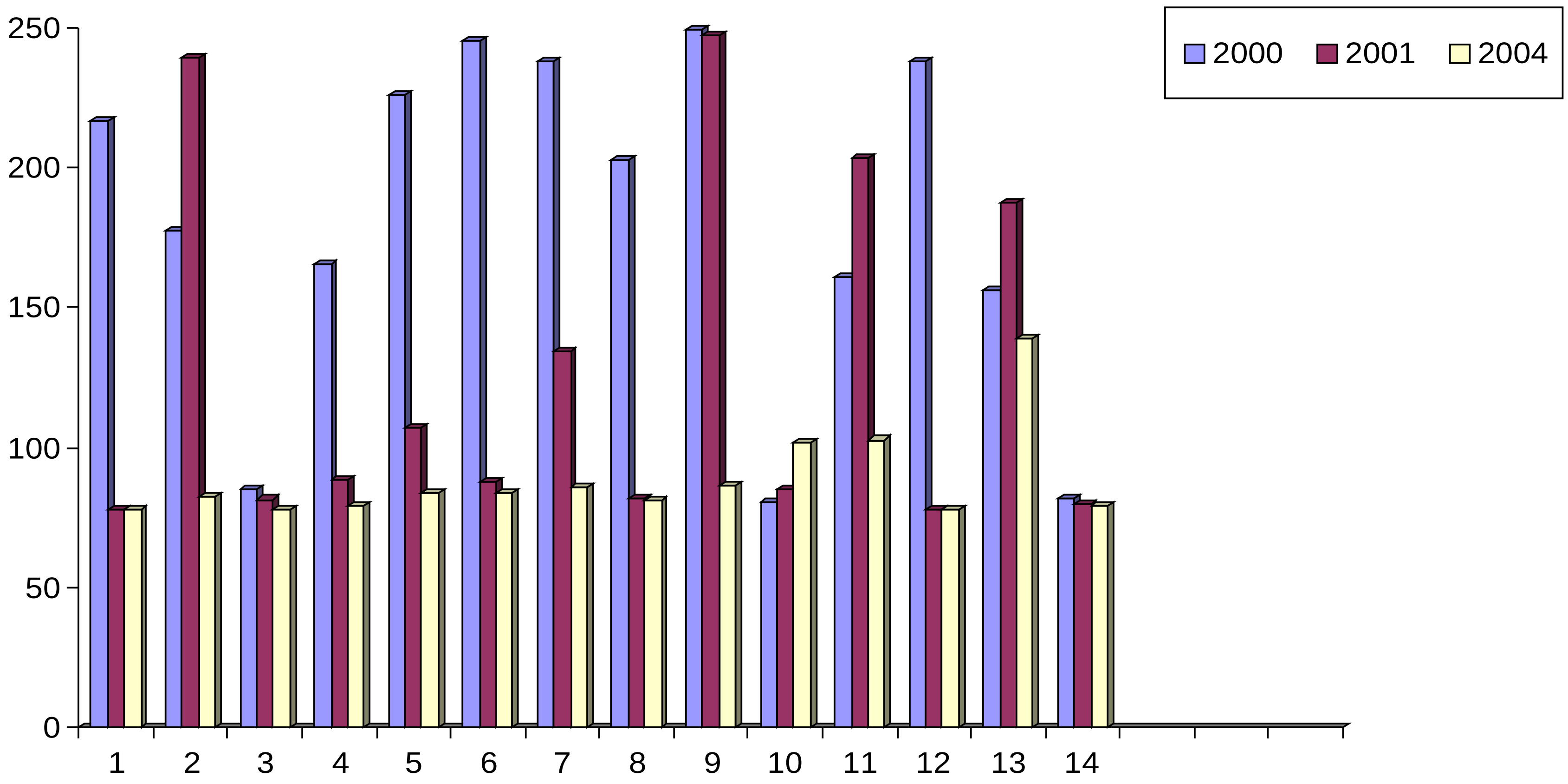


Figure 5.1: Variation of Water Quality Index for Calicut Corporation Area Before and After Treatment

It has been found that all the wells except the bore well had higher water quality index in all the seasons before treatment. After treatment, during 2001, the water quality was found to be improved. The WQI during 2004 shows that it is still improved when Strychnos potatorum has been used for treating all the wells. This shows that Strychnos potatorum can be successfully employed in such types of wells, whose hardness is high.

7.2 Kannur and Kasaragod districts

Details of the study of bacterial contamination of ground water in the selected wells of Kannur and Kasaragod districts are given in chapter IV. The results show that most of the well water are not potable. The water quality index of the samples are generally found to be above 100, showing that these samples are highly contaminated. The results are given in Tables 4.59 to 4.69. Elayavoor, Cheruthazham and Payyavoor Panchayats of Kannur district and Muliyar panchayat of Kasaragod district are selected for the study Water samples were collected during pre-monsoon monsoon and post monsoon seasons of the year and analysed to find its quality. The water quality index has been calculated and are shown in Tables 5.8 to Tables 5.19. The results show that all the samples are microbiologically contaminated. No treatment has been done in this area because it is a tedious work and it will need more time. The treatment can be carried out through panchayats.

Table 5.8

Water Quality Index (WQI) of study places in Kannur District Elayavoor Panchayat 2005 Monsoon

Parameter	ICMR std (SI)	Unit Wt (w)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P^H	7-8.5	0.004	0	0.053333	0.106667	0.213333	0.213333	0.24	0	0	0	0	0	0	0.213333	0.346667	0.613333	0.48
Turbidity	0.2	5	0.32	0.32	0.8	0.16	0.4	1.44	1.44	1.44	1.92	0.8	1.92	1.44	2.72	0.96	1.12	1.76
MPN	1 Per	0.1	40.41393	43.50211	33.22219	40.41393	40.41393	33.22219	40.41393	40.41393	43.80211	36.62758	43.80211	40.41393	33.22219	36.62758	40.41393	40.41393
qiwi			40.73393	44.17545	34.12886	40.78726	41.02726	34.90291	41.85393	41.85393	45.72211	37.42758	45.72211	41.85393	36.15553	37.93424	42.65393	42.65393
WQI			113.9932	145.314	112.266	124.1686	13.9581	114.8098	137.6774	137.6774	150.4017	123.117	150.4017	317.6774	118.9327	124.7837	140.309	140.309

Table 5.8 Contd...

Parameter	ICMR std (SI)	Unit Wt (w)	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
P^H	7-8.5	0.004	0.213333	0.373333	0.026667	-0.08	0.053333	0	0	0.133333	0.426667	0.24	0	0	0.16	0.4	0.16	0.282667
Turbidity	0.2	5	0	1.44	1.6	1.96	2.08	0.96	0.8	0.64	1.28	1.76	0.48	2.08	1.16	0	0.64	2.72
MPN	1 Per	0.1	48.75061	43.80211	36.62758	43.80211	43.80211	36.62758	33.80211	43.80211	36.62758	40.41393	43.80211	29.68483	40.41393	40.41393	33.22219	40.41393
qiwi			48.96395	45.61545	38.25424	44.68211	45.93545	37.58758	34.60211	44.57545	38.33424	42.41393	44.28211	31.76483	41.73393	40.81393	34.02219	43.41659
WQI			161.0656	150.0508	125.8363	146.9806	151.1034	123.6433	113.8227	146.6298	126.0995	139.5195	145.6648	104.4896	137.2827	134.2563	111.9151	142.8177

Table 5.9

Water Quality Index (WQI) of study places in Kannur District Elayavoor Panchayat Post Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P^H	7-8.5	0.004	0.08	0	0	0.373333	0	0.026667	0	0	0.026667	0.026667	0	0	0.026667	0.506667	0.48	0.133333
Turbidity	0.2	5	0.9684	0.8	0	0.48	0.16	0	0.32	0.48	0.8	2.56	0.16	0.8	1.76	7.04	4	1.16
MPN	1 Per	0.1	40.41393	46.0206	40.41393	23.61728	33.22219	31.76091	63.80211	36.62758	63.80211	36.62758	63.80211	63.80211	33.22219	31.76091	36.62758	63.80211
qiwi			41.46233	46.8206	40.14393	24.47061	33.38219	31.78758	64.12211	37.10758	64.62878	39.21424	63.96211	63.80211	35.00886	39.30758	41.10758	65.09545
WQI			136.3892	154.0151	132.9405	80.49543	109.8098	104.5644	210.928	122.0644	212.5947	128.9942	210.4017	212.5069	115.1607	129.3012	135.2223	214.1298

Table 5.9 Contd...

Parameter	ICMR std (SI)	Unit Wt (w)	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
P^H	7-8.5	0.004	0.16	0.133333	0.293333	0.453333	0	0.08	0.106667	0.053333	0	0.213333	0.026667	0	0.08	0.133333	0.106667	0.186667
Turbidity	0.2	5	0.48	0.6	0.32	1.16	0.48	4.16	0.32	0	0.48	0.96	0.32	0.32	0	0.64	0.48	1.28
MPN	1 Per	0.1	63.80211	60.41393	33.22219	26.33468	63.80211	40.41393	36.62758	63.80211	36.62758	33.80211	63.80211	63.80211	63.80211	33.22219	29.68483	29.68483
qiwi			64.44211	61.14726	33.83553	27.94802	64.28211	44.65393	37.05424	63.85545	37.10758	34.97545	64.14878	64.14878	63.88211	33.99553	30.2715	31.1515
WQI			211.9806	201.1423	111.3011	91.93427	211.4543	146.8879	121.889	210.0508	122.0644	115.0508	211.0157	211.0157	210.1385	111.8274	99.57729	102.472

Table 5.10

Water Quality Index (WQI) of study places in Kannur District Elayavoor Panchayat Pre-Monsoon 2006

Parameter	ICMR std (SI)	Unit Wt (w)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
P^H	7-8.5	0.004	0.16	0.213333	0.213333	0.266667	0.293333	0.32	0.16	0.16	0.186667	0.426667	0.426667	0.373333	0.373333	0.373333	0.4	0.266667
Turbidity	0.2	5	1.12	0.16	0	0.32	1.76	0	1.12	0	0.16	0.64	0.64	2056	0.8	2.4	3.36	2.08
MPN	1 Per	0.1	36.62758	48.75061	40.41393	40.41393	36.62758	36.62758	36.62758	40.41393	50.41393	43.80211	46.62758	40.41393	40.41393	33.80211	40.41393	51.76091
qiwi			37.90758	49.12395	40.62726	41.00059	38.68091	36.94758	37.90758	40.57393	50.76059	44.86878	47.69424	43.34726	41.58726	36.57545	44.17393	54.10758
WQI			124.696	161.5919	133.6423	134.8704	127.2398	121.5381	124.696	133.4669	166.9756	147.5947	156.889	142.5897	136.8002	120.314	145.309	177.9855

Table 5.10 Contd...

