ASSESSING THE GROUND WATER QUALITY IN COIMBATORE

By

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CERTIFICATE

This is to certify that the dissertation entitled **"Assessing the Ground Water Quality in Coimbatore"** submitted to Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore for the award of the degree of **MASTER OF PHILOSOPHY IN RESOURCE MANAGEMENT** the record of original research work done by **A. LAKSHMI PRIYA** during the period of her study in the Faculty of Home Science, Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore under my supervision and guidance and thesis had not formed the basis for the award of any Degree/Diploma/ Associateship/Fellowship or other similar title to any candidate of any University.

30. 8. 2004

Signature of the Guide

Signature of the Head of the Department

DECLARATION

I hereby declare that the dissertation entitled **"Assessing the Ground Water Quality in Coimbatore"** submitted to Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, is the result of investigation carried out by me in the Faculty of Home Science, **DEPARTMENT OF RESOURCE MANAGEMENT,** Avinashilingam Institute for Home Science and Higher Education for Women (Deemed University), Coimbatore, and has not formed the basis of the award of any Degree/Diploma/Associateship/Fellowship or other similar title to any candidate of any University.

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Signature of the candidate

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INTRODUCTION

The ability to see, hear and speak are useless in the absence of adequate water

- Atharvana Veda

Water is an essential natural resource and an absolute necessity for sustaining life. It is the life blood of the environment and the human beings solely depend upon the availability of water for living and livelihood (Rao and Kumar, 2000). Water is the most fabulous gift of the nature supporting it's creation and is described as one of the 'panchbhutas' in our ancient vedas. Water plays a unique role in the traditional economy and culture of the native people and in it's natural state is a 'life saviour'. Today, by ignoring these facts man is indiscriminately polluting water and unknowingly providing the nature a complex situation (Randhawa and Sarma, 1997).

The Indian subcontinent is one of the wettest places on earth. Although $1/4^{th}$ of world's surface area is covered by water, still we are thirsty. Today about 40 per cent of the world's population depend upon sound water sources (Chhatwal, et al., 1999). However, the water distribution is not uniform in all countries. India alone has 2.45 per cent of the world's fresh water resources for it's country's population which is about 16 per cent of the world's population. According to the National Commission of Agriculture, in the year 2025, the utilizable water resources of the country would be 105 m.ha.m (Subramanian, 2002).

The predicted water demand for future is alarming (Ou, 2001). In India, there is a clear visible threat on the quality of water. Continued economic growth, urbanization and industrialization, increase in health

consciousness and jumbo increment in global population are creating enormous stress and threat on the limited fresh water sources. The indiscriminate disposal of liquid waste, solid waste, toxic substances, garbage and other wastes by industries and community, induces an even greater concern for water resources (Rao, 1997). All these factors directly lead to increase in demand for good quality water (Subramanian, 2002).

Gross misuse of water resources cause widespread degradation of soil, disrupt the supply of potable water and generate massive economic loss (Agarwal and Narain, 1997). It is predicted that nearly 1.4 billion of the world's population would face severe water shortage in the new millennium (Schmitz, 1996). Pollution due to human activities has destroyed aquatic logo, inhibited the reproductive capacity of mammals and birds and has posed a serious threat to human health. The results of man made crisis has also resulted in global warming, bringing about changes in the climatic condition and disturbances in the natural cycle (Ignacimuthu, 1998).

Of all the natural resources available, water is probably the most critical resource (Satake, et al., 1994). Natural conditions and human activities, over the years, have affected the quality and quantity of the available water. The standards of the quality of drinking water were legally defined, strenghtening their safety networks (Abbasi, 1998). But sanitation has not received much attention, leading to the poor state of affairs. Provision of safe drinking water is a political and social problem rather than a technical one. In the developing world, it is intimately connected to the issue of poverty, underdevelopment and depletion of the ecology (Vaidyanathan, 2003).

The groundwater resources are of vital importance to all. The nature replenishes the groundwater resources annually through rainfall by way of infiltration through soil layers. However, the water resource scenario presents a rather critical picture, especially the status of ground water development and availability of water is causing great concern (Raphael, 2002). This is due to urbanization and concretisation in turn affecting the natural percolation of rainwater into the ground, resulting in drying up of wells. Apart from the severe threat to sustainability of the sources due to indiscriminate groundwater depletion, quality problem in drinking water, emerging as major issue has added a new dimension to the problems in the sector. It is therefore necessary to conserve and augment the renewable natural groundwater. The need for conservation and optimising the available resources is thus paramount (Ignacimuthu, 1998).

Rain is the parent source of all the water available in the world (Randhawa and Sarma, 1997). The quantity of rainfall is eractic, reduced and uncertain. As per the Indian Meteriological Department, most of the rainfall in India (76 per cent) occurs as a result of the South-West Monsoon between June and September. However, because of the topographical, hydrological and other constraints, only 690 BCM of the water can be utilized. Together with annual replenishable groundwater resources of 432 BCM, the total utilizable water in the country is assessed as 1122 BCM (Saxena, 2003). To ensure adequate supply of good quality groundwater for the people today, as well as for future generation, every effort to protect the quality and quantity of our groundwater is of utmost importance, since, polluted groundwater is the major cause for the spread of epidemics and chronic diseases such as typhoid, jaundice, dysentry, diarrhoea, tuberculosis and hepatitis (Sharma and Kaur, 1995).

Due to severe depletion of groundwater levels in urban areas, open wells and bore wells have gone dry (Paneerselvam and Ramakrishnan, 1996). If this phenomenon continues, the natural calamity may be invited. It is therefore in the interest of mankind to restore the natural balance by natural means aided with modern technology. In fact, the magnitude of the water problem has brought to life the saying that "necessity is the mother of invention" (Sinha, 2003). Conservation of ground water is important because it takes years to be replenished. In areas where groundwater is used, care must be taken to minimize the quantity of water withdrawn to bring it on par with the quantity of water that is replenishable (Agarwal, et al., 2001).

We have not realised the value of each drop of rain water (Devi and Kumari, 2003). Rainwater harvesting is the process of augmenting the natural infiltration of rainwater or surface run-off into the ground by some artificial methods. Water harvesting can no longer be labelled a technology of the past and fit only for the poor and rural areas. Water harvesting is as relevant today for the rich as it is for rural areas. Equally, it is as relevant for arid areas as it is for high rainfall, humid regions. It is a universal technology which is relevant to all with location - specific application (Bhushan, et al., 1998). There is clearly an urgent need to give greater importance to harness local rainfall and local run-off to meet water needs, thereby achieving a better balance of surface and groundwater (Subramanian, 2002).

One of the main and major problem that is confronting Tamil Nadu is the water scarcity. It has been stressed that safe water, being one of the necessities of life must be freely available to all. A new paradigm in water management is already emerging due to the efforts of both government and non-government agencies. A survey of developments within India in the

past decade, shows that numerous projects have been undertaken to promote local water harvesting both in urban and rural areas to improve the ground water table (Randhawa and Sarma, 1997). It is not just important to promote water harvesting projects but it is equally important to protect and revive the existing water harvesting structures both in urban and rural India to their fullest potential, since, it improves the local ecology and the living standard. Rain water harvesting is an ideal solution to mitigate water problem and should be essentially local (Agarwal, et al., 2001). The effort should be to make each locality manage it's own water needs through water harvesting and conservation schemes. The thrust in future planning in respect of water must be towards bringing about a vast network of thousands of local initiatives (Chary and Vyasalu, 2000). All efforts should be directed towards strengthening institutions, scientifically and technologically, training the existing manpower and exchanging information and integrating knowledge by complementing the efforts of agencies dealing with environment (Ghanta and Rao, 1998).

There is also a need for a more regular basic monitoring of the drinking water quality. It should be the aim to decentralize the basic water quality monitoring to the lowest appropriate level and ensure the result. The provision of water supply without ensured quality may defeat the purpose of the whole exercise (Khopkar, 1998). It is estimated that nearly 70 per cent of water available in India is polluted (Sastri, 1996). The growing scale of cultural and technological development poses new threats to water quality. Quality monitoring of water supply involves sampling and testing of public supply sources at specific intervals to assume that water standards are

maintained. Constant and regular monitoring can ensure and help in effective water quality management in order to avoid use of contaminated water (Anjaneyalu, 2002). With this backdrop, a study is framed to assess the groundwater quality in selected areas of Coimbatore to ensure permissible standards.

Objectives:

1. To assess the impact of the rainwater harvesting units put up at households.
2. To analyse and compare the status of groundwater.
3. To promote and create awareness of water conversation and
4. To increase consciousness on groundwater quality.

Review of literature

II REVIEW OF LITERATURE

The literature pertaining to the topic are reviewed under the following headings:

A. Water crisis - causes and impact

B. Groundwater quality and biological contamination

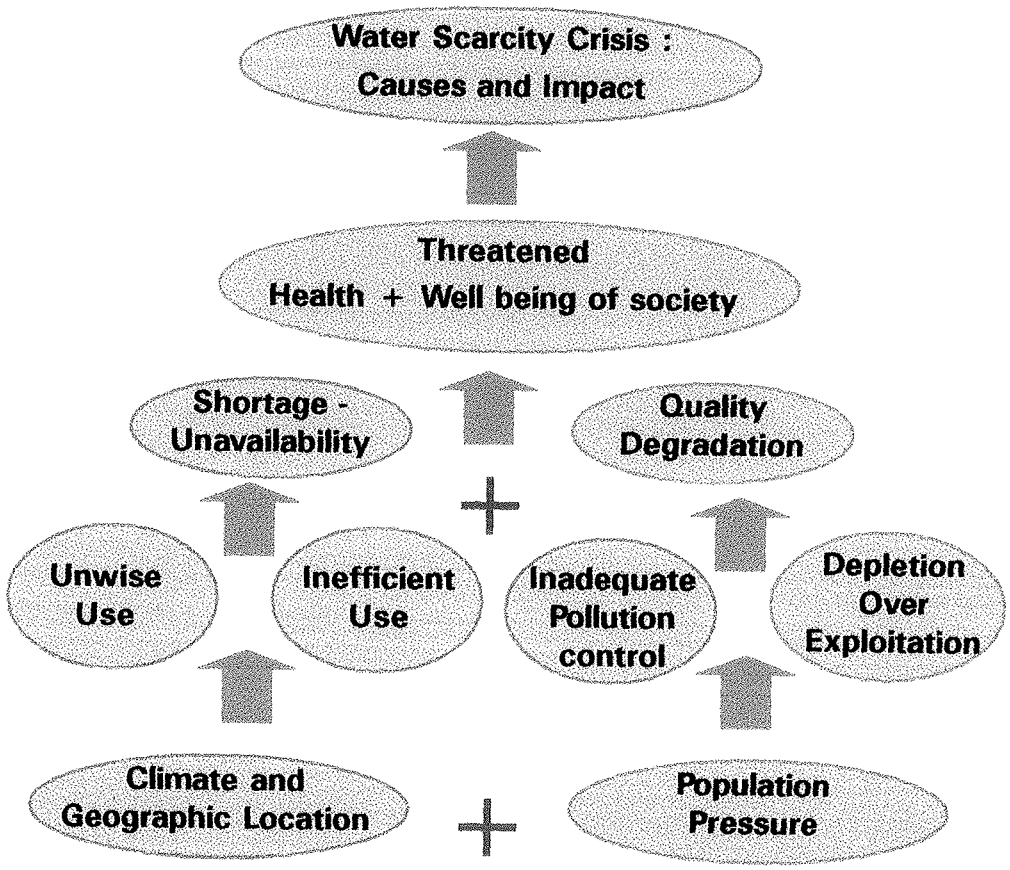
C. Community participation towards water conservation

D. Programmes and policies for conserving water quality

A. *Water crisis - causes and impact*

Water is an essential commodity for survival of mankind and other living organisms on earth. Indian mythological evidences prominently indicate the great efforts of Bhagiratha in bringing water to the mother earth (Rao and Kumar, 2000). Water resources are renewable and can constantly be refreshed and recycled by the hydrological cycle (Ball, 2004). Water is used for different purposes throughout our economies and natural ecosystem. The socio-economic development, population size, climatic conditions and the physical nature of a region determine the water use levels around the world (Gleick, 2000).

Although the fact that everything on our planet grow and prosper polluting the rivers, lakes and oceans subsequently, slowly and surely harm our planet to the point where organisms are dying at a very alarming rate (Huang, et al., 2004). For the first time in the history, mankind has entered a new century to face the threat by self inflicted extinction, with explosive population growth bringing not just more people but also more pollution, thus moving environmental issues from a peripheral to central concern of the global agenda (Saxena, 2003). The condition is expected to further worsen due to continued population growth by 2050 A.D., taking the projected annual per capita availability of water 1168 cu.m to the threshold of water scarce conditions (Gadgil, 1998) (Figure 1).



Water scarcity crisis - causes and impact

Figure 1

The reasons for water scarcity are failure of the monsoon, destruction of forests and over population leading to water table depletion. An enlightened mystic of this age, Osho, has proclaimed that the third world war can break due to water or rather, lack of it. The statistics report the same, as the share of fresh water per person decreases globally and the population demanding it increases. There are bound to be conflicts which as history dictates can lead to military acts and ultimately, a world war (Garg, et al., 1995).

The phrase "Water wars" often find a mention in a variety of reports ranging from World Water Commission to the Government of India. It is believed that the challenge of 21st century would be that of raising water availability presenting a picture of acute water shortage and the situation is becoming worse in the days ahead. Drought has become a regular phenomenon in our country, engulfing many areas. In the year 2002, the country witnessed the worst drought (Vaidyanathan, 2003). An international research study and United Nations Population Projection indicates that India will be among the 34 countries of the world, likely to face severe water shortage by the year 2025 (Chand, 2002).

Pollution and scarcity of water resources and climate change would be the major emerging issues in the next century (Gupta, et al., 1996). Around one-third of the world population at present live in countries with moderate to high water stressed condition says the GEO (Global Environment Outlook) 2000, the UNEP's millennium report. About one-fifth of the world's population lack access to safe drinking water and with the present consumption pattern, two out of every three persons on the earth would live in water-

stressed condition by 2025. More than 2000 million people would live under conditions of high water stress by the year 2050. The UNEP (United Nations Environment Programme) warns that water could prove to be a limiting factor for development in a number of regions in the world (Jogi, 2000).

It is estimated that by 2025 the total water requirement will exceed the available water resources and by 2050 A.D., 22 per cent of the geographical area and 17 per cent of population of the country will be under absolute scarcity conditions having access to water availability of less than 500 cu.m/year and 70 per cent of the area and 76 per cent of population will be on the verge of affected health and economic activities with access to water availability of less than 1000 cu.m/year, which is identified as stress or scarcity level (Saxena, 2003).

The scarcity however can be prevented by not wasting water unnecessarily, providing proper provisions to store water, keeping the tanks and dams in good condition and preventing destruction of forests (Kannan, 1997). To create an awareness on the threat faced by the earth, World Environment Day was celebrated by the United Nations General Assembly to mark the opening of the Stockholm Conference on Human Environment. The theme for the World Environment Day - 2003 being 'Water - Two Billion Dying for it' (Saxena, 2003).

B. Groundwater quality and biological contamination

The planet earth is unique because it has water which supports life and mankind (Humphrey, et al., 2002). Rain and snow, the basic water resources responsible for the formation of rivers and lakes seeps into the

ground to form groundwater storages (Ravi, 1995). India has diverse hydrogeological setting giving rise to varying groundwater situations in different parts of the country. The annual groundwater recharge largely depends on the hydrogeological and climatic conditions (Ghosh and Verma, 2002).

India is tottering on the brink of a nationwide drought situation (Sabri, 2004). This predicted water demand for future is quite alarming, focussing the need for considerable groundwater resource to be developed (Ghanta and Rao, 1998). Use of groundwater and its scientific management will obviously be an important strategy for the development. Concentrated efforts have to be put in for planning safe and optimum utilisation of the groundwater resources of the country based on the principles of techno-economic and ecological efficiency and equity (Sivanappan, 1999).

Of all the receptor systems exposed to the contaminants, ground water has received little attention in the past because of the common belief that groundwater was pristine (Bhushan, et al., 1998). However, the water resource scenario presents a rather critical picture, especially causing concern over the status of groundwater development and availability (Bali, et al., 2002). Apart from the severe threat to sustainability of the sources due to indiscriminate groundwater development, quality problem in drinking water emerging as major issue, has added a new dimension to the problems in the sector (Chand, 2002). Figure 2 depicts the extent of groundwater depletion in quantity and quality.

Groundwater, which is the main source of drinking water has become a cocktail of chemicals and human waste (Vaidyanathan, 2003).

Excess rainfall but poor storage

Poor groundwater quality causes concern

THE HINDU, SUNDAY, JULY 4, 2004 CITY

SAMPLES TESTED / EXCESSIVE EXPLOITATION, LACK OF MECHANISM

'Quality of water in India among the worst'

pH of rainwater

TAMIL NADU

THE HINDU, Tuesday, March 30, 2004

High TDS levels in Coimbatore groundwater: survey

By V.S. Palanlappan

COIMBATORE, MARCH 29. A recent study on the quality of water in and around Coimbatore city has expressed concern at the presence of high levels of Total Dissolved Solids (TDS) in groundwater.

During 2003-2004, the CPR Environmental Education Centre (CPREEC) conducted the survey in Coimbatore. The crisis in both availability of water and pollution is worsening with each day. On the one hand, the groundwater table was going down rapidly, and on the other, the quality was getting worse, said the survey report. It was released recently at a seminar on "Water Quality and Resources Management in Coimbatore City."

Samples were taken from 130 different sources, largely borewells and wells. One sample was taken from water supplied from the Siruvani. It was taken from an overhead tank in the Veerakeralam town panchayat. The samples were tested and analysed at the CPREEC laboratory in Chennai. The samples were collected in well-cleaned plastic bottles and transferred to the laboratory under cold condition. They were tested as per the methods recommended by the Bureau of Indian Standards and the American Public Health Association. The samples were tested for colour, odour, turbidity, pH, electrical conductivity, TDS, alkalinity, chloride, total hardness, calcium, magnesium, sulphate, phosphate, nitrate, fluoride and manganese.

The TDS levels exceeded 500 mg per litre in at least 88 per cent of the groundwater samples and only 12 per cent showed the desirable limit of 500 mg per litre or less as per the drinking water specifications, IS 10500:1991. Twenty-three per cent of the samples contained more than 2,000 mg per litre of TDS, the maximum permissible limit. Based on the TDS content, the water was classified as potable, less brackish, moderately brackish, highly brackish and brine.

High levels of TDS would affect water taste and lead to gastrointestinal irritation. Samples collected from 50 sources contained more than 100 mg per litre of nitrate, the maximum permissible limit in drinking water. Excessive nitrate content was hazardous to infants. For, the nitrates would turn into nitrites in the intestinal track and cause the blue baby syndrome, the report cautioned. Higher levels of lead content beyond 0.05 would lead to hypertension, anaemia and constipation, while sulphate beyond 200 mg per litre would lead to dysentery and pH content beyond 6.5-8.5 units per litre would affect the mucous membrane.

The survey report said proper resource management and rainwater harvesting could ease the situation considerably. When water contained more salt, more freshwater was being added to dilute the taste; likewise by enabling more percolation or infiltration of rainwater, salinity and the TDS levels could be reduced. Overexploitation of groundwater should be stopped on a war-footing, the report said.