Parameter	ICMR std (SI)	Unit Wt (w)	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
P^H	7-8.5	0.004	0.373333	0.346667	0.32	0.613333	0.693333	0.186667	0.16	0.24	0.24	0.24	0.213333	0.133333	0.186667	0.186667	0.586667	0.48
Turbidity	0.2	5	0	24	08	2.4	0.64	0	0	0.8	0.48	1.12	0.16	0.16	0.48	0.32	0	0
MPN	1 Per	0.1	46.6275	40.4139	40.4139	36.6275	51.7609	43.8021	36.6275	43.8021	40.4139	40.4139	51.7609	53.8021	48.7506	40.4139	36.6275	40.41393

			8	3	3	8	1	1	8	1	3	3	1	1	1	3	8	
qiwi			47.00091	64.76059	41.53393	39.64091	53.09425	43.98878	36.78758	44.84211	41.13393	41.77393	52.13425	54.09545	49.41728	40.92059	37.21424	40.89393
WQI			154.6083	213.0283	136.6248	130.3977	174.6521	144.6999	121.0118	147.5069	135.309	137.4142	171.4942	177.9455	162.5568	134.6072	122.4153	134.5195

Table 5.11

Water Quality Index (WQI) of study places in Kannur District Cheruthazham Panchayat Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	C1	C2	C3	C4	C5	C6	C7	C8
P^H	7-8.5	0.004	0.16	0	0.293333	0.24	0.266667	0.186667	0.453333	0.293333
Turbidity	0.2	5	2.08	1.28	4	1.44	1.76	1.76	1	4
MPN	1 Per	0.1	50.41393	40.41393	60.41393	33.80211	43.80211	50.41393	46.62758	60.41393
qiwi			52.65393	41.69393	64.70726	35.48211	45.82878	52.36059	48.08091	64.70726
WQI			173.2037	137.1511	212.8528	116.7175	150.7526	172.2388	158.1609	212.8528

Table 5.12

Water Quality Index (WQI) of study places in Kannur District Cheruthazham Panchayat Post Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	C1	C2	C3	C4	C5	C6	C7	C8
P^H	7-8.5	0.004	0.293333	0.186667	0.426667	0.32	0.32	0.373333	0.56	0.506667
Turbidity	0.2	5	0.56	0.64	1.28	0.32	1.76	0.96	0	0.48
MPN	1 Per	0.1	60.41393	33.22219	60.41393	36.62758	40.41393	50.41393	51.76091	53.22219
qiwi			61.26726	34.04886	62.12059	37.26758	42.49393	51.74726	52.32091	54.20886
WQI			201.537	112.0028	204.3441	122.5907	139.7827	170.2213	172.1083	178.3186

Table 5.13

Water Quality Index (WQI) of study places in Kannur District Cheruthazham Panchayat Pre-Monsoon 2006

Parameter	**ICMR std (SI)**	**Unit Wt (w)**	**C1**	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**
P^H	7-8.5	0.004	0.373333	0.426667	0.346667	0.293333	0.426667	0.426667	0.453333	0.346667
Turbidity	0.2	5	0.16	0.96	0.64	0.64	0.8	1.6	0.96	2.72
MPN	1 Per	0.1	51.76091	63.62758	60.41393	40.41393	43.80211	46.62758	48.75061	50.41393
qiwi			52.29425	38.01424	61.40059	41.34726	45.02878	48.65424	50.16395	53.48059
WQI			172.0205	125.0469	201.9756	136.0107	148.121	160.0469	165.013	175.923

Table 5.14

Water Quality Index (WQI) of study places in Kannur District Payyavur Panchayat Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
P^H	7-8.5	0.004	0.293333	0.586667	0.24	0.266667	0.346667	0	0	0	0.4	0	0	0.346667	0.4	0.266667	0.293333
Turbidity	0.2	5	0.32	1.92	3.36	2.24	20.8	0.64	0.48	0.96	1.12	0.64	0.64	2.24	0.32	1.28	1.12
MPN	1 Per	0.1	40.41393	46.62758	40.41393	43.80211	43.80211	40.41393	43.80211	36.62758	40.41393	40.41393	36.62758	40.41393	33.22219	46.62758	33.80211
qiwi			41.02726	49.13424	44.03193	46.30878	46.22878	41.05393	44.28211	37.58758	41.93393	41.05393	37.26758	43.00059	33.94219	48.17424	35.21545
WQI			134.9581	161.6258	144.7827	152.3315	152.0684	135.0458	145.6648	123.6433	137.9405	135.0458	122.5907	141.4493	111.652	158.4679	115.8403

Table 5.15

Water Quality Index (WQI) of study places in Kannur District Payyavur Panchayat Post-Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
P^H	7-8.5	0.004	0.373333	0.346667	0.213333	0.266667	0.16	0.186667	0.133333	0.266667	0.32	0.426667	0.16	0.293333	0.346667	0.266667	0.24
Turbidity	0.2	5	1.44	3.36	2.72	1.6	1.76	0.96	1.12	0.96	0.96	3.4	1.92	1.92	0.96	0.96	1.28
MPN	1 Per	0.1	40.41393	40.41393	50.41393	43.80211	43.80211	46.62758	33.22219	40.41393	46.62758	31.76091	33.80211	30.79181	30.79181	41.46128	33.22219
qiwi			42.22726	44.12059	53.34726	45.66878	45.72211	47.77424	34.47553	41.64059	47.90758	35.58758	35.88211	33.00515	32.09848	42.68795	34.74219
WQI			138.9055	145.1335	175.4844	150.2262	150.4017	157.1521	113.4063	136.9756	157.5907	117.0644	118.0333	108.5696	105.5871	140.4209	114.2835

Table 5.16

Water Quality Index (WQI) of study places in Kannur District Payyavur Panchayat Pre-Monsoon 2006

Parameter	ICMR std (SI)	Unit Wt (w)	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14
P^H	7-8.5	0.004	0.48	0.613333	0.506667	0.32	0.373333	0.453333	0.373333	0.186667	0.506667	0.373333	0.426667	0.4	0.48	0.4
Turbidity	0.2	5	0.48	1.6	7.68	2.08	2.4	1.12	0.64	4.96	1.92	3.36	1.92	0.32	2.4	0
MPN	1 Per	0.1	40.41393	43.80211	48.75061	46.62758	40.41393	51.76091	46.62758	40.41393	40.41393	36.62758	36.62758	36.62758	46.62758	40.41393
qiwi			41.37393	46.01545	56.93728	49.02758	43.18726	53.33425	47.64091	45.56059	42.84059	40.36091	38.97424	37.34758	49.50758	40.81393
WQI			136.0984	151.3666	187.2937	161.2749	142.0634	175.4416	156.7135	149.8704	140.923	132.7662	128.2048	122.8539	162.8539	134.2563

Table 5.17

Water Quality Index (WQI) of study places in Kasraod District Muliyar Panchayat Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
P^H	7-8.5	0.004	0.16	0	0	0	0.16	0.426667	0	0	0.266667	0	0.293333	0.08	0	0
Turbidity	0.2	5	4.48	0	1.92	0.32	18.88	0.48	17.28	1.92	3.04	0.32	0.16	0.8	0.32	0
MPN	1 Per	0.1	40.41393	36.62758	40.41393	33.80211	50.41393	43.80211	48.75.61	48.75061	46.62758	48.75061	48.75061	33.80211	48.75061	46.62758
qiwi			45.05393	36.62758	42.33393	34.12211	69.45393	44.70878	66.03061	50.67061	49.93424	49.07061	49.20395	34.68211	49.07061	46.62758
WQI			148.2037	120.4855	139.2563	112.2438	228.4669	147.0684	217.206	166.6796	164.2574	161.4165	161.8551	114.0859	161.4165	153.3802

Table 5.18

Water Quality Index (WQI) of study places in Kasraod District Muliyar Panchayat Post-Monsoon 2005

Parameter	ICMR std (SI)	Unit Wt (w)	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
P^H	7-8.5	0.004	0.213333	0	0		0.026667	0.026667	0.053333	0	0.32	0	0.053333	0	0.346667	0
Turbidity	0.2	5	4.64	1.28	0.96		1.28	0.8	8.16	1.76	6.56	3.2	1.76	0.32	2.56	0.96
MPN	1 Per	0.1	53.80211	53.22219	53.80211		40.41393	33.22219	53.80211	51.76091	56.62758	43.80211	33.22219	30.79181	60.41393	53.22219
qiwi			58.65545	54.50219	54.76211		41.72059	34.04886	62.01545	53.52091	63.50758	47.00211	35.03553	31.11181	63.32059	54.18219
WQI			192.9455	179.2835	180.1385		137.2388	112.0028	203.9982	176.0556	208.9065	154.6122	115.2484	102.3415	208.2914	178.2309

Table 5.19

Water Quality Index (WQI) of study places in Kasraod District Muliyar Panchayat Pre-Monsoon 2006

Parameter	ICMR std (SI)	Unit Wt (w)	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14
P^H	7-8.5	0.004	0.746667	0.453333	0.4	0.48	0.16	0.373333	0.693333	0.64	0.746667	0.56		0.613333	0.56	0.613333
Turbidity	0.2	5	13.12	7.84	2.72	0.48	1.44	0.96	1.28	8.8	2056	2.4		1.44	5.6	1.28
MPN	1 Per	0.1	40.41393	46.62758	43.80211	40	40.41393	40.41393	46.62758	46.0206	40.41393	48.75061		40.41393	48.75061	43.80211
qiwi			54.28059	54.92091	46.92211	40.96	42.10393	41.74726	48.60091	55.4606	43.72059	51.71061		42.46726	54.91061	45.69545
WQI			178.5546	180.6609	154.3491	134.7368	138.2037	137.3265	159.8714	182.4362	143.8177	170.1007	0	139.6949	180.627	150.314

7.3 Tribal area of Kannur District

Payyavoor panchayat has been selected for the study, Kanjirakkolly and Vanchiyam are two wards of the panchayat where there is water scarcity and there is tribal colony. The details are given in chapter IV. The water quality index has been calculated for the 26 samples of wells and olys for the three seasons. The results are shown in Table 5.20 to 5.25. The results show that all the samples have WQI higher than 100, which shows contamination of the samples. The concentration of dissolved ions is very low (very soft water), but microbial contamination is high. All the wells need treatment. The treatment of the samples has been conducted during 2008 pre monsoon season and the results are shown in chapter IV. The results show that there is a considerable reduction in the bacterial concentration and increase in hardness after treatment using a mixture consisting of Gooseberry, Muthanga, Ramacham, Strychnos potatorum, Kudangal and Amaranthus grain. Because the dissolved constituents are very low, this mixture is very effective in such types of waters rather than Strychnos potatorum because it removes dissolved constituents. Hence it is concluded that Srychnos potatorum can be used for hard waters and the above mixture can be used for soft waters.