Recommending available technology for removing the TDS and nitrate levels, the report suggested that reverse osmosis, electro dialysis, distillation, ion exchange and solar still could be taken up. Of these, only the solar still belonged to the low-cost technology category but it would produce very little water and only on sunny days. Hence, rainwater harvesting was the need of the hour to tide over the problem over a period of time, concluded the report.

The C.P. Ramasamy Aiyar Foundation, in association with the Ministry of Environment and Forests, Government of India, established the CPREEC, a centre of excellence.

Extent of groundwater depletion in quantity and quality

Figure 2

The factors affecting groundwater quality are rainfall pattern, depth of water table, distance from the source of contamination, and soil properties such as texture, structure and filtration rate. Today human activities are constantly adding industrial, domestic and agricultural wastes to groundwater reservoirs at an alarming rate (Handa, 1997). Excessive mineralization of groundwater degrades water quality producing an objectionable taste, odour and excessive hardness. Although the soil mantle through which water passes acts as an adsorbent retaining a large part of colloidal and soluble ions with its cation exchange capacity, the groundwater is not completely free from the menance of chronic pollution (Sharma and Kaur, 1995). The problem is particularly serious when the polluted water has accumulated in deep layers of rock where there is very little oxygen available for purification preventing efficient natural decay and cleaning. Assessing the full extent of the pollution of underground resource and purifying these systems artificially is very difficult (Ignacimuthu, 1998).

Water being precious, finite and in view of the growing demand, ultimately is a scarce natural endowment (Kalyanaraman, 2002). Water quality is closely linked to water use and to encourage sustainable development, increasing standards of living without destroying the environment is necessary (Chaurasia, 1992). The water quality depends on the intended use of the water which may be consumptive (human consumption) and non consumptive (industries, agriculture, power generation, recreation etc.) (Dhameja, 2000).

According to the latest UN report, the water quality in India is third worst in the world. Water resources in India as elsewhere in the world, have large temporal and spacial variability leading to the poor water quality

condition. Clean water is our most precious resource. But more than one fourth of the world's reliable water supply could be rendered unsafe for use by the year 2010 (Saxena, 2003). Potable or drinking water is defined as having acceptable quality in terms of its physical, chemical and bacteriological parameters so that it can be safely used for drinking and cooking (Kudesia, 2000).

Water quality has degraded throughout the country with intensive agriculture and industrialisation (Compendium of environment statistics, 2000). Arsenic pollution of drinking and irrigation water has emerged as a massive health threat in India, where wells drilled are tapping poisoned water (Huang, et al., 2004). Common water pollutants are petroleum products, pesticides and herbicides, heavy metals, hazardous chemical wastes, fertilizers and sediments (Kumar and Varma, 2004). Sewage and not the industrial pollution accounts for more than 75 per cent of the surface water contamination in India. Due to negligence, groundwater is increasingly getting contaminated (Vaidhyanathan, 2003)

Water-borne diseases from fecal contamination of surface waters are a major cause of sickness and death in the developing world (Kumar, 2001). The World Bank estimates 21 per cent of communicable diseases in India are water related. Of these diseases, diarrhoea alone killed over 700,000 Indians in 1999. The highest mortality from diarrhoea in children under the age of five, highlights an urgent need for focussed interventions to prevent diarrhoeal diseases in this age group. Estimates suggest that nearly 1.5 billion people lack safe drinking water and that atleast 5 million deaths per year can be attributed to water-borne diseases. While water-borne diseases

have been eliminated in the developed world, outbreaks of cholera and other similar diseases still occur with alarming frequency in the developing countries (Colwell, 2003).

Since world war II and the birth of the "Chemical age", water quality has a heavy impact worldwide by industrial and agricultural chemicals (Cunningham and Saigo, 1995). Eutrophication of surface water from human and agricultural wastes and nitrification of groundwater from agricultural practices has greatly affected large parts of the world. Acidification of surface water by air pollution is a recent phenomenon and threatens aquatic life in many area of the world (Krantz and Kifferstein, 2003).

Many causes of pollution including sewage and fertilizers contain nutrients such as nitrates and phosphates. In excess levels, nutrients over-stimulate the growth of aquatic plants and algae. Excessive growth of these types of organisms consequently clogs water ways; use up dissolved oxygen as they decompose, and block light to deeper waters. This in turn, proves harmful to aquatic organisms as it affects the respiration ability of fish and other invertebrates that reside in water. Under natural conditions, lakes, rivers and other water bodies undergo eutrophication, an aging process that slowly fills in the water body with sediment and organic matter, impairing fish respiration. Pollution in the form of organic material enters waterways as sewage, leaves and grass clippings, or as runoff from livestock feedlets and pastures. The natural bacteria and protozoan breakdown the organic material to use up the oxygen dissolved in the water. When the levels of dissolved oxygen drop below two to five parts per million, naturally the aquatic organisms is killed in large numbers distrupting the food chain (Krantz and Kifferstein, 2003).

To ensure an adequate supply of good quality groundwater for the people today, as well as for future generations, every effort need to be made to protect the quality and quantity of the groundwater (Schwab, et al., 1996). It is not simply an instance where prevention is better than cure but where the prevention is the only available solution (Singh, 2001).

C. Community participation towards water conservation

In order to overcome the alarming water crisis both in quantity and quality an urgent ordinance was passed to harvest the rain. The history of human civilization is entangled with the history of the ways, humans have learned to manipulate and use fresh water. Water harvesting systems in various forms are prevalent in India since ancient times (Kishore, 2004). Numerous references are available in vedas and ancient scriptures. Over a period of time, these practices have undergone continuous refinements and modifications depending upon the location specific objectives and needs of the people (Samra, et al., 1996).

Long term solutions to the Indian and essentially global water crisis include tackling the problem of over-population inorder to decrease the demand for water (Singh, 1992). In addition, not only new ways of water conservation are needed but infact the old ways of water consciousness of recognizing the true value of water is essential (Andrew and Jackson, 1996). Efficient methods of harvest, increases 40% of unused water to be utilized, as well as lessening the risks of floods and national problem of water stress. Water harvesting has traditionally meant valuing the raindrop and water conservation. The simple urban rainwater harvesting which is quite low in cost can provide water around the year. This new move can free water shortages (Palanisami, et al., 2001).

Groundwater being a dynamic and replenishable resource, the average annual recharge could safely be subjected to development by means of suitable groundwater structures and harnessed for various purposes, especially for irrigation (Trivedi and Raj, 1992). Currently the strategy for development of this resource is based on using the dynamic component by adopting available groundwater resources to optimum use such as, using the static groundwater component to cope up with drought situation, enhancing natural recharge potential through rainwater harvesting and soil conservation methods and artificial recharge techniques (Rao and Kumar, 2000).

The value of groundwater as a source to meet the needs of the ever increasing population is highly significant (Singha, et al., 1999). Protecting groundwater as a primary source of drinking water is becoming critical both for maintaining the sustainability of existing investments as well as for meeting future requirements with affordable alternatives (Iganacimuthu, 1998). Groundwater resource is a vital and limited resource. Though the official figure of utilization of groundwater is about 60-70 per cent, in reality it is much more. Almost 85 per cent of rural drinking water needs are met from groundwater, 50 per cent of total groundwater extraction is needed for domestic water supply, while, irrigation accounts for 90 per cent and industry takes the remainder 5 per cent (Chand, 2002).

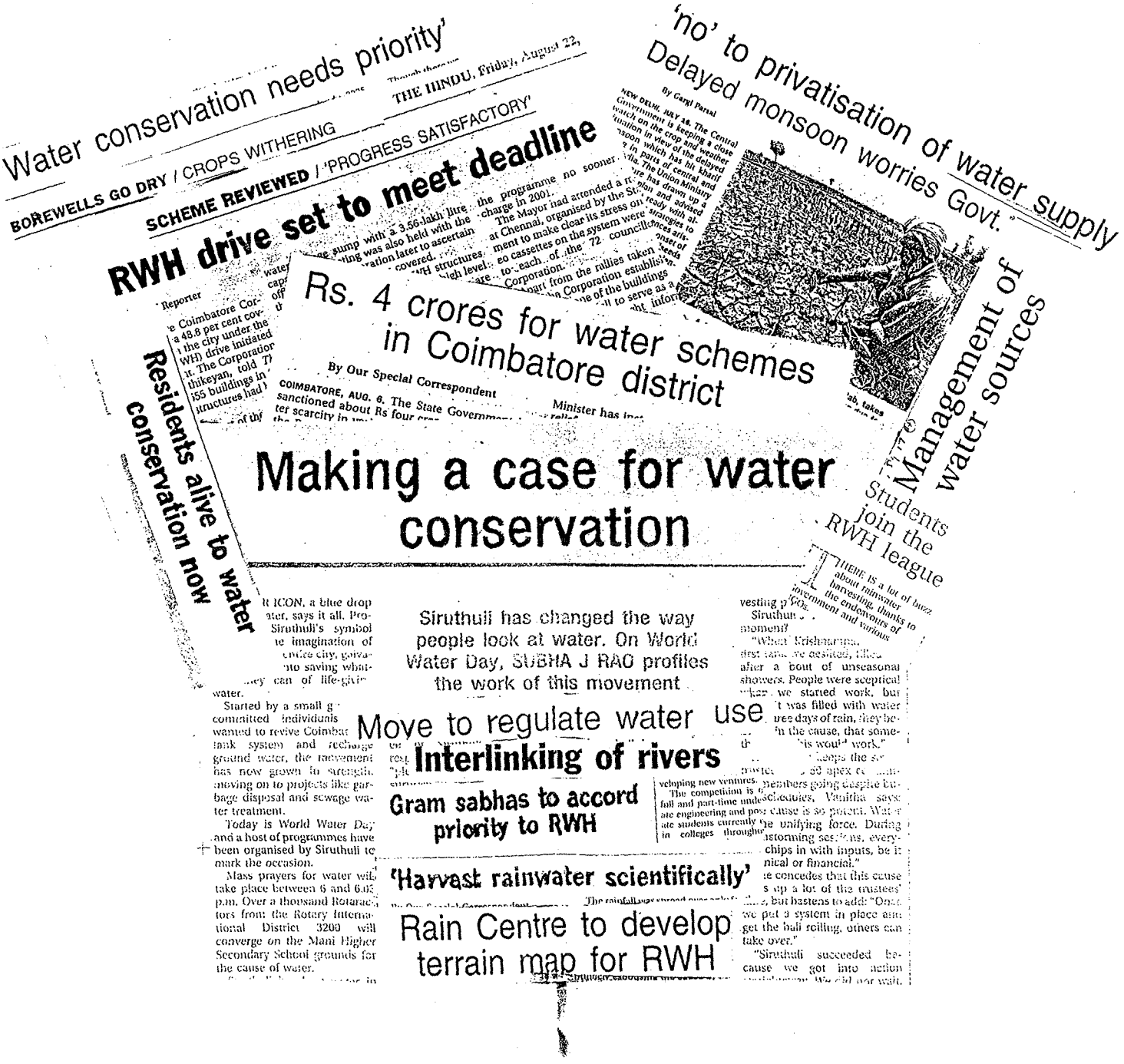
The Indian agrarian economy largely depends on water (WAPCOS, 2002). Without water there is no activity and without pure water life is impossible. Groundwater is often hidden from sight and a large number of human activities are directly contributing to the groundwater pollution (Bhushan, et al., 1998). Studies carried out in India reveal that, most important cause for groundwater pollution is unplanned urban development,

industrialization without adequate attention to sewage and waste disposal (Rao, 1997). Concentration of population in selected areas has also resulted in over exploitation of groundwater, besides recharge not being kept in pace with the rate of utilization (Trivedi and Singh, 1994). Thus in India, there is a clear visible threat on quality and utilization of water sources. Sincere attempt is to be made to replenish the groundwater table by conserving rainwater during monsoon (Devi and Kumari, 2003).

In this context harvesting rainwater in urban and rural areas to recharge the groundwater assumes importance and has been accorded highest priority by the Government of India (Saxena, 2003). Groundwater technology have been revived through artificial recharging and harvesting rainwater to the maximum extent possible with minimum cost effect (Mathew and Senthilvel, 2003). Rainwater improves the quality of groundwater through dilution and enhances water yield in wells. If groundwater is systematically recharged with rainwater, the grey areas will be converted into white areas with regard to groundwater storage (Devi and Kumari, 2003).

Rainwater is pure, free from organic matter and bacteria and soft in nature (Singh, 2002). With the proliferation of complexes and concretisation, all the areas have been paved and percolation of rainwater into the soil is almost arrested. It is the responsibility of the government and every citizen to rise together to battle this problem (Trivedi and Raj, 1996). Figure 3 is a proof for Government and peoples efforts in sensitisation drive and acceptance of measures to improve water quality.

Water conservation and water recycling can solve water scarcity (Sodhi, 2000). But the combinations of more people and more prosperity will



Proof for Government and peoples efforts in sensitisation drive and acceptance of measures to improve water quality

Figure 3

cause water requirements to grow geometrically. Water scarcity is a myth. The need for regulating the extraction of groundwater arises from the consideration of protection of resource against over-exploitation and quality degradation, to ensure social equity to guarantee minimum provision to all sectors of the society (Chand, 2002).

Over many parts of Tamil Nadu, Karnataka, and Andhra Pradesh, exceptional stresses on water resources have led to rain harvesting as a means of intercepting flows that may otherwise be "lost" as run-off to the ocean, and put them to immediate beneficial use. While attractive in the short-term, intensive rain harvesting over long periods of time has the potential to seriously impact groundwater levels, aquatic habitats, and sediment supplies (Ramesh, et al., 1998).

In principle, harvesting consists of intersecting rainfall where it occurs, saving the water in various storage structures, and beneficially using it locally. The reasoning is that the water is captured for beneficial use. Modern science unequally believes that life cannot exist without water. It is within this simple, and yet profound framework that rain harvest needs to be understood (Murty, 1994).

Surfacewater that flows in streams plays an extremely important role in transporting sediments and nutrients, as well as sustaining the habitats of many plants and animals, collectively referred to as ecosystems (Prabhakar, 2001). Water that infiltrates underground partly remains in the soil, sustaining plant life, and partly remains below the water-table in the form of groundwater. This groundwater feeds natural springs and the wells that supply domestic, agricultural, and industrial needs. Observations made

in California have shown that groundwater gets significantly recharged by rainwater along the foothills, where highly permeable sand and gravel abound (Mitchell and Paul, 2000).

It is apparent that undue interception and storage of rainfall over large areas can significantly affect stream flows, leading to reduced transport of sediments and nutrients, destruction of habitats and reduction of groundwater recharge (Mayer, 2001). In short, intensive rain harvesting over large areas can significantly disrupt the hydrological cycle. It is this potential for serious disruption of the hydrological cycle that needs to be borne in mind as governmental and non-governmental agencies vigorously pursue rain harvesting with best intentions of ameliorating the water crisis (Manavalan, 1998).

For all practical purposes, groundwater was treated as the property of the overlying land owner, and groundwater pumping was uncontrolled. However, over the past three decades, it has come to be recognised that surfacewater, groundwater, wetlands and ecosystems are intimately interlinked. Vigorous water exploitation has led to substantial reduction in stream flows, groundwater mining, and destruction of life-sustaining habitats. Inevitably, laws are being enacted which became mandatory for integrated management of surfacewater and groundwater (Mason, 1993).

Rain harvesting is implemented to meet the water crisis in the short-term. Government at various levels need to formulate long-term plans for integrated water development. The Government, people and NGO's should join together to implement the rainwater harvesting units in every households

and buildings to improve the quality of water (Sivanappan, 2003). To beneficially manage the available water, surface water, artificial recharge and groundwater withdrawal, water conservation practices will become components of integrated water management and science technology (Agarwal, 2002). It has to be guided by local values, traditions and institutions. This coming together of science and human values, in a situation of limited resources, presents extraordinary challenges and unprecedented opportunities for shared living (Majumdar, 2000).

D. Policies and programmes for conserving water quality

Water is everybody's turf and today sufficient and effective management of water supply system is an urgent need of the hour (Nadakavukasen, 1995). The aim of the legislations and management is to achieve and maintain water quality at acceptable levels (Trivedi and Singh, 1994). Some of the approaches are as follows:

- Establishing standards for water pollution control
- Licensing of discharging effluents for preventing water pollution
- Economic incentives for control of water pollution
- Monitoring network of water quality and
- Environmental impact assessment

Human beings have an inalienable resource of water (Manivasakam, 1995). To tackle the problem of drought that rockes the country, the Ministry of Water Resources has drawn up a programme for rainwater harvesting and recharge. Rs. 45 crore plan has been earmarked for

rainwater harvesting and recharge in the ninth plan. The ministry has sanctioned Rs. 25 crore for the Central Ground Water Board Programme, which involves states and user agencies in rural and in-accessible areas. The Central Ground Water Authority ensures directives to the states and municipal bodies to undertake roof top harvesting and its recharge to groundwater mandatory for every dewelling unit by amending city bylaws (Government of India, 2002).

Recharge of groundwater through storm run-off and roof top water collection, diversion and collection of run-off into dry tanks, playgrounds, parks and other vacant places are being implemented by Town Panchayats, Municipalities, Municipal Corporations and other Government establishments with special efforts. Instructions have also been issued to help the citizens and builders to adopt suitable recharge method through demonstration and also by offering subsidies for materials and incentives. The Government of Tamil Nadu had passed an emergency ordinance compulsory for all the private and public buildings to construct RWH structures by the end of October 2003. This strategy to implement the groundwater recharge was launched in a major way in Tamil Nadu.

Laws to control water pollution

The Government of Tamil Nadu has formulated and has passed various laws to control water pollution and exploitation of water.

- Water (Prevention and Control of Pollution) Act 1974 (Amended in 1988).
- Ground Water Over Exploitation Committee (1979)

- Ground Water Estimation Committee
- Tamil Nadu Ground Water (Development and Management) Act 2003
- National Water Quality Monitoring Programme monitors the quality of rivers.
- Ground Water Legislation recommends registration of all the ground water structures.
- Under section 24 and 43 of the Water Act, anyone found polluting water resources will be liable for fine and imprisonment extending upto a maximum of 6 years.

Realising the importance of water quality monitoring and the need for creating infrastructure for assuming it, the mission had taken a policy decision in 1989-90 to establish district level water quality testing laboratories in the country. It is expected that a network of laboratories will help in effective water quality monitoring to identify the above contamination caused by unhygienic condition.WHO and Population Services International (PSI) have partnered to develop and test safe drinking water strategy and improve conditions of hygiene and sanitation in India (Sharma, 2004).

Rain Water Harvesting Cell has also been established with the following objectives: to create public awareness on importance of RWH; to popularise simple and cost effective RWH methods among the public; to offer technical guidance and assistance based on the local geological formations; to monitor the water table and water quality in the rainwater harvested areas and to assure proper maintenance of the RWH structures after installation.

Swajal is the most recent rural water supply and sanitation programme launched at the national level with support from the World Bank to assist the state government to identify and implement appropriate policy frame work to promote long-term sustainability of the rural water supply and environmental sector; to deliver sustainable health and hygiene benefits to the rural population through improvement in water supply and environmental sanitation; to improve rural incomes through time saving and income opportunities for women; to test alternatives to the existing supply driven delivery mechanism and to promote sanitation and gender awareness

Akash Ganga Rain Centre in Chennai and **Centre for Science and Environment,** a Non-Government Organisation in New Delhi are active in promoting RWH and improving the status of natural resources - water all over the country. **The National Water Policy (NWP) 2002,** accorded private sector participation in "building, owning, leasing and transferring of water resource facilities". The unequal and unjust distribution of water, land and natural resources has been one of the structural causes of socio-economic marginalisation and the consequent poverty. People's inalienable right on water level and other natural resources must be recognised and privatisation of natural resources must be opposed to stop further marginalisation of the disadvantaged (Bryce and Susan, 2001).