Table 5.20

Water Quality Index (WQI) of study places in Kannur District Tribal area (Kanjirakkolly) Pre-Monsoon 2007

Parameter	ICMR std (SI)	Unit Wt (w)	K1	K2	K3	K4	K5	K6	K7
P^H	7-8.5	0.004	0.16	0.026667	0.026667	0.133333	0.053333	0.106667	0.133333
Total Hardness	300	0.0033	0.0209	0.0198	0.0187	0.022	0.0187	0.0132	0.0187
Bicarbonates	120	0.0088	0.172917	0.179833	0.138333	0.179833	0.179833	0.083	0.172917
Chloride	250	0.004	0.0144	0.0128	0.0128	0.0176	0.0128	0.016	0.0176
MPN	1per	0.1	33.80211	26.33468	26.33468	18.45098	36.62758	19.54243	33.80211
qiwi			34.17033	26.57378	26.53118	18.80375	36.89224	19.76129	34.14466
WQI			285.7051	222.1888	221.8326	157.222	308.4636	165.2282	285.4905

Table 5.21

Water Quality Index (WQI) of study places in Kannur District Tribal area (Kanjirakkolly) Monsoon 2007

Parameter	ICMR std (SI)	Unit Wt (w)	K1	K2	K3	K4	K5	K6	K7
P^H	7-8.5	0.004	0.106667	0.026667	0.133333	0.106667	0.08	0.24	0.16
Total Hardness	300	0.0033	0.0077	0.011	0.0154	0.0154	0.0187	0.0044	0.0088
Bicarbonates	120	0.0088	0.034583	0.069167	0.055333	0.069167	0.025592	0.069167	0.069167
Chloride	250	0.004	0.008	0.016	0.0128	0.016	0.0112	0.016	0.016
MPN	1per	0.1	21.76091	23.0103	19.54243	23.0103	20.41393	23.0103	24.47158
qiwi			21.91786	23.13313	19.75929	23.21753	20.54942	23.33987	24.72555
WQI			183.2597	193.4208	165.2115	194.1265	171.8179	195.1494	206.7353

Table 5.22

Water Quality Index (WQI) of study places in Kannur District Tribal area (Kanjirakkolly) Post Monsoon 2007

Parameter	ICMR std (SI)	Unit Wt (w)	K1	K2	K3	K4	K5	K6	K7	K8
P^H	7-8.5	0.004	0.266667	0.293333	0.24	0.266667	0.16	0.186667	0.266667	0.266667
Total Hardness	300	0.0033	0.0275	0.0077	0.0099	0.0033	0.0033	0.0044	0.0099	0.0077
Bicarbonates	120	0.0088	0.10375	0.089917	0.083	0.076083	0.14525	0.14525	0. 069167	0.089917
Chloride	250	0.004	0.016	0.00848	0.024	0.0176	0.032	0.0288	0.032	0.032
MPN	1per	0.1	16.0206	16.0206	19.54243	19.54243	24.47158	19.54243	23.0103	19.54243
qiwi			16.43452	16.42003	19.89933	19.90608	24.81213	19.90754	23.38803	19.93871
WQI			137.4123	137.2912	166.3823	166.4388	207.4593	166.451	195.5521	166.7116

Table 5.23

Water Quality Index (WQI) of study places in Kannur District Tribal area (Vanjiam) Pre-Monsoon 2007

Parameter	ICMR std (SI)	Unit Wt (w)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11	V12
P^H	7-8.5	0.004	0.24	0.16	0.133333	0.133333	0.186667	0.026667	0.133333	0.026667	0.133333	0.133333	0.4	0.213333
Total Hardness	300	0.0033	0.0099	0.0176	0.0077	0.011	0.0088	0.0099	0.0165	0.011	0.0154	0.0088	0.0143	0.0132
Bicarbonates	120	0.0088	0.034583	0.10375	0.034583	0.048417	0.034583	0.069167	0.034583	0.110667	0.027667	0.034583	0.048417	0.034583
Chloride	250	0.004	0.0336	0.0064	0.0096	0.0096	0.016	0.0112	0.0144	0.0112	0.0112	0.0128	0.0096	0.0112
MPN	1per	0.1	33.0963	43.80211	24.47158	31.76091	31.76091	40.41393	24.47158	33.22219	29.68483	30.60698	43.80211	43.80211
qiwi			33.41439	44.08986	24.6568	31.96326	32.00696	40.53086	24.6704	33.38173	29.87243	30.7965	44.27443	44.07443
WQI			279.3845	368.6443	206.1605	267.2514	267.6167	338.8868	206.2742	273.1114	249.7695	257.4958	370.1874	368.5153

Table 5.23 Contd...

Parameter	ICMR std (SI)	Unit Wt (w)	V13	V14	V15	V16	V17	V18
P^H	7-8.5	0.004	0.133333	0.133333	0.186667	0.133333	0.4	0.213333
Total Hardness	300	0.0033	0.0099	0.011	0.011	0.0121	0.022	0.0077
Bicarbonates	120	0.0088	0.069167	0.10375	0.034583	0.069167	0.048417	0.076083
Chloride	250	0.004	0.0112	0.0112	0.0112	0.0144	0.0112	0.0048
MPN	1per	0.1	23.61728	43.80211	40.41393	33.22219	43.80211	31.76091
qiwi			23.84088	44.0614	40.65738	33.45119	44.28373	32.06283

WQI			199.3384	368.4063	339.9446	279.6922	370.2653	268.0839

Table 5.24

Water Quality Index (WQI) of study places in Kannur District Tribal area (Vanjiam) Monsoon 2007

Parameter	ICMR std (SI)	Unit Wt (w)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
P^H	7-8.5	0.004	0.026667	0.106667	0.24	0.186667	0.106667	0.053333	0.026667	0	0	0.026667	0
Total Hardness	300	0.0033	0.0176	0.0264	0.0517	0.0385	0.0242	0.0187	0.0154	0.0165	0.022	0.0297	0.0165
Bicarbonates	120	0.0088	0.110667	0.166	0.325083	0.242083	0.152167	0.117583	0.096833	0.10375	0.138333	0.255917	0.159083
Chloride	250	0.004	0.016	0.0112	0.0144	0.0128	0.016	0.024	0.0144	0.0144	0.0128	0.0144	0.0192
MPN	1per	0.1	36.62758	43.80211	43.80211	36.62758	33.80211	43.80211	23.61728	43.80211	29.68483	36.62758	40.41393
			36.79851	44.11238	44.4333	37.10763	34.10115	44.01573	23.77058	43.93676	29.85796	36.95426	40.60871
			307.6799	368.8326	371.5159	310.2645	285.1266	368.0245	198.7507	367.3642	249.6485	308.9821	339.5377

Table 5.24 Contd...

Parameter	ICMR std (SI)	Unit Wt (w)	V12	V13	V14	V15	V16	V17
P^H	7-8.5	0.004	0	0.053333	0.053333	0.053333	0	0.026667
Total Hardness	300	0.0033	0.0165	0.0187	0.0165	0.0253	0.0154	0.0231

Bicarbonates	120	0.0088	0.22825	0.152167	0.14525	0.14525	0.076083	0.235167
Chloride	250	0.004	0.016	0.0176	0.0144	0.0128	0.0112	0.0128
MPN	1per	0.1	40.41393	40.41393	36.62758	23.22219	23.22219	33.80211
			40.67468	40.65573	36.85706	23.45888	23.32488	34.09985
			340.0893	339.9308	308.1694	196.1445	195.024	285.1158

Table 5.25

Water Quality Index (WQI) of study places in Kannur District Tribal area (Vanjiam) Post Monsoon 2007

Parameter	ICMR std (SI)	Unit Wt (w)	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
P^H	7-8.5	0.004	0.293333	0.266667	0.213333	0.293333	0.24	0.186667	0.266667	0.186667	0.186667	0.186667	0.16
Total Hardness	300	0.0033	0.0099	0.0253	0.0143	0.0231	0.0132	0.0132	0.0213	0.0176	0.0176	0.0121	0.0275
Bicarbonates	120	0.0088	0.069167	0.14525	0.166	0.221333	0.117583	0.083	0.076083	0.152167	0.152167	0.14525	0.26975
Chloride	250	0.004	0.0416	0.0272	0.0256	0.032	0.024	0.0304	0.0224	0.0272	0.0272	0.032	0.032
MPN	1per	0.1	16.0206	16.0206	18.45098	18.45098	16.0206	18.45098	20.41393	16.0206	16.0206	16.0206	16.0206
qiwi			16.4346	16.48502	18.87021	19.02075	16.41538	18.76425	20.80218	16.40423	16.40423	16.39662	16.50985
WQI			137.413	137.8346	157.7777	159.0363	137.2524	156.8917	173.9312	137.1591	137.1591	137.0955	138.0422

Table 5.25 Contd...

Parameter	ICMR std (SI)	Unit Wt (w)	V12	V13	V14	V15	V16	V17	V18
P^H	7-8.5	0.004	0.293333	0.266667	0.213333	0.186667	0.16	0.266667	0.213333
Total Hardness	300	0.0033	0.0242	0.011	0.011	0.022	0.0319	0.0176	0.0132
Bicarbonates	120	0.0088	0.26975	0.076083	0.117583	0.214417	0.235167	0.138333	0.1245
Chloride	250	0.004	0.032	0.0224	0.0256	0.024	0.032	0.024	0.0272
MPN	1per	0.1	16.0206	16.0206	25.91065	18.45098	31.76091	23.0103	18.45098
qiwi			16.63988	16.39675	26.27816	18.89806	32.21998	23.4569	18.82921
WQI			139.1295	137.0966	219.7171	158.0106	269.3978	196.1279	157.4349

Since most of these samples have bacterial contamination they must be purified. Disinfection of community wells, proper sewage- drainage systems, periodical quality monitoring of Corporation water, simple and communal water treatment along with public awareness programme on sanitation would prove beneficial to avoid water borne epidemics and pollution in these Malabar areas.