Water planners and managers are on the verge of a fundamental change in thinking **WATER** - a change from a focus on new construction to a focus on evaluating how best to meet human needs and desires. Hence, new approaches to water planning and management are beginning to address issues of use directly, which can lead to changes in management and improvement in long-term sustainable water use (Magdolena, 2003).

Design of the Study

III DESIGN OF THE STUDY

Excessive exploitation of groundwater and lack of mechanism and systems to ensure recharge have led to the deteriorating standards of the groundwater. The groundwater which is more than 100 feet below the ground level gets polluted and contaminated resulting in water scarcity (Sivanappan, 2003). Hence a study on "Assessing the Quality of Ground Water in Coimbatore" was initiated to find out the extent of pollution and contamination of water in Coimbatore city. The design formulated for the study consisted of the following phases.

Phase I: Creating awareness on water conservation among the public.

Phase II: Analysing the groundwater quality in Coimbatore.

Phase I: Creating awareness on water conservation among the public.

Saving water is a global problem. It is high time that serious thought is given on this major issue (Linter, 1997). All efforts should be directed towards strengthening institutions, scientifically and technologically, training the existing man-power and exchanging information and integrating knowledge by complementing the efforts of agencies dealing with environment. Everyone has a role to play in rehabilitating our environment (Chandola, 1995). The people have to join together and work to create awareness on the best possible water conservation methods to avoid falling into the 'not a drop to drink' trap in the years down the line. This part of the study consists of the following:

A. Sensitisation drive

B. Household survey

C. Case study

A. Sensitisation drive

A process of social mobilisation is needed to involve and encourage the communities and households to undertake water management to meet the water needs (Murthi, 2004). Inorder to sensitise, educate and create awareness on importance of water, need for water conservation, rain water harvesting and status of quality of groundwater, various methods were used to the rural mass, students and the urban community.

Methods used: Conducting individual visits, Organizing exhibition, lecture, demonstration, human chains, rallies, and arranging meetings were carried out to convey the information. Different methods were used to communicate the message which would stimulate the desire and create interest (Reddy, 2001) (Plate 1). Model Rain Water Harvesting (RWH) unit was set to demonstrate the procedure for installation and also the different methods of harvesting rainwater was explained. This was done to sensitise the utility of providing RWH structures. Inorder to conduct effective sensitisation, charts were developed by the investigator. The charts were self explanatory conveying the importance of water, types of water harvesting methods, effect of drought etc., (Plate 2). The investigator also attended different meetings and played an active role in gaining valuable information regarding water (Plate 3 and Appendix I). Booklet bearing messages on basic information about water was prepared to be distributed to the public (Appendix II). Leaflet was prepared in local language and was distributed to local mass as well as to the students (Appendix III).

Individual Visits

Exhibition

Lecture

Demonstration

Rally

Leaflet Distribution

Plate - 1
METHODS OPTED FOR SENSITISATION DRIVE BY THE INVESTIGATOR

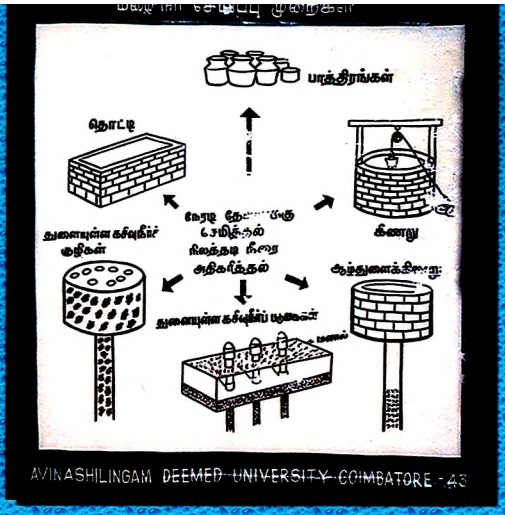


Plate - 2
CHARTS DEVELOPED BY THE INVESTIGATOR

Plate - 3
MEETINGS ATTENED BY THE INVESTIGATOR

B. Household survey

As per the mandate of the Tamil Nadu Government, every household in the state is expected to harvest the rainwater as a step towards improving the groundwater table and the water quality and quantity and to solve the water crisis (Prabhakar, 2001). Survey research gathers data from a relatively large number of cases at a particular time. Kothari (2001), refers survey as the method of securing information concerning a phenomenon under study; it has the advantage of wider scope and accuracy of information. Hence, survey method has been adopted to study the effect of the rainwater harvesting units in recharging groundwater and the impact of the same on different water management practices. The design formulated for the survey to gather necessary information pertaining to the study consisted of the following steps:

1. Selection of the study area
2. Selection of the samples
3. Selection of the method
4. Framing of research tool
5. Conduct of the survey
6. Analysis and presentation of data

1. Selection of the study area:

The man made crisis has resulted as global warming bringing about changes in the climatic condition (Pickering and Owen, 1994). The rains have become more irregular because of disturbance in natural cycle and also the quantity of rainfall is exotic, reduced and uncertain. Due to

urbanisation, use of more water and concretisation has resulted in the dire need for conservation of rainwater both as surface water and as ground water (Kudesia, 1998). The rural mass depend on groundwater sources for carrying out all the household activities (Perman, et al., 1996). The survey was carried out along with the awareness campaign in the N.S.S. (National Service Scheme) activity areas of Avinashilingam Deemed University. The selected rural areas were Parameshwaranpalayam, VaiyaliPalayam, Ramanathapuram and Pannimadai villages in Coimbatore.

2. Selection of the samples:

One hundred households (25 from each selected village) who had installed Rain Water Harvesting units and have directed the rainwater to the borewell or well in order to recharge the groundwater were selected as samples for the study. The households were selected of the basis of purposive sampling method considering the nature and scope of the study (Gupta and Gupta, 1995). This discretion formed the major basis for the selection of the samples.

3. Selection of the method:

Interview cum observation method was adopted for the collection of the data. The interview method is unique which involves the collection of data through direct verbal interactions between the interviewee and the investigator. It is an effective tool for collecting relevant data says Gupta (1995). Interview method also helps to collect first hand information in a face to face manner. As remarked by Saravanavel (1999), observation method is subjected to check and control with respect to validity, reliability and precision. Therefore, interview cum observation method was the tool used for collecting details relevant for the study.

4. Framing of research tool:

In order to study the impact of rainwater harvesting units an interview schedule was prepared in a precise manner (Appendix IV). According to Choudhary (1991), a schedule is the name given to a list of questions to which responses are obtained from the respondent in a face to face contact. The authentic interview schedule was designed to cover socio-economic profile of the family, water management practices and impact and opinion on the rainwater harvesting units installed in the selected households.

Pretest and pilot study are the essence of a good schedule. A pilot study is a necessity as a small scale replica of the main survey. It provides guidelines to acquire knowledge of the population, the approach to be followed in data collection and identify ambiguity in questions. It helps in enriching the design of the schedule and assists in testing the validity and reliability of statistical techniques to be adopted in the data processing and analysis (Saravanavel, 1999). Keeping this in view, a pilot study was conducted choosing ten households as samples. The schedule was then modified accordingly incorporating the necessary changes.

5. Conduct of the survey:

Direct personal interview method was adopted, since responses are stimulated, accurate informations are obtained and personal rapport is well established (Boniface, 1995). The investigator established good rapport with the people to elicit first hand information. The respondents were approached during their convenient time. The questions were putforth one by one in an orderly manner. Relevant and authentic informations were carefully recorded.

6. Analysis and presentation of data:

The data analysed is presented under the chapter Results and Discussion.

C. Case study

The need of the hour is to recognise the people's capabilities and involvement in the system. People have done miracles in the field of water conservation (Sinha, 2003). In order to evaluate the community participation in conserving rain water, the investigator carried out case studies on **'Avinashilingam Deemed University'** and **'Project Siruthuli'**.

Phase II: Analysing the groundwater quality in Coimbatore

Coimbatore, which is the 'Manchester of Tamil Nadu' is highly industrialised and is selected as the locale of the study. Coimbatore once flourishing with it's surplus Siruvani water supply, due to the recent monsoon failure has now turned out to be drought-hit area. The quality of the ground water in Coimbatore city has exceeded the recommended standards of drinking water quality. Excessive exploitation of groundwater has led to further deteriorated standards of the groundwater (Groundwater year book, 2000-2001). This part of the study which involves analysing the extent of exploitation of groundwater consists of the following aspect:

A. Selection of area
B. Collection of water samples
C. Parameters analysed

A. Selection of area

Most of the rural areas and the city depend upon groundwater for household activities (Prabhakar, 2001). Groundwater is threatened with pollution from the sources such as domestic, agricultural and industrial wastes,

run-off from urban areas and soluble effluents (Shastree, 1997). In order to assess the quality of groundwater in Coimbatore, water samples were collected from 20 areas covering 9 unions (Figure 4). The areas selected for the collection of the samples were purely on the guidelines and suggestions of the authorities working for Rural Water Supply and the Tamil Nadu Water and Drainage (TWAD) Board, Coimbatore. The areas and the source points selected for the collection of samples are given in the Table I

Table I Sample collection areas and source points

Union	Panchayat	Location	Source*
Karamadai	Chikkarampalayam	Kannarpalayam	HP
Karamadai	Irumborai	Pethikuttai	HP
Karamadai	Illuppanatham	Vaiyalipalayam	BW
P.N. Palayam	4, Veerapandi T.P.	Thiruvalluvar Nagar	HP
P.N. Palayam	Somayampalayam	Somayampalayam	HP
Sulur	Koduvettipalayam	Chandrapuram	HP
Sulur	Neelambur	Venkittapuram	BW
Sulur	Kalangal	Kalangal	HP
Madukkarai	Seerapalayam	Bodipalayam	OW
Madukkarai	Malumitchampatty	Malumitchampatty	BW
S.S. Kulam	Kallipalayam	Kallipalayam	HP
Sulthanpet	Selekarachal	Selekarachal	HP
Sulthanpet	Thalakkarai	T. Vadugapalayam	BW
Sulthanpet	Bogampatty	Bogampatty	OW
Avinashi	Pudupalayam	Vanjipalayam	BW
Avinashi	Sevoor	Kandankulampudur	BW
Avinashi	Punjaithamaraikulam	Punjaithamaraikulam	BW
Palladam	Semmipalayam	Nehru Nagar	BW
Annur	Ambothi	Nachipalayam	BW

* HP - Hand Pump, BW - Bore Well, OW - Open Well

B. Collection of water samples

Water samples from borewells and openwells were collected to analyse and assess the status of ground water, in Coimbatore city. The samples were collected in properly and well cleaned plastic containers. Care was taken to clean the container thrice with the sample water.

Unions selected for sample collection

Figure 4

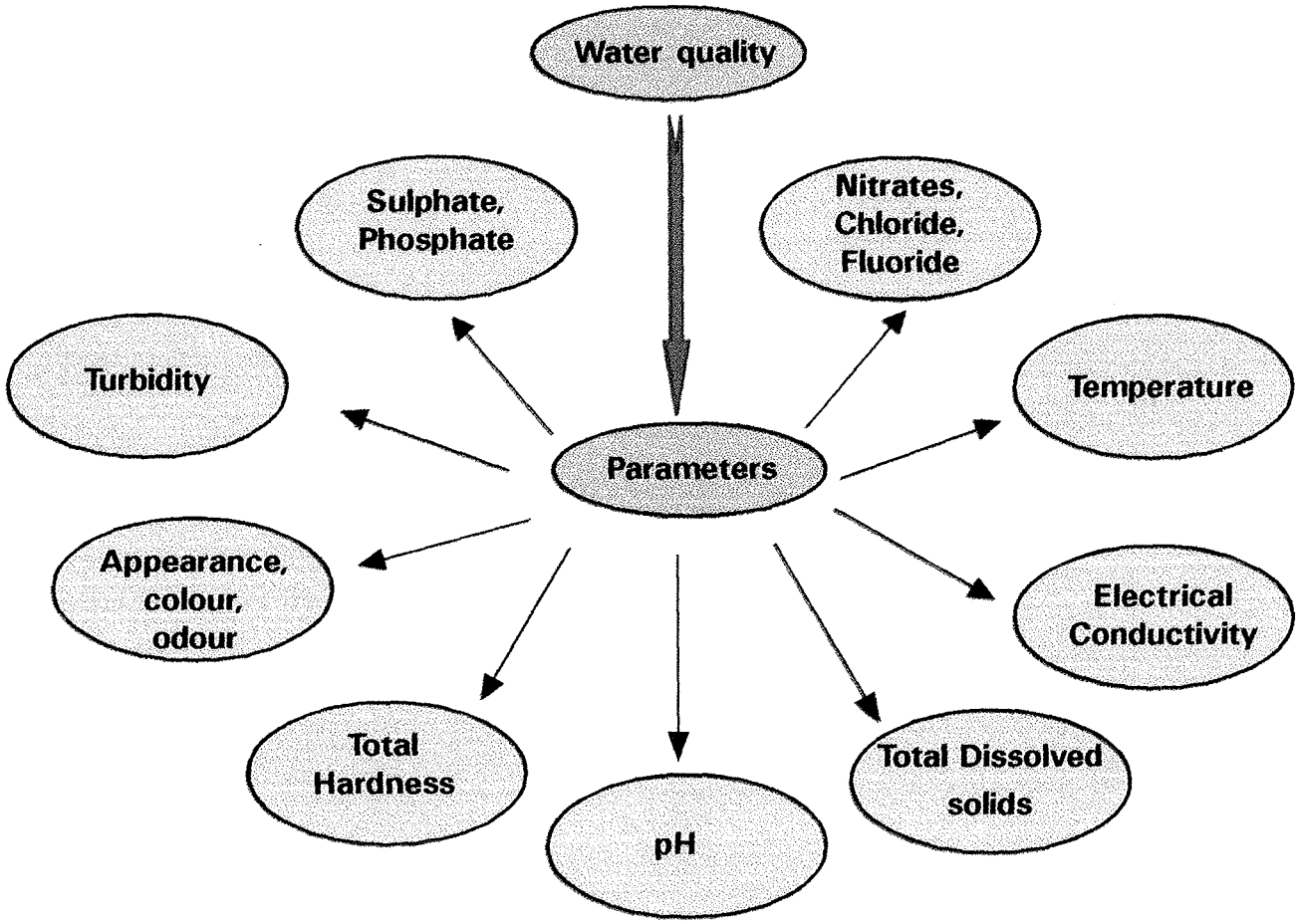
This was an important aspect to be considered while collecting the water samples. It was made sure that collection of water samples were done by allowing considerable quantity of water to first flow out from the outlet tap. The collected samples were then transferred to the TWAD laboratory, Coimbatore under natural condition for analysis.(Appendix V)

C. Parameters analysed

Experimentation is the most sophisticated, exacting and powerful method for discovering and developing an organised body of knowledge. In this method, the researcher measures the efforts of an experiment which is conducted intentionally (Kothari, 2001). Some areas of the country are affected by excess fluoride, nitrate and arsenic in the groundwater and microbial contamination making it unfit for human consumption. Besides, the quality of water is also facing problems due to large fertilizer use and poor solid waste management.

The analysis required for water samples on the intended use of the water should meet certain quality criteria, with respect to the appearance (turbidity and colour), potability (taste and odour), health (nitrate, fluoride, and chloride), and toxicity, These criteria are established by health regulating agencies to ensure that the water quality in a resource is suitable for the proposed use (Jeyanthi, et al., 2000). The standards of water quality by no means are static, they are constantly under review in the light of new knowledge (Jee, et al., 2004).

The parameters considered for analysis were appearance, colour, odour, turbidity, pH, electrical conductivity, total dissolved solids (TDS), total hardness, chloride, ammonia, sulphate, phosphate, nitrate, and fluoride (Figure 5). The quality was analysed with respect to selected physical and



Parameters selected for sample analysis

Figure 5

chemical parameters to verify the potability of the water. The reports of the same source point taken earlier in year-2000 were obtained as secondary data from the TWAD water laboratory and a comparative analysis was carried out with the samples collected now in year-2004 to understand the quality status of groundwater. The values were compared with the standard data's specified by World Health Organisation (WHO) to assess the potability (Appendix VI). The analysis of the test reports are presented under Results and Discussion.

Results and Discussion

IV RESULTS AND DISCUSSION

The findings pertaining to the research study on "Assessing the Ground Water Quality in Coimbatore", are presented under the following main headings:

Phase I. Impact of the awareness creation campaign on water conservation

Phase II. Results of the groundwater quality analysis

Phase I. Impact of the awareness creation campaign on water conservation

This part of the results are discussed under

A. Response of the awareness campaign

B. Outcome of the household survey

C. Case study report

A. Response of the awareness campaign

The awareness campaign response are presented under

1. Response of the sensitisation drive

2. Response of households installed with rainwater harvesting units

1. Response of the sensitisation drive

The need to sensitise people to understand the urgency to install Rain Water Harvesting (RWH) structure was reflected through the expression by constructing the structures in their households. The rural mass who were made to understand the meaning, need and importance of the Rain Water Harvesting structures supported the efforts of the Government and the students. They also expressed that they had realized their role played indirectly to conserve water, inorder to revive the water table and to improve the quality of water, a step to solve water crisis. The people also expressed that the various methods and the aids used to educate them were clear, easy to understand, impressive, apt and timely. The explanation given in local language

by the students were much appreciated. These indicate that the need is to focus on sensitizing the people for co-operative effort on issues which are pressing and urgent.

2. Response of households installed with rainwater harvesting units:

The awareness drive was timely and had drawn positive response from the public and had resulted in the implementation of the Rain Water Harvesting units at a fairly good pace in the selected rural areas. To help and enable below poverty line families to construct RWH units in their households, the help of the university students were sought to mobilise resources. It was quite encouraging to observe that 97 per cent of the households had completed the task of constructing the units. The involvement of the local bodies and authorities in the hectic activity to meet the deadline fixed by the Government to install Rain Water Harvesting structures proved fruitful.

B. Outcome of the household survey

This aspect is discussed under:

1. Socio-economic profile of the respondents
2. Details on water management practices
3. General details on quality of rainwater and its effects.

1. Socio-economic profile of the respondents

The profile of the respondents such as type of family, size of the family, age, education, occupation and family income of the selected families are discussed under this heading. This helped the investigator to have a clear cut background information of the selected households which further furnished details to carryout the study in an efficient manner. Table II presents the socio-economic profile of the respondents.

Table II Socio-economic profile of the selected households

S.No.	Factors	Category	Percentage N : 100	
1.	Type of family	Nuclear family	54	
		Joint family	46	
2.	Household size	Small (1-3)	47	
		Medium (4-6)	53	
3.	Age range		Male	Female
		0 - 2	4.3	3.1
		2 - 6	4.8	5.5
		6 - 12	6.6	4.9
		12 - 18	7.2	6.1
		18 - 40	30.7	28.8
		40 - 58	32.5	34.4
		Above 58	13.9	17.2
4.	Educational Status		HOF	HM
		Illiterate	26	31
		Middle school	29	27
		Higher secondary	23	29
		Graduate	22	13
5.	Occupational status		HOF	HM
		Field workers	59	39
		Small scale business	20	11
		Teacher	9	13
		Domestic servants	5	18
		Unemployed	7	19
6.	Income (Rs.) per month	Rs.1250-2500	43	
		Rs.2650-4450	21	
		Rs.4450 and above	36	

HOF-Head Of Family, **HM**-Home Maker

Type of family:

Table II clearly depicts the moving trend from joint family system (54 per cent) to nuclear family system (46 per cent). This represents the disintegration of joint family system even in the rural areas. Transformation from the once predominant joint family system to the nuclear family system

in inevitable due to several factors such as employment opportunities, desire and freedom to taste ones own decision and economic conditions.