CHAPTER VI

WASTE WATER TREATMENT AND SOLID WASTE DISPOSAL

6.1 WASTE WATER TREATMENT

In many developing countries, the water resources are heavily polluted, mainly with domestic wastes, both solid and liquid. Existing health risks from poor quality water are even higher in a country with great water consumption. The domestic wastewater is let out into the nearby surface water sources like streams and rivers. From there, they reach the nearby ground water sources. Thus public water supply systems and domestic wells are affected. Solid wastes like food residues, vegetable residues, etc. which are thrown away by people pollute the environment [**Adward A Louis, 1976**].

Recently many researchers have focused on the effects of wetlands on water quality and the possibility of constructing wetlands for water treatment. Natural wetlands can purify water but if used for wastewater treatment, they will be destroyed. They must be preserved. Hence artificial wetlands are constructed for wastewater treatment [**Breen P, 1996; Geary PM et al**].

6.1.1 CONSTRUCTED WETLAND FOR WASTE WATER TREATMENT

In transitional areas between land and water nature forms wetlands. Wetlands are saturated with water either permanently or temporarily. It is not necessary for such lands to be completely submerged Water may be present at or near the soil surface or even within the root zone. Wetlands are distinguished by wet soils, plants that are adapted to wet soils, and a water table depth that maintains these characteristics. Wetlands provide an attractive home for a variety of plants and animals, guard against flooding and help protect water quality. Wetlands maintain water quality by storing some of the nutrients such as nitrogen and phosphorous and removing some of the sediment from water that runs off upland areas, reducing the amount of pollutants that enters water ways. Natural wetlands also help to reduce shoreline erosion, to maintain the levels of rivers, lakes and streams by storing and slowly releasing floodwaters. The US. Environmental Protection Agency encourages the use of constructed wetlands for the treatment of domestic wastewater [**Cooper PE, 1996; Goel PK, 2003**].

The wetlands have considerable impacts on water and environment management of an area from the points of view of controlling floods, recharging ground water cleansing polluted waters, protecting shorelines and this aquatic system provides unique habitats for a wide variety of flora and fauna, of commercial, aesthetic and environmental value. Wetlands often serve as sources, sinks and transformers of a multitude of chemical, biological and genetic materials. Therefore the wise use of wetlands is vital for the environmental sustainability of a region [**Billere et al; Graddy C et al., 1980**].

It is possible to classify all wetlands into two basic types, tidal (coastal) and fresh water (inland). Most wetlands store water derived from rainfall, from surface runoff and from ground water. Therefore they first act as resources [**Johnson W, et al., 1985**]. The stored water is then slowly released to supply the downstream reaches of rivers, streams and lakes and to recharge ground water. Like the inland wetlands, the tidal ones show the flow of water moving through the system and allows the setting of sediment and pollutants intrusion from sea, enabling ground water recharge, removing sediments and pollutants and are ‘ gold mines’ in their yield of fish and crustaceans [**Wiliams TC, 1979; Gram AJ, 1973; Hendersen UB and Went FS, 1976**].

6.1.2 Threat to Wetland Eco System

The wetlands are currently subjected to acute pressure of rapid developmental activities and indiscriminate utilization of land and water. Consequently the system is being destroyed, especially in the tropics, at an alarming rate of one percent per year. Though there exists any or no quantitative estimate on the rate of destruction of wetlands in Kerala, the qualitative degradation of the ecosystem is more or less, well understood. Natural causes such as erosion, storm damage, drought, eutrophication and biotic interference also destroy the wetlands. Artificial wetlands are constructed to improve the quality of wastewater. The management of the wetlands includes treatment of the effluent discharge, regulating industrial growth, regulating port and fishing activities and improvement in transportation and modernization of coir industry. There is an immediate requirement of the stoppage of waste disposal in aquatic bodies. Integrated management of agricultural practices can regulate the excess usage of pesticides and chemical fertilizers [**Kadlec RIT, 1996; Nuller RW, 1969**].

By maintaining water table level, they protect ground water resources against salt-water intrusion. Along with supplying water, wetlands play a role in improving the quality of water by trapping or transforming pollutants before they reach the larger water resources. Wetlands provide critical life support to the local people as timber, fuel, feed and manure, as well as fisheries. The brackish water and reclaimed mangrove area are used as fishponds after the monsoons; they are drained and used as saltpans. The mud from wetlands is periodically removed and used as manure for paddy and coconut plantations [**Trivedi PK, 2001; Rao MN and Amal KD, 1987**].

Besides depleting the area, wetlands have been violated by fertilizers, and animal waste that has upset the balance of nutrients. Similarly, in coastal areas, subsurface withdrawals of water [for aqua culture farms for instance], allows salt-water intrusion into fresh water wetlands, modifying these habitats to the extent that it has threatened the billion-dollar fisheries industry [**Reddy KR and Smith, 1987; Van Felde K et al., 1997**].

The more recent culprit includes urbanisation and industrialization. Both bring a concentration of organic matter, wastes, pesticides, fertilizers, heavy metals and hydrocarbons, all of which are major pollutants. Both create large tracts of impermeable surfaces, because such surfaces prevent rainfall from percolating into the soil, they hasten the flow of these wastes into streams and wetlands. Thirdly, such surfaces raise the temperature of water runoff, thus decreasing its dissolved oxygen. Together, these three factors cause immense stress on all aquatic life and therefore the food web. Sedimentation also reduces the water storage capacity, reduces the penetration of light, and reduces oxygen. In short, it makes wetlands unproductive, with grave consequences on the food chain [**Reddy KK, 1994; Vijay PS, 2003**].

6.1.3 How Wetland Improve Water Quality

Several studies have shown that wetlands reduce nitrogen and phosphorus concentrations in runoff and flood water to a significant extent by transforming them and releasing them into the atmosphere. High proportions of suspended solids make a water cloudiness which prevents downstream ecosystems from entering the wetlands. Moreover several pollutants affecting water quality are often absorbed onto these suspended solids, thus removing pollutants from water while the sediment deposit itself provide multiple benefits to downstream water quality [**Nuller WJ, 1962**].

Wetlands help maintain water quality by storing some of the nutrients, such as nitrogen and phosphorus, and removing some of the sediment from water that runs off upland areas, reducing the amount of pollutants that enters water ways. Natural wetlands also help to reduce shoreline erosion and to maintain the levels of rivers, lakes and streams by storing and slowly releasing floodwaters. The USEPA encourages the use of constructed wetlands for the treatment of domestic wastewater. It is often reported that constructed wetlands are relatively inexpensive to build, need almost no maintenance, are pleasant to look at, become a habitat for wild life and effectively remove bacteria and nutrients from water [**Person J et al.,**]

Concentrated waste waters such as those from animal production place a large burden on the wetland’s ability to remove pollutants. There is a great risk of proper wastewater treatment in developing countries. Due to the financial situation and to the more stringent standards, wastewater sewerage treatments are much more developed in industrialized countries. Consequently there is an enormous pool of experience and knowledge in these countries with a lot of different systems based on scientific and practical work.

The most promising technology for application in developing countries seems to be constructed wetlands due to their characteristic properties like utilization of natural processes, simple construction, simple operation and maintenance, process stability, cost effectiveness, etc [**Vijay P Singh, 2003**].

Since Seidel [**Seidel, 1978**] demonstrated the role of bulrushes [Scirpus Lacustris] in wastewater treatment, all kinds of plants have been tried and wetland construction is fast becoming a business. A constructed wetland for wastewater treatment is planned, designed, built and operated to simulate a natural wetland in terms of its ability to remove pollutants from water. Advantages over a planned system as compared to a natural system are increased flexibility and control over where the wetlands are located and where the water comes from. Constructed wetlands are being used to treat municipal, industrial and agricultural wastewaters.

Geographic location, which determines climate, vegetation, and soil types, is critical to the effectiveness of constructed wetlands. Sedimentation, sorption, filtration, biological processes, and biochemical interactions are the principal mechanisms by which wetlands remove pollutants. Any change in wetland characteristics affects pollutant removal efficiency. Because of variations in characteristics treatment effectiveness vary from one wetland to another.

Plants also play an important role in the functioning of wetlands. Roots and stems in the water serve as a medium for bacterial growth and for filtration and absorption of solids. Stems and leaves at or above the water surface provide shade, which reduces the growth of algae. Many wetland plants can transport oxygen to and from the roots, which allows oxygen demanding changes in nitrogen to take place in the rotation. These changes convert nitrogen to a form that can be used by the plant, there by keeping it entering surface water or ground water. Choosing the proper plants is an important part of wetland construction.

The major pollutants normally are nitrogen, phosphorus, trace elements and oxygen demanding materials. These water pollutants are the major components of fertilizers and soil amendments that are necessary for food production. Recycling them into the soil can save on fertilizer consumption as well as improve water quality. In general the pollutant materials are removed by soil, plants or microorganisms. The particular mechanisms for removal vary with the system.

The age and maturity of a wetland area can also influence its ability to treat wastewater. If the system is not planned properly, increased infiltration in newly formed soils may allow more contaminants to leave the system and move into surface water or ground water. In old systems, the opposite may happen. The soils may become saturated with nutrients, thus reducing the wetland's ability to assimilate pollutants and purify wastewater [**Trivedi PR, 1998**].

Flow characteristics of the area are another factor in wetland performance. Changes in wastewater loading, detention time, water level and season alter the wetland's ability to remove pollutants. A well-planned water flow is essential for proper functioning of the wetland system.

Depending upon their location in the landscape, wetlands fall into three categories. First, the typical bogs (raised bogs), which are perched at a higher level and are totally cut off from the influence of surface water. They are entirely dependent upon precipitation for their water and nutrient supply and are therefore very poor in major plant nutrients. Second the palustrine wetlands which are located in a shallow depression surrounded by upland and receive nutrients, with the run- off from their surroundings. The nutrients are likely to accumulate or move out with subsurface water movement. The third most common category includes wetlands lying at the interface between upland and open waters, eg. on the shores of lakes, rivers and oceans. These wetlands receive nutrients passing through them from land towards open waters. Periodic rise in water body brings the nutrients back into the wetland from the open water [**Trivedi PK and Sidharth K, 2001**].

Several physical, chemical and biological processes are involved in the transformation of nutrients within the wetland. The major process is setting of suspended particulate organic matter. The reduction in the particulate organic matter is a major cause of reduction in BOD of wastewaters. The chemical processes include adsorption, chelation and precipitation, which are responsible for major removal of phosphorus and heavy metals. Among the biological processes, the most important are those mediated by micro – organisms and include the oxidation and reduction of C, N, and S depending on the availability of oxygen. Generally, the reduction reactions dominate the system in the presence of higher organic matter in the effluents and most of the nitrogen is lost through denitrification [**Denney P, 1996**]. The inter-relation between these processes and the biota are fairly complex and several elements such as Fe, Al and Mn play an important role in the removal of P [**Grabtree ME, 1994**]. It is note worthy that the anaerobic condition which causes denitrification is not favorable for adsorption and precipitation of P from wastewater. In fact, the P accumulated in the sediments is readily released by the addition of high BOD wastewater [**Nelter, 1993; MAD, 1976**].

Aquatic plants are an essential component of a wetland and contribute to the nutrient transformation by the abetting in physical chemical and microbial processes besides removing nutrients for their own growth. They offer mechanical resistance to flow, increase the retention time and facilitate settling of suspended particulates. They improve conductance of the water through the soil as the root grow and create spaces after their death. Many plants actively transport oxygen to the anaerobic layers of the soil and. thus helps in oxidation and precipitation of heavy metals in the root surfaces. The algae contribute much to the wastewater precipitation process as in oxidation ponds.

Hydrology regulates all the characteristics of wetland structure and function. Natural wetlands especially in tropical regions, experience large water level changes seasonally. The constructed wetlands differ from the natural wetlands mostly in their hydrology because the water level is usually maintained uniform through out the year except for the variation in the availability of wastewaters.

Apart from hydrology and water quality the constructed wetlands further differ in the nature of the substratum, which is designed to optimize the hydraulic movement. Another major difference lies in the biodiversity. Despite the dominance of one of two species of macrophytes in an area the natural wetlands support large biodiversity. Constructed wetland tends to promote single species strands. Although diversity may increase over the years of operation or may be promoted, periodic harvesting of macrophytes which is necessary to maintain the system active and efficient keeps the diversity low.

Constructed wetlands and water pollution control ponds are becoming widely used for the treatment of storm water and combined sewer overflows.. Constructed wetlands include free water surface as well as recently developed subsurface flow system. The later systems involve subsurface flow through a permeable medium. The root zone method and the 'rock reed filter' are other names for these systems. The use of soil and rock affected only the hydraulic conductivity of the system. The constructed wetland is simple by principle and requires no maintenance. To prevent percolation of the wastewater into the ground, the bottom of the filter must be sealed.

6.1.4 Artificial wetland for waste water treatment constructed at CWRDM

Wetlands help maintain water quality by storing some of the nutrients, such as nitrogen and phosphorus, and removing some of the sediments from water. Natural wetlands also help to reduce shoreline erosion and to maintain the levels of rivers, lakes and streams by storing and slowly releasing flood waters.

The wastewater treatment unit at CWRDM has started functioning on June 2003. The wetland is constructed as part of a project on 'Integrated Development Plan for Calicut City', funded by Mission for Application of Technology for urban renewal under UNDP as a subprogram through Department of Science and Technology. Constructed wetland is defined as wetland that utilizes natural process involving wetland vegetation, soils and their associated microbial assemblages to assist at least partially in treating an effluent or other water sources. An artificial wetland has been constructed at CWRDM to treat the wastewater from the canteen. The wastewater is allowed to pass through few tanks.

(1) Sedimentation tank

In this tank larger particles are settled down due to gravity, and they can be removed by an outlet at bottom and this solid waste is converted into vermicompost. This tank has a capacity of 120 x 115 x 100cms.

(2) Skimming tank

Wastewater from canteen contains plenty of oil particles. It must be removed; otherwise it will cause fungal growth in pipes. Oil is removed using rice hull. Rice hull is put in the tank. The oily particles get stick on to the rice hull. After some time, the rice hull is removed manually. This can be used to make vericompost. It can also be dried and used as fuel. The presence of oil increases its calorific value. The water from skimming tank passes to the next tank through a slanting outlet to prevent the passage of oily particles which floats at the top layer.

(3) Filtration tank

The tank is filled with sand (1ft thick) and gravel. The removal of colloidal and suspended particles takes place in this tank.

(4) Storage tank

The filtered water is stored in the storage tank

(5) Constructed Wetland

The filtered water then enters the constructed wetland. It consists of a cement tank filled with sand, crushed stone (1) crushed stone (2) and gravel Plants like Scheonoplectus Lacustris, Acorus Calamus, Phragmites Karaka, Lagenandra, etc are used.

The plant overview is given in table 6.1 and results are given in table 6.2. The hydraulic retention time has to be adjusted according to the organic loading. The filter can successfully treat domestic wastewater with in a few days of retention. Such filter can also reduce bacterial contamination to a significant level.

(6) Storage tank

After the treatment by the artificial wetland, water is collected in a storage tank and the water is used to irrigate crops. The lay out of the constructed wetland at CWRDM is shown in fig. 6.1

The analysis of the treated sample indicate that there is reduction in the BOD, COD, TSS, Total kjeldhal nitrogen, MPN, oil and grease. Algal growth occurred in this artificial wetland due to the passage of sunlight. Pistia was used as a plant cover and was found to grow very well in this wastewater. The results are given in table 6.3. Then water hyacinth has been tried. No other plant cover is required when water hyacinth is used. The results are given in Table 6.4. Water hyacinth is found to be very effective in removing pollutants from waste water [**Dinges R, 1976**].

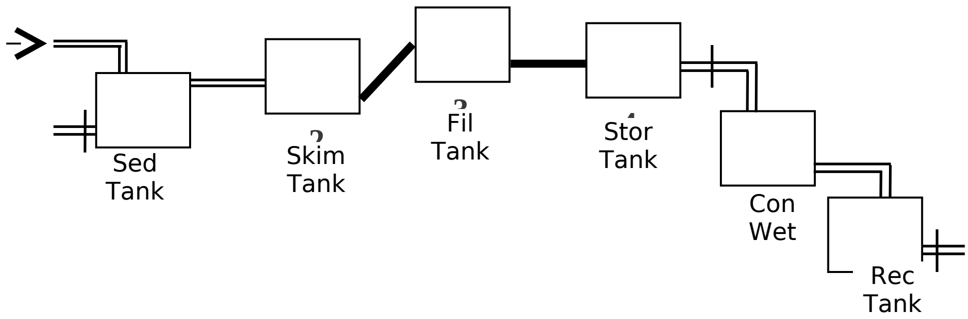


Figure 6.1: Constructed Wetland at CWRDM

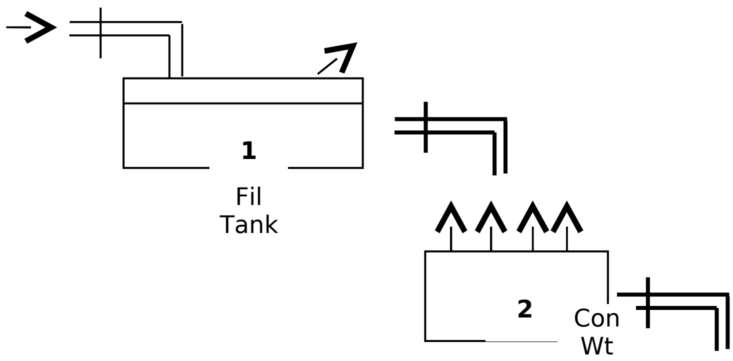


Figure 6.2: Constructed Wetland for Individual House Hold

Table 6.1

Plant overview

Retaining structure	**Ferrocement**

Waste water Type	Domestic
Pre-treatment	Settling tank. Skimming tank, Filtration tank,
Main treatment	Constructed wetland
Plants used	(1) Scheonoplectus Lacustris (2) Phragmites Karka (3) Acorus Calamus (4) Lagenandra (5) Pistia (6) Water Hyacinth (Eicchormia spp.)

This was a pilot study only. The water get clogged when sand and gravel was used to filter the waste water. The sand must be removed frequently. All the tanks must be covered to prevent sunlight entering inside, which will cause algal growth. Net must be provided to all the tanks to prevent mosquito growth. In the artificial wetland fish like guppy is used which will consume the larvae of mosquitoes.

Table 6.2

Improvement of waste water quality using constructed wetland

Plants used	Scheonoplectus Lacustris, Phragmites Karka, Acorus Calamus, Lagenandra.		
	Composition of Inflow water	Composition of outflow water	Percentage reduction
P^H	5.4	6.4	15.7
BOD	205	32	84.7
COD	912	35	96.1
TSS	33	11	66.7
TKN	10.1	1.02	89.9
Oil and grease	45	15	66.7
Total coli forms	7,2400	210	68.6

Table 6.3

Removal of pollutants in wastewater using constructed wetland

Plants used	Schenoplectus Lacustris, Phragmites Karka, Pistia.		
	Inflow waste water	Discharge water	% Removal.
P^H	5.3	7.2	35.8
BOD	205	3.5	98.4
COD	930	259	72.2
Oil and grease	6.8	3.6	47.1
TSS	32	19	40.6
TKN	32	19	40.6
Total coli form	7,2400	7,2400	
E coli	+Ve	+Ve	

Table 6.4

Improvement of the quality of wastewater by constructed wetland

Plants used	**Water Hyacinth [Eichhorria spp].**		**% Removal**
	Inflow water	**Discharge water**	
BOD	200	25	87.5
COD	800	250	68.8
TKN	10.1	1.2	88.1
Total coli forms	1100	24	97.1

Waste Water Treatment for Individual Household

This type of constructed wetland discussed above need space. In city and towns where space is limited, it may not be practical. Each household must treat their domestic wastewater before it is allowed to flow out. Only two tanks are needed .In the first tank, the water gets collected after passing through a bed of rice hull at the top. Thus oil and solid particles are removed. Then it is allowed to enter the artificial wetland where water hyacinth can be used for the treatment. Other aquatic plants can also be selected which will be suitable for a particular type of wastewater. The retention time can be few hours. This treated water can directly be used to irrigate crops. Wastewater from kitchen contains sodium chloride, which is harmful to plants. This will be removed by this type of filter and the treated water can be used to irrigate kitchen garden and garden plants. The sketch of this filter is given in fig. 6.2.