Household size:

This is discussed based on the classification of Devadas and Jaya-1983. It clearly shows the trend in transformation of medium size family to small size family. Medium sized (4-6 members) household stages majority (53 per cent) followed by 47 per cent comprising of small size family (1-3 members). Absence of large size family is a proof for the shift towards small family size showing the impact of family planning efforts of the Government.

Age range:

This is based on the classification of Bigner-1983. The stages under this classification are infancy (0-2), early childhood (2-6), middle childhood (6-12), adolescence (12-18), early adult (18-40), middle adult (40-58) and old age (above 58). The table clearly reveals that when considered for male and female ratio the male dominate compared to females. More member of people both in male and female ratio are in middle adulthood (66.9 per cent) followed by early adulthood (59.5 per cent) and old age (31.1 per cent).

Educational status:

It is clear from the table that 74 per cent of the heads of the families are literate having studied upto middle school (29 per cent), higher secondary (23 per cent) and graduates (22 per cent), while rest (26 per cent) were illiterate. It is also encouraging to note that female literacy level is increasing steadily. A majority of 69 per cent of the home makers were literate. On an average 28 per cent having studied upto higher secondary and

middle school and 13 per cent were graduates. However it was disheartening to note that 31 per cent of the female population are still illiterate who are to be motivated to join the adult literacy programme. Education is said to develop facilities of the human mind, thereby enhancing the awareness of self will on the surrounding environment leading to meet the challenges a head.

Occupational status:

Majority of male population (93 per cent) have better job security compared to their female counterparts. Since the area under survey comprises mainly rural people, a majority of 59 per cent were field workers. Women in rural areas are utilising their leisure time gainfully by lending a helping hand in the field work (39 per cent) which is seasonal. Eighty one per cent of the female population contribute their earning for family expenditure. Due to the improvement in literacy level, teachers (22 per cent) have emerged with a sense of responsibility to educate the children. Though unemployment prevails among the people (26 per cent), the home makers have expressed their views in opting gainful employment.

Income (Rs.) per month:

This is tabulated based on HUDCO classification - 2000. Table II depicts the economic status of the selected family. Since majority of the people are field workers, 43 per cent of the population come under low income level having an income below Rs.1250 - Rs.2650 per month. Thirty six per cent and 21 per cent of the population come under high income level (Above 4450) and middle income level (Rs.2650 - Rs.4450). General income level is comparatively low due to the low wage pattern prevailing in rural areas.

2. Details on water management practices

This part of the result is discussed under

a. Source, nature of water and quantum procured
b. Methods of harvesting adopted

a. Source, nature of water and quantum procured.

Table III presents the source and nature of water and the quantum of water procured.

Table III Sources, nature of water and quantum procured

Source	Quantum			Nature	
	percentage				
	Normal	Surplus	Deficit	Soft	Hard
Well (76)	46	9	21	32	44
Borewell (57)	14	-	43	26	31
Siruvani scheme (43)	13	4	26	39	4
Athikadavu scheme (57)	41	-	16	29	28
Water tanker (21)	21	-	-	-	21
Total	135	13	106	126	128

The major source of water in the rural area is the well (76 per cent) followed by bore well (57 per cent). Athikadavu and Siruvani are the two major schemes which supply drinking water to households in Coimbatore City. Fifty seven per cent and 43 per cent were provided with individual pipeline to have the water supply from these two schemes, while 21 per cent who were also beneficiaries were supplied by water tankers. Due to the monsoon failure, water mismanagement and depletion of community source-dam, 106 sources of water have dried up in Coimbatore. Due to the above reasons the quality of water is also at stake leading to hardness of water to be higher in 128 sources. The remaining 126 source of water is soft in nature. The nature of the water is declining due to man's unhygienic dealings with the environment.

b. Methods of Harvesting adopted

Methods of harvesting

Every drop of rain has to be harvested, well conserved and pond preserved.

Majority of the RWH units constructed comprised of recharging the groundwater (93 per cent) followed by directing the water to the borewell or well (56 per cent) consequently recharging the ground water. Roof top harvesting was practiced by 16 per cent. The adoption exhibit the interest evinced by the households.

Table IV clearly represents the cost and the construction particulars of RWH units.

Table IV Construction of RWH units

Methods	Percentage*		
	Roof Top Harvesting	Recharge to ground	Recharge to borewell/well
No. of units	16	93	56
Cost of construction			
< 1000	11	7	12
1001 - 2000	5	49	44
2001 - 3000	-	37	-
> 3001	-	-	-
Duration of construction			
1 day	7	-	-
2 days	9	41	47
3 days and more	-	52	9

* Multiple response

Construction cost

The cost of construction was mainly for the labour and materials which included mainly the PVC pipes, GI sheets, accessory fittings and pebbles However, the cost was towards procuring pipes for draining the water inorder

to recharge the groundwater. A majority of 98 per cent of the households had spent between Rs. 1001 and 2000/- for the construction while 37 per cent of the households had spent between Rs. 2001 to 3000 and 30 per cent of households had spent less than Rs. 1000. The amount spent for the construction of the RWH units depended on the method preferred and the capacity to invest in the structure.

Duration of construction

Ninety seven per cent of the households completed the construction work within two days followed by 61 per cent who required three days and more. All the units constructed possessed red soil which is water absorbent. Hence, the quality of water in expected to be upgraded due to quick recharge through natural filtration process.

3.General details on quality of rainwater and its effects

a. Methods of improving water quality
b. Problems due to poor water quality
c. Awareness of water-borne diseases
d. General awareness on water management

a. Methods of improving water quality

Table V furnishes the methods adopted for improving the quality of stored water at household level.

Table V Methods of improving water quality

Methods	Percentage*	
	No. of households	
	Before	After
Filtering	4	13
Bleaching powder	13	86
Chlorination	13	83

* Multiple responses

Water gets contaminated under three conditions - air, sunlight and organic matter. By shielding the entry of organic matter through proper filtration and by storing rainwater in a closed container without access to air and sunlight water will retain its quality for a longer duration. Taking these above facts into consideration, people have adopted few steps to improve the quality of water. It was encouraging to note that the awareness campaign conducted to sensitise people had proved to have a positive impact.

The methods adopted at household level to protect the water are filtration and addition of bleaching powder and chlorination. Bleaching powder is used to protect the tanks in which water is stored. This practice helps in maintaining the quality of water and also prevents the growth of harmful organisms. It was encouraging to know that 86 per cent of the households added bleaching powder and 83 per cent of the households chlorinated the stored rainwater periodically by adding smaller dosage to maintain and enhance the quality of stored rainwater. Thirteen per cent of the households adopted the filtering method i.e. passing the rainwater through sand filter or plain cloth and then stored in clean tank or containers respectively. Constant encouragement, awareness creation and sensitisation programmes on issues which needs attention could definitely create impact and bring better and improved results.

b. Problems due to poor water quality

Table VI depicts the varied problems encountered due to poor water quality.

Table VI Problems encountered

Problems	Percentage*
Salt deposits on vessles and PVC pipes	94
Soap not lathering	76
Spoilage of food	57
Growth of algae	51
Bad odour	23
Horizontal brownish streaks on teeth	23

* Multiple responses

Water quality gets degraded due to poor storage practices. Longer storage without adopting proper methods and also due to the presence of septic tanks near the storage tanks can cause pollution of groundwater. Direct recharge of rainwater will contaminate the groundwater leading to poor water quality. The problem related to poor quality of groundwater by the selected household were reported. Majority of the respondents (94 per cent) complained of white deposits caused by salts on the vessels and PVC pipes. Seventy six per cent complained about difficulty in soap lathering. Food spoilage (57 per cent) and growth of algae (51 per cent) were also mentioned as major problems. Bad odour (23 per cent) and horizontal brownish streaks on teeth (23 per cent) were also expressed as problem faced due to poor quality of water.

These problems can be averted by improving the quality of water by rainwater harvesting. Periodically water quality can be a monitored by testing the water quality to assure safety of water.

c. Awareness of water-borne diseases

Table VII shows the awareness of water-borne diseases as reported by the respondents.

Table VII Water-borne diseases

Disease	Acquired Percentage*
Diarrhea	46
Dysentry	31
Skin diseases	29
Typhoid	13
Tuberculosis	9
Jaundice	8

* Multiple response

The people are well aware that the reasons for the occurrence of infection are through water-borne diseases. Inspite of the fact, they have continued to live without adopting any safe water management practices. It was recorded that majority of the households had been affected by diarrhoea (46 per cent) followed by dysentery (31 per cent) and skin diseases (29 per cent). Typhoid, tuberculosis and jaundice were the other water-borne diseases reported. Due to nationwide campaign, people have now become aware to act to improve the water quality.

d. General awareness on water management

Table VIII depicts the different category, number of participants and methods adopted for creating awareness on healthy water management practices.

Table VIII Awareness campaign

Category	Methods adopted	No. of participants
Students	Lecture Discussion forum Demonstration Leaflet distribution	108
University students	Lecture Discussion forum Demonstration Leaflet distribution Rally	88
Faculty	Lecture Discussion forum Demonstration	43
General public	Visits Lecture Discussion forum Demonstration Leaflet distribution	127

Table clearly depicts the four different category who participated in the campaign. The total number of participants were 366. Lecture cum discussion and demonstration was used to convey information both in English and local language depending on the clientele. Emphasis was given to importance of water, methods to be adopted to harvest rainwater, safe water management practices and hygienic way of water disposal. Demonstration was carried out with model RWH unit. Charts and posters were prepared by the investigator on relevant information to be conveyed. Tamil leaflet on the key points of saving water was prepared and distributed to different sectors. Awareness was also carried out with the door to door survey. The participants were greatly benefitted and had a clearcut vision on the role of water in man's life. Assistance from Rural Water Supply and TWAD Board was sought to convey constructive and relevant information.