The rice hull can be removed frequently and either can be used as a fuel or can be converted into compost. This type of filter will prevent the pollution of water resources due to domestic wastewater.

A trial experiment was set up in the house to find out the efficiency of constructed wetland for treating kitchen waste water. The results are given in table 6.5

Table 6.5

Improvement of the quality of kitchen waste water using constructed wetland for a house hold

Plant used- Eicchornia spp.			
Retention time – 6 hours			
Sl. No.	**Parameter**	**Before Treatment**	**After Treatment**
1	pH	7.24	7.5
2	Chloride	60	50
3	Nitrate –N	6.8	2.8

6.2 SOLID WASTE DISPOSAL

Nowadays disposal of solid waste has become a problem all over the world. Vermicomposting is the cost-effective, eco-friendly method of converting solid waste into biofertilizer. The earthworm castings contain more nutrients than the fertilizers commonly used. This can be done indoors also. Use of vermicompost promotes soil fertility. The whole environment can thus be saved from pollution due to solid waste.

6.2.1 Vermi Culture and VermiComposting

Garbbage is an undesirable consequence of prosperous, high technology and disposable economics. It is a problem through out the world. The daily garbbage production is increased and it has become a big problem to the municipalities. The only solution found is to reduce the waste at source and dispose it off at source as early as possible. The wastes from houses contains mainly vegetable cuttings, left over foods, fruit wastes, fruit seeds, fruit peelings and remnants, waste vegetable, roots and straws, wasted flowers, rotten food, milk, used paper, garden waste, glass, metals, used cosmetics and medicine bottles, rubber, leather, plastics, textile, etc. The present practice is to throw the entire waste into a nearby dustbin. The ill maintained and not so regularly cleaned dust bins pose a pathetic scene to water. The organic waste gets fast degraded and starts stinking badly. The bad stink further prohibits the house wives and attendants to deposit the fresh water into bins proper; and thus the waste starts getting spread around setting the chain of filth and unhygienic conditions to a further degree. Every industry whether chemical, mechanical or even agricultural produce lot of pollution in liquid, gaseous or solid forms. So in the circumstances what is needed is a safe technology, which can utilize the wastes and convert it into useful products to again increase the productivity of land [**Shirkie R, 1978**]. The problem can be easily solved in the house itself in the scientific way of vermicomposting. Biotechnology Resources Centre in the last 15 years has developed a vermiculture biotechnology and successfully implemented in several chemical industries, food based industries, wood based industries and also in mechanical industries. The domestic organic waste can also be converted into vermicompost [**Joseph LP et al., 1987; Michael EH, 1978**].

6.2.2 Composting

Composting is a biochemical process in which diverse mixed group of organisms break down organic materials into humic substances. The composting process varies from aerobic to anaerobic and from mesophilic to thermophilic conditions, depending on the nature of microorganisms present, and on the moisture and aeration levels of the compost mass. The vermicompost is prepared from the compost, which contains a mixed microbial culture of decomposing microorganisms. Vermiculture is the growing of earthworms for various uses. Worms required to culture must be of superior quality [**MC Graw MG, 1978**].

6.2.3 Earthworms

Earthworms are segmented invertebrate animals belonging to the phylum Annelida, order Oligochaeta and class Citellata. The earthworms vary in size, colour and behavior. The distribution of earthworms in soil is influenced by several factors of which the soil texture and aeration, temperature, moisture, pH, inorganic salts, organic matter, dung litter, reproductive potential and dispersive power of the species are important.

In general earthworms are resistant to many pesticides and heavy metals. Worms could overcome the effect by increasing mucus secretion, restricting the movement and increasing the reproductive potential up to certain concentration levels. Earthworms are also known to concentrate the pesticides and heavy metals in their tissues. Earthworms concentrate Na, Cd, Co, Hg and Zn. The worms play important role in waste disposal and pollution control. They decompose natural organic matter such as vegetable matter, paper, leaves, dung and animal excrement into rich composted fertilizer. A single worm produces 1000-1500 off springs in a single year. Earthworms feed on every thing except plastic and metal. Any decayed organic matter appears to be good food for worms but the feed should not be contaminated by detergents or insecticides. The common enemies of earthworms are spiders, rats, mites, ants, birds, toads, beeble larvae, snails, centipedes and termites.

Earthworms such as Eudrilus Eugeniae, Eisemia Fetida and Periyenix Excavatia were easily adaptable to agricultural wastes like after harvest stribbles, sugar cane thrash, coir waste and paper pulp, fecal matter of cow, sheep, horse, activated sludges and biogas sludges of poultry droppings. The break down of these materials or the degraded organic matter by worm activity is called the ‘vermin compost’, which can be used as the top soil or the organic manure in the fields to prevent organic carbon deficiency and soil erosion. Worm cast is a better source of organic manure over compost. Earthworm dead tissues [dead cocoon, empty cocoon case, body issue mucus, worm caste and urine] are added to the soil as nitrogenous fertilizer. The nitrogenous material in casts and urine contains ammonia, urea, uric acid, protein and amino acids. Earthworm cast contains more nutrients such as C, N, Ca, Mg, K, N, P than the soil. The vermicomposting helps to process waste simultaneously giving biofertiliser for agricultural/ horticultural uses and a high quality protein as low as animal food. There is a vast potential for vermiculture development in India. It is a promising low cost source for animal protein feed that does not require skills, materials and energy. However a thorough survey and identification of locally available earthworm species for effective management of organic wastes, simplification and modernisation of vermiculture techniques, effective control of diseases, pests and predators, systematic harvesting and effective utilization will not only enhance the production of low cost preotein but also play a significant role in pollution control.

6.2.4 Vermiculture

Culturing of earthworms is to be done indoors in humid places with proper shelter to avoid direct sunlight or heavy downpours. Cement tanks, wooden boxes or plastic trays of approximately which accommodate 1,000 worms may be used as containers. These should be free from cracks and holes to avoid escape of worms. Suitable covers should be provided to protect the worms from predators and prevent them from escaping during nights. For the bedding material, saw dust or husk, fine sand or layers of garden soil are used. Three centimeters each of the material is to be spread in the container. Water is to be sprinkled on the bed to get a moisture level of 40-50%. After the preparation of bed, cocoons or worms can be introduced into the containers.

The dung of cattle, sheep, horses, pigs or droppings of poultry birds and vegetable waste form the ideal feed for the worms. Cattle dung can be fed as such where as the other dung material or vegetable wastes are to be mixed in equal quantity with cattle dung for the feed acceptability.

India has about 3000 species of earthworms which are adopted to a range of vermiculture needs. In Asia, vermicomposting is being efficiently practiced in the Philippines. The steps followed are as follows. The pits of 4mx3mx1m size are dug and floor of pit is covered with a lattice of wood strips to provide drainage. The pit is filled with organic residues including straw, stubbles, animal manure, green weeds, leaves and so on. The filled pit is covered loosely with soil and kept moist. The worms are placed on the top, which burrow down into the damp soil. The pits are shaded from hot sunshine and to keep the material moist. Within two months about 10Kgs. castings are produced per Kg of worms.

Lind Wist (1941) reported that earth worm increases the nitrate production by stimulating bacterial activity and through decomposition of their own bodies. The presence of earthworm had a marked effect upon nitrogen transformation in a tissue waste or cow slurry mixture. Nitrogen mineralization was greater in the presence of earthworms and this mineral nitrogen was retained in the nitrate form, which is due to the favorable condition for nitrification product. Earthworms accelerate the mineralization rate and convert the manures into castings with a higher nutrient value and degree of humification. The production of cast by earthworms depends on the season and the type of vegetation. It is observed that maximum worm cast production occurred in rainy season and minimal production in summer.

Use of vermicompost promotes soil aggregation and stabilizes soil structure. Application of vermicompost increases the available N, P and K content in soil. Earthworms improve the aeration of soil by their burrowing activity [**William JS, 1970**].

6.2.5 Earthworms and Pollution control

The urban and rural wastes being generated continuously are undesirable pollutants for the environment and a menace to the health of the community. The sources of toxic substances reaching the soil surface are mainly the solid wastes containing heavy metals released from the industries and pesticides used for the health and agriculture. In recent years increasing amount of metals like mercury, lead, arsenic, cadmium, etc. are discharged to the environment by industrial establishments. These metals progressively reach the human being through food chains. The special characteristics of heavy metal chemicals are their strong attraction to biological tissues and the slow elimination from biological systems. Residues of heavy metals like cadmium, lead, zinc and nickel have been recorded in their bodies. The accumulation of toxic chemicals in earthworm tissues is very significant ecologically, because these animals are important components in the food chain of several species of birds and mammals. The earthworms serve as a part of diet of some birds. Earthworms can process household grabbage, city refuse, sewage sludge and wastes from paper, soil and food industries. They dominate the soil invertebrate biomass in many ecosystems of the world.

Vermi culture biofertilizer is excellent potting mix for green house and tissue cultured orchids and ornamentals. Yield and size of the fruits also increases. Besides there was substantial saving because of reduced use of pesticide consumption. There is a vast potential for vermiculture development in India. However a thorough survey and identification of locally available earthworm specie for effective management of organic wastes, simplification and modernization of vermiculture techniques, effective control of diseases, pests and predators, systematic harvesting and effective utilization will not only enhance the production of low cost protein but also play a significant role in pollution control.

Vermicompost unit constructed at CWRDM

The solid waste from the canteen and the constructed wetland were used to make vermicompost at CWRDM. A vermicompost unit has been constructed and the solid particles along with green leaves were allowed to remain in the tank for 7 days. The tanks were covered with net and there was a channel filled with water around the unit to prevent ants entering the tanks, which will kill the earthworms. Then earthworms were added to the tank and after a period of one month vermicompost was ready for use.

Solid waste disposal for individual house hold

Vermicomposting converts solid wastes into excellent manure for garden. But in cities and flats, the space is limited. The vermicompost can be prepared in small cement tanks. Small vermicompost units for individual households are now available from panchayats. Thus the water pollution due to solid waste can be avoided.

The vermicompost has been analyzed to find out its N, P and K values. The results are given in Table 6.6.

Table 6.6

Results of Analysis of Vermicompost

Sl. No.	Parameter in Percentage	Set I	Set II
1	N	1.4	1.24
2	P	0.3215	0.24
3	K	0.478	0.261

CHAPTER VII

TRADITIONAL KNOWLEDGE FOR DRINKING WATER TREATMENT

Introduction

The greatest impact of water pollution on human health comes through drinking water, the source of which may be degraded by municipal sewage, storm water run off, cattle feed lot drainage and discharges from meat and poultry processing plants. Ground water used by about 60 million people is untreated or partially treated. Private to marginally treated public supplies is not always free from contaminants. Contaminated ground water supplies were responsible for over 50% of the water borne out breaks during the period 1940 – 1970.

Nearly 70% of the present global population lives in the developing parts of the world and since the rate of increase in the population in many such areas is also higher than in industrialized countries, the share of the third world population will have increased to almost 80% by the year 2000. Many developing countries either suffer from chronic shortages of fresh water or the readily accessible water resources available there are heavily polluted, mainly with domestic wastes. The larger proportion of the population in developing countries lives in rural and suburban areas and conventionally treated drinking water is generally available in such settings. Even though urban centre in these countries have centralized facilities for conventional treatment of drinking water, the quality of such treated water is often suspect, either because of improper treatment or as a result of its contamination during distribution or storage. This lack of sufficient quantities of fresh water and the consumption of unsafe water are known to be responsible for a large proportion of the disease burden in these regions. Therefore, provision of adequate quantities of safe water for the growing population of the developing world has become a challenging task. Provision of safe drinking water in the home with in 15 minutes walking distance was one of the objectives of primary health care in the global strategy for the health of all by the year 2000.

Safe water is defined as water that does not contain harmful chemical substances or micro organisms in concentrations that could cause illness in any form An adequate water supply is one that provides safe water in quantities sufficient for drinking and for culinary, domestic and other household purposes so as to make possible the personnel hygiene of members of the household. A sufficient quantity of the safe water should be available on a reliable, year round basis, near to or within the household where the water is to be used. The daily percapita consumption of drinking water in the rural areas of the developing world ranges between 35 and 40 liters. In urban areas where house connections are available the water consumption rate may be as high as 150 liters per day.

Basic Considerations in Domestic Water Treatment

The most desirable drinking water supply is one that requires no treatment at all. Unfortunately, the wide – spread pollution of water has rendered readily accessible sources of water undesirable for human consumption, without some degree of treatment. This is also true of ground waters in many areas of the world. In fact, in some tropical countries the combined influence of high population density, rampant pollution of available raw water that its treatment for drinking virtually accounts to waste water reclamation.

The general lack of sufficient quantities of safe drinking water in the developing world continues to be a serious problem; this is particularly true for rural and suburban communities. Thousand to two thousand years ago, people living in what are now developing regions had better systems of water supply than they do today. This is not only a reflection of the high priority ancient civilization has placed on this issue, but it is also an example of development moving backwards. The increasing awareness of the importance of water in economic development is putting ever greater pressures on the best available water resources. Since new water resources are not available in many areas, there are fears of an impending water crisis. But very little information is available thus far on the removal and inactivation of harmful micro organisms by processes and devices which appear to show some promise.

The use of chlorine (in the form of calcium hypochlorite) is likely to continue as the most appropriate form of drinking water disinfection in rural communities of the developing world because of its relatively low cost, residual effect and broad spectrum of activity.

Home Treatment Activities

There are a number of devices that have been developed for home treatment of public water supplies. Such devices use a variety of basic process concepts [filtration, adsorption, ion exchange, reverse osmosis and distillation] to achieve a desired contaminant reduction. Water purifiers are treatment devices that must remove all types of pathogenic organisms from the water so that the processed water is safe for drinking.. Inclusion of silver as a bactereostatic agent appears to be of limited benefit in controlling the bacterial quality of the product water [**Gorden, 1974**].

Many communities boil their water before drinking which destroys a wide variety of infectious agents and requires wood. The increasing shortage of burning wood makes this method undesirable unless alternate sources of energy are available. The use of solar energy shows some promise in this regard. The use of a variety of devices for the in – home filtration / or disinfection of water is rapidly increasing in many parts of the developing world and greater efforts are required to control their quality and assess their suitability for tropical settings.

Providing safe drinking water can immediately and dramatically improve the health of many communities and can also lead to the elimination of serious diseases. Any attempt at providing safe and adequate quantities of water to the developing regions of the world must be properly integrated with other aspects of development such as sanitation and education. Many developing countries either suffer from chronic shortages of fresh water or the readily accessible water resources available there are heavily polluted, mainly with domestic wastes.

Having a clean, safe supply of drinking water is still not possible in our towns and cities. Most of us either install a water filter or boil the water we drink to stay away from water borne diseases. Existing health risks from poor quality water are even higher in a country with greater water consumption. Water purification according to methods applied in public drinking water treatment facilities are not fit for native household. The United Nations warns that unless action is stepped up the number of people without access to safe water will increase to 2 – 3billion by 2005, with the number of those who die from unsafe water expected to jump sharply as well. How did people manage in the past? What were the traditional ways of purifying water before drinking it?

One way mentioned as early as in the Sushrutha Samhita is using the seeds of the Nirmali tree [Strychnos potatorum]. [**Gorden, M**] These seeds are rubbed on the inner walls of the khada [Matka] before water is poured into it, so that once the water is poured in, it will purify it. The ripe seeds are used for clearing muddy water. They are reported to be very effective as coagulant aids. Alum added by the seeds has been found to be very effective in removing the suspended impurities from coal washing wastes. The clarification is due to the combined action of colloids and alkaloids in the seed. The albumin and other colloids sensitize the suspension, and the coagulation is then caused by the alkaloid ions. The trees are found in the deciduous forests of Andhra Pradesh and Kerala.

In Sushruta Samhita, it is also said that the seeds of drum stick tree are also used as water purifiers. Research shows that these seeds known as Moringa seeds can replace the costly alum used in most water treatment plants used today. These seeds are so effective that just 30 seeds can purify as much as 40 liters of water. At present, the Universities of Malawi [Africa and Leicester [U K] are carrying out a conjoint research study on how Moringa seeds can be used to meet contemporary needs.

In certain parts of our country copper bottomed vessels were used for storage of water. In other parts of India, such as Kerala wells were regularly cleaned by throwing in burnt coconut husks, Tulasi leaves and amala wood have also traditionally been used for water purification.

People of Kerala have used plants like Brahmi, Lagenandra [Kinar vazha], etc. into their domestic wells to purify water. They can be used in cases of moderate pollution only. Fishes like Carp, Channa, Tilapia, etc. were used to treat water in open wells.

Bentonite and Kaolinite clays were also found to be helpful in water purification. Activated charcoal and bone char also are reported as water treatment components.

The tribal people of Wayanad, Kerala have their own culture and indigenous knowledge. They construct a structure called keni to conserve water. They used barks of Nelli, Pana, Angili, etc. trees to make kenis. They were planting Acorus calamus near the springs which will purify the water.

The traditional technologies for drinking water treatment has been practiced in many parts of India, Africa and South America. The preliminary aim of water purification is to remove any potentially dangerous chemicals or microorganisms and also to render the water aesthetically appealing. The drinking water should be free of colour, odour, turbidity and microorganisms.

In Western Sudan, rainwater is stored in the live, hollowed out Tibaldi trees. This tree is thought to produce bactericidal substance that leaches into the stored water. A hole is made in the trunk at the level of the first branches, and the inside of the tree is dug out for the water storage area. After filling the tree with rain water, the opening is closed with a mixture of soil and animal dung. The water can be stored in this way for long periods and is still potable up to ten years. The tree is not damaged by this use. Chinese folklore texts from the 19^{th} century refer to water clarification using the sap from the ‘funa’ cactus [Opuntia fiscus indica]. The traditional use of the M. olefera seeds for domestic household water treatment has been limited to certain rural areas in Sudan. Village women collecting water from the River Nile would place powdered seeds in a small cloth bag to which a thread is attached. This would then be swirled around the turbid water. The powdered seeds attach themselves to and bind between the suspended particles forming solids which would then be allowed to settle prior to boiling and subsequent consumption of the water.

Ruwaq is a form of bentonite used by villagers of Sudan for the treatment of turbid water. Many rural people use sand and rice hull ash filters for filtering drinking water. In Indonesia, water filters made of fibrous materials like coconut husk and charcoal from rice hull are in practice for the treatment of drinking water.

Existing health risks from poor quality waters are even higher in a country with great water consumption. Water purification according to methods applied in public drinking water treatment facilities are not fit for native households. Providing safe water can dramatically and immediately improve the health of many communities and can also lead to the elimination of serious diseases. Many developing countries either suffer from chronic shortage of fresh water or the readily accessible water resources available there are heavily polluted, mainly with domestic wastes. Hence, it is essential to develop an eco- friendly home treatment method for purifying drinking water that can be adopted by common man.

Methodology

It is believed by the people of India that when Rudraksham (Elaeocarpus sphaericus) is put in a glass of water before going to sleep and in the morning, drink the water, no illness will occur. Rudraksham, which has five faces (panchamukhi) and taken from the tree directly are used for this purpose. In North India, a lot of research has been conducted about the Rudraksham. It has electromagnetic properties. Our ancestors have given a sacred place for Rudraksham. It is believed that Rudraksham is Lord Siva himself [**Mohan Makkar,**] [**Rajappan Nair, 2004**], [Narain Bhatia,2004). The traditional knowledge prevalent among the people of North Malabar for purifying well water is to put a powdered mixture of Gooseberry (Emblica officinalis), Muthange (Cyperus rotendus) Vertiver (Vertiveria squarosus), Thettamparal (Strychnos potatorum) Kudangal (Centella Asiatica), and grains of Amaranthus, wrapped in a cloth bag [**Sree kumar et al., 2006**].

Experiments were carried out in the laboratory to find out the efficiency of Rudraksham and the mixture of plant materials in improving the water quality.

MATERIALS USED FOR WATER TREATMENT

(a) Rudraksham (Elaeocarps sphacricus)

This tree is found in the Himalayas. This is commonly known as the rosary nut and the fruits are used as medicine for a variety of diseases. The alkaloids present in Rudraksham are iso elaeo carpilin, elaeo carpilin, elaeo carpidine and iso elaeo carpin. It is used as medicine for small pox, chicken pox, measles, hypertension, mental tension and vata-pitha doshas.

(b) Strychnos Potatorum [Thettamparal]

The Sanskrit name is Nirmala, which means that purifies. The tree is found to be present in the deciduous forests of Kerala [Marayoor], Maharashtra and Andhra Pradesh. An alkaloid namely diabolin is separated from it. Other constituents are b – cita sterol, stigma sterol, oleanoic acid, 3-b-acetate, suphanin, galactose, mannose4, etc. It has been used as medicine for eye diseases, diabetis, leprosy, etc. It can cure kapha-pitha diseases.

(c) Emblica Oficinalisis [Goosberry]

It is rich in Vitamin C. It is used in Ayurveda treatments as a resayana medicine. It contains large quantities of pectin, Vitamin C, B complex, calcium, iron, gynic acid, tannic acid, resin, sugar, carbohydrate, protein, albumin, cellulose, etc. It is used to cure vata – pitha –kapha diseases, hyper acidity, diabetis, etc. It can give coolness to the eyes and increases eye sight. It can give strength to nadis and increases intelligence.

(d) Vertiveria Squarosus [Ramacham]

The roots contains a –vertivone and b – vertivone. It also contains khusol, iso – bisobolin, C -14 –Ketone, cisanoin, livogaisol, epi cisanoic acid, etc.

(e) Cyperus rotundus [Muthanga]

It contains carbolydrate, sugar, resin, albumin, perfumed oil, alkaloids, etc. It is used as medicine.

(f) Centella Asiatica [Kudangal]

It is used in Ayurveda medicine. It contains amino acids, aspartic acid, glycine, glutamic acid, phenyl alanin, etc. Its ash contains chloride, phosphate, iron, calcium, magnesium, sodium, etc. Gacitosterol is isolated from kudangal. It is used to cure kapha – pitha diseases.

(g)Amaranthus (Grain)

The grains of amaranthus is also used for water treatment after grinding well. Experiments conducted in the laboratory shows that it can destroy bacteria (E.coli and Streptococci).

RESULTS AND DISCUSSION

Goseberry, Ramacham, Muthanga, Amaranthus grain, Thettamparal and Kudangal are taken in equal quantities ground well, wrapped in a cloth bag sterilized and put in the well for water purification. 50g of the mixture is needed for a normal well. The quantity of mixture can be increased according to the rate of pollution. This mixture can be applied in the case of well water samples, whose hardness is very low because the mixture increases hardress slightly. Strychnos potatoum can be employed for water treatment. Recent studies revealed that it can remove all the dissolved constituents from water and destroy bacteria. Studies were conducted in the laboratory to find out the efficiency of this nut. The study revealed that it can destroy E coli and Faecal streptococci from water. It can be employed to treat the well water samples whose hardness values are higher.

Experiments conducted in the laboratory shows that maximum reduction of bacterial density occurs within 1hour time period with the mixture. Presence of Amaranthus grains in the mixture increases the rate of bacterial removal.

Experiments were conducted in the laboratory to find out the efficiency of Rudraksham in water treatment. Panchamukhi Rudraksham [which has 5 faces], taken fresh from the tree has been used for the study. Experiments conducted in earthen pot gave better results than using glass vessel. One Rudraksham which has a weight of approximately 3 gm is placed in a glass of water before going to sleep. In the morning, after removing the Rudraksham and the water can be used for drinking purposes. The results of nine days' analysis are given in the Tables 7.1 and 7.2. The salient findings are given below.

(i) pH has been found to be neutralized (ie.7) irrespective of it was acidic or alkaline before

(ii) There was a slight reduction in conductivity, and inorganic constituents like hardness, alkalinity, chloride, etc.

(iii) There was reduction in MPN index, the density of E. coli and Faecal streptococci were also found to be reduced. The reduction has been found to be maximum within 1hour time period.

Table 7.1

Treatment of water using Rudraksham in earthen pot same Rudraksham has been used for all the days

Wt Rudraksham = 3gms (1no)
Vol of water = 700ml

After 15hrs.	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	9th day	Control
P^H	7.1	7.6	7.4	7.2	7.3	7.2	7.5	7.2	7.1	8.2
EC	70	60	60	70	60	60	60	60	60	60
Total Hardness	9	8	13	10	10	10	8	9	10	14
Alkalinity	18	10	10	15	14	17	17	16	15	7
Chloride	26	25	25	24	18	17	17	24	19	26
Iron	A	A	A	A	A	A	A	A	A	A
MPN / 100ml	1100	210	210	120	120	43	43	28	28	≥ 2400
E coli	+Ve	+	-	-	-	-	-	-	-	+Ve
Fecal streptococci	1100	210	210	93	93	23	23	23	23	≥ 2400

Table 7.2

Experiments with the mixture after 1hr in glass vessel

Wt mixture = 30gm.
Vol of water = 1000ml

After 1hour	Mixture in glass vessel		Mixture put in clay pot	
	After Treatment	Control	After Treatment	Control
P^H	8.5	6.7	7.2	4.4
Ec (Micro mhos/cm)	20	30	210	130
MPN / 100ml	28	2400	2400	28
Fosecal streptococci	20	2400	1100	210

SUMMARY AND CONCLUSIONS

The present investigation deals with systematic monitoring of important parameters in different water samples collected from Kozhikode Corporation, rural areas of Kannur and Kasaragod districts and a tribal area of Kannur district. Water quality index of different samples have been calculated. New methods of drinking water and wastewater treatment has been tried. Statistical techniques used in this study are

- Correlation analysis

  Multiple correlation analysis

- Water quality index

Values of WQI of wells during pre monsoon, monsoon and postmonsoon seasons and after treatment have been calculated using statistical programme.

Piper trilinear diagram have been constructed for ground water samples of Kozhikode district.

A systematic hydro chemical study of the ground water resources of Kozhikode Corporation area have been carried out to examine the suitability of water for drinking purpose.

The study has been conducted at Kozhikode, Kannur and Kasaragod districts of Kerala. In Kozhikode Corporation area, 14 wells have been identified and water samples were collected and analyzed to find out its quality. The results show that most of wells are contaminated and hardness ranges from moderately hard to very hard. One bore well alone was found to be potable and 86% of the wells were found to be microbiologically contaminated. The wells were treated using, aquatic plant – Langenandra, fish like Cyprimus Carp and Strychnos potatorum. Strychnos potatorumm was found to be very effective in the removal of dissolved constituents and bacteria from water.

A study has been carried out at Kannur and Kasaragod districts to find out the bacterial contamination of ground water sources at four panchayats. The study revealed that in these rural areas, all the wells are microbiologically contaminated and none of the wells were found to be potable. Presence of E coli and faecal streptococci in the samples indicate that the contamination is from faecal matter, ie., due to poor sanitation facilities in the area. Open dug well without parapet wall and platform was found to contain higher levels of faecal coliforms than others. Septic tanks exhibit some reduction in the contamination Wells near single pit latrines have high level of contamination compared to wells near double pit latrines.

A tribal area of Kannur district at Payyavur panchayat has also been selected for the study. Water samples were collected during the three seasons of the year and analyzed to find out its quality. The results of the study showed that all the samples are very soft and microbiologically contaminated. None of the wells were found to be potable. The well water was then treated with a mixture of plant materials consisting of Goosberry, Muthanga, Vertiver, Kudangal, Thettamparal and grains of Amaranthus. They were taken in equal quantity, powdered well wrapped in a cloth bag and put in the wells. After 15 days, the samples were tested to find out the improvement of its quality. The results show that there is reduction in the faecal coliforms and quality has been found to be improved.

Correlation between the parameters and water quality index for the wells were also calculated. Domestic wastewater has been treated using constructed wetland. Plants like Scheonoplectus Lacustris, Phragmites Karka,Acorus Calamus, Pistia, Lagenandra and Eicchornia spp. etc. has been tried in the wetland. Fish like guppies has also been employed to prevent mosquito growth. The results show that Eicchornia (Water Hyacinth) was found to be very effective. Vermicomposting is the safest, low cost and ecofriendly way of converting solid waste into vermicompost, which is a very good biofertiliser. Thus the environmental pollution due to solid waste and waste water can be reduced. The constructed wetland discussed above requires space, which is very limited in urban areas. A constructed wetland suitable for individual house hold, which requires limited space only, has also been designed. Rudraksham and the above discussed mixture of the plant materials were found to be very effective for drinking water treatment in each house. They are very efficient in the removal of bacteria from water with in a short time period of one hour. This method of drinking water treatment is very useful to common man.

In conclusion it can be said that the present studies are able to provide the following inference.

1) The metallic concentrations and various parameters of ground water samples of North Malabar area are found to be good with in the permissible limits. In Kozhikode Corporation area the ground water samples are moderately hard to very hard. In Kannur and Kasaragod districts, the ground water samples are very soft. In the tribal area of Kannur district also the samples are very soft. In all these areas bacterial contamination occurs and it is very high in the rural areas of Kannur and Kasaragod districts.

2) The study provides a good understanding of the correlation of various parameters and a fairly good idea of comparison of WQI values before and after treatment

3) The only source of pollution in the study area is that of bacteriological origin and useful methods are suggested for effective removal of this pollution based on a series of experiments.

4) A successful method of constructing artificial wetland for wastewater treatment has been developed and is tested experimentally.

5) Experiments were conducted in the laboratory to find out the efficiency of Rudraksham and a powdered mixture of Gooseberry, Muthanga, Vertiver, Thettamparal,grains of Amaranthus and Kudangal in improving the water quality, especially of North Malabar area.

6) Modern statistical tools have been utilized effectively in interpretation of data.

The results obtained from the above studies are presented in the thesis as detailed below. While in the first two chapters introduction and review of the work are presented, the third chapter is devoted to experimental aspects. The data and discussion related to water, WQI, wastewater treatment and method of improving WQI are presented in chapter IV, V, VI, and VII. Summary and conclusions are described in the final chapter.

International Drinking Water Standards

Parameter	WHO In mg/1	IS 10500 BIS Desirable limit In mg/1
Calcium (Ca)	-	75
Chloride (Cl)	250	250
Coliforms (E. coli) (organisms/100mL)	0	0
Coliforms (Total) (organisms/100mL)	0	10
Color	15HZ	5HZ
Fluoride (F)	1.5	1.0
Hardness	-	300
Iron (Fe)	0.3	0.3
Magnesium (Mg)	-	30
Nitriate/ Nitrite (Total) (N)	-	-
Nitrates	50.0 (as NO_3)	-
P^H	6.5 - 8.5	6.5 - 8.5
Potassium (K)	-	-
Sodium (Na)	200	-
Solids, Total Dissolved	1000	500
Suifate (SO_4)	250	200