The main focus of the awareness campaign was "Harvesting rainwater is a viable technology for augmenting water supply. RWH is a process of collection, storage and use of rainwater during scarce season. Rainwater is the pure form of water which if collected under hygienic conditions is a desirable potable source of water".

C. Case study report

The case studies of 'Avinashilingam Deemed University' and 'Siruthuli' have clearly depicted their efforts to harveness the rainwater.

Case study I: Efforts of Avinashilingam Deemed University in implementing rainwater harvesting structures

Avinashilingam Deemed University situated in Coimbatore covers an area of 14.28 acres. This educational institution with the infrastructures has to meet the demands of thousand of individuals associated with it.

Demand for water is at it's peak due to population rise, groundwater depletion, failure of monsoon and unplanned utilization of the available water resource. Due to this acute state, the University faced critical water scarcity situation.

Water is a precious resource with varied uses, but drinking water is the basic need of every human being. The three sources of water are rain water, surface water and groundwater. Since rain is the main source for the other two, the rainwater is to be conserved and used efficiently.

Groundwater which is the main source of water meets the requirements of the hostelers which is depleted due to over extraction. The university manages it's water demand from two bore wells while another two bore wells have faced pucca drought situation. The university purchases water when the demand exceeds the reserve.

As the demand of water requirements increased from 1.5 lakhs litres/day in 1999 to 2.1 lakhs litres/day in 2004, the university chalked out plans to overcome the situation. To asses this trend of water scarcity, **Rain Water Harvesting (RWH)**, a simple logic was initiated in 2000. It was also a period when RWH was accorded the highest priority by the Government and in October 2002, building regulations were amended, making it mandatory for RWH structures to be constructed in all the building with a deadline of 31st August 2003.

Rainwater is one of the purest sources of water available freely from nature. It is the ultimate source of fresh water. It is upto the individuals to conserve the same with a logical thinking. The activity of collecting rain water directly or recharging it into the ground improves the ground water storage in the aquifer. Rainwater is harvested to conserve and augment the storage of ground water, to reduce water table depletion and to improve the

quality of ground water. The University considering all these important aspects threw a pioneering vision of constructing Rain Water Harvesting structures.

As an initiative work, the run off from the built-up area i.e., roofs (about 13,000 sq.m.) and roads were diverted into storm water drains. Thirty thousand litres capacity of five storage tanks were constructed along with the filtration tanks diverting the roof top water into the storage tanks. These structures are also provided with the first flush device. The storage tank is designed according to the water requirements, rain fall and catchment availability. Water quality improves over the time during storage in the tank since impurities settle in the tank if the water is left undisturbed. Even the pathogenic organisms gradually die due to storage in due course.

The University already has two bore wells and an extra two bore wells are drilled. In order to augment the groundwater table with the run off water, the university had planned and implemented a number of bore well points with recharge structures at various places. However, recharge to ground water is limited because of decreasing availability of permeable soil surface which is below 4 feet from the top layer. The black cotton soil in the first layer (till 4 feet) hinders the recharging of water. Finally ten bore wells were drilled to a depth of 75 feet along with recharge pits for easy penetration of water.

As Avinashilingam Deemed University has started harnessing the liquid gold - **'WATER'**, the cost incurred on buying water is expected to fall down to zero thereby saving a lump sum amount annually. Avinashilingam Deemed University's efforts to harness rainwater will achieve it's target making the campus self-sufficient with water. Figure 6 and Plate 4 shows a clear cut work of Avinashilingam Deemed University in promoting rainwater harvesting thereby improving the groundwater quality.

தினத்தந்தி 9—8—2003

இவ்வூர் செய்திகள்

அவினாசிலிங்கம் பல்கலைக்கழகம்

கோவை அவினாசி லிங்கம் நிகர்நிலை பல்கலைக்கழகம் மனை நிர்வாக துறை மற்றும் பல்கலைக்கழக நாட்டு நலப் பணித்திட்ட அலுவலகமும் இணைந்து மழைநீர் சேகரிப்பு பற்றி விழிப்புணர்வு கூட்டம் நடத்தியது.

இதில் கோவை குடிநீர் வடிகால் வாரியத்திலிருந்து தொழில் நுட்ப வல்லுநர்கள் மழைநீர் சேகரிப்பு பற்றி உரை நிகழ்த்தினார்கள்.

இந்த நிகழ்ச்சியில் முனைவர் விஜயலட்சுமி, ஜெயாமுத்து மேற் பார்வை என்ஜினீயர் கே.ஜெய சந்திரன் மற்றும் ஆர்.வெங்கட சாமி உதவி செயற்பொறியாளர் மணிவாசகம் மற்றும் புலர் கலந்து கொண்டனர்.

IN COIMBATORE TODAY

RELIGION

Rathina Vinayagar Temple: Special puja, D.B. Road, R.S. Puram, 8.30 p.m.

Sadhana Sadhan: Sowndharya Lahari, Madhav Nagar, Vadavalli, 11 a.m.

Sri Ayyappan Puja Sangham: Discourse on Srimad Narayaneeyam, Sathyamurthy Road, Ramnagar, 6.30 p.m.

Sri Ramakrishna Bhaktha Sabai: Discourse on Srimad Bhagavatham by Krishna Premi, Sri Ramkrishna Kalyana Mandapam, Avarampalayam Road, Siddhapudur, 6 p.m.

GENERAL

Avinashilingam University: Meeting on 'Rain Water Harvesting', 11 a.m.; Inauguration of Nutrition Association and World Breast Feeding week celebrations, 2.30 p.m.

CMS College of Science and Commerce: Seminar on 'Personality Development', Chinnavedampatti, 9.30 a.m.

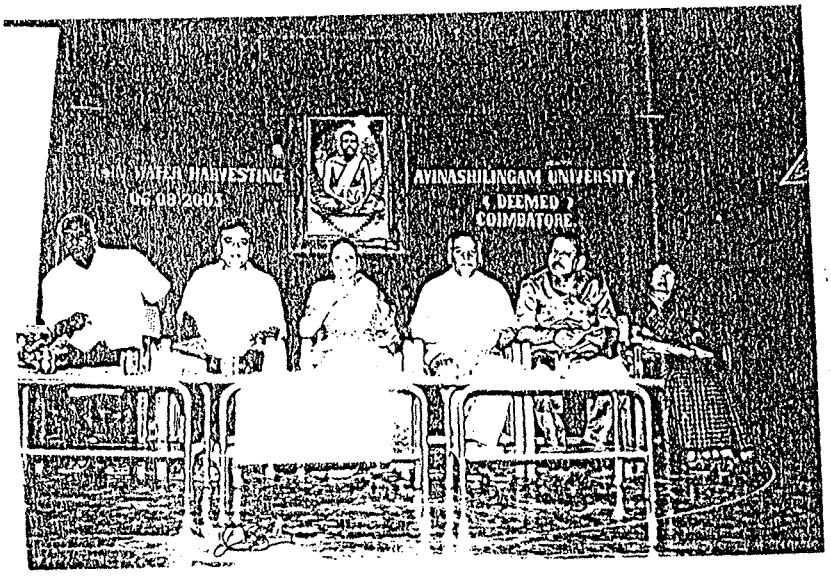
Jansons School of Business: Lecture on 'Scenario Planning', Karumathampatti, 10 a.m.

Karpagam Arts and Science College: Inauguration of Microbiology Association activities, 10.30 a.m.

Karunya Institute of Technology: Inaugural of INSTRA, Karunya Nagar, 2 p.m.

PSG College of Arts and Science: Symposium on 'Implementation of VAT Proposals', 10 a.m.

PSGR Krishnammal College for



மழை நீர் விழிப்புணர்வு கூட்டம்

கோவை, ஆக. 9-

கோவை அவினாசிலிங்க பல்கலைக் கழகத்தில் மழை நீர் சேகரிப்பு விழிப்புணர்வு கூட்டம் நடந்தது.

அவினாசிலிங்கம் பல்கலைக் கழகம், கோவை இந்திய மனையியல் சங்கம், மனை நிர்வாக துறை, பல்கலைக் கழக நாட்டு நலப் பணித்திட்டம் ஆகியவை இணைந்து மழை நீர் சேகரிப்பு விழிப்புணர்வு கூட்டத்தை நடத்தியது. கழு தாய கல்வி மற்றும் சுயதொழில் வளர்ச்சித் துறை தலைவர் டாக்டர் விஜயலட்சுமி அனை வரையும் வரவேற்றார். மனை யியல் துறை புலன் தலைவர் டாக்டர் ஜெயா முத்து தலை மை வகித்து பேசியதாவது:

மழை நீர் சேகரிப்பின் அவ சியம் பற்றி அனைவரும் உணர வேண்டும். அதனை நடைமு றைப்படுத்த ஒவ்வொருவரும் போர்க்கால அடிப்படையில் நடவடிக்கைகள் மேற்கொள்ள வேண்டும். நீரைச் சேமித்து, நல்ல முறையில் உபயோகித்து இனி வரும் சந்ததியினருக்கு நாம் எல்லோரும் உதவ வேண்டும்.

இவ்வாறு அவர் பேசினார். தமிழ்நாடு குடிநீர் வடிகால் வா ரிய மேற்பார்வை பொறியாளர் ஜெயசந்திரன், 'நீரும் அதன் தன்மையும், நிலத்தடி நீர் மட்டத்தை உயர்த்த வேண்டி யதன் அவசியம்' என்ற தலைப்பில் பேசினார். குடிநீர் வடிகால் வாரிய உதவி செயற் பொறியாளர் மணிவாசகம், 'ம ழை நீர் சேகரிப்பு முறைகள்' என்ற தலைப்பில் பேசினார்.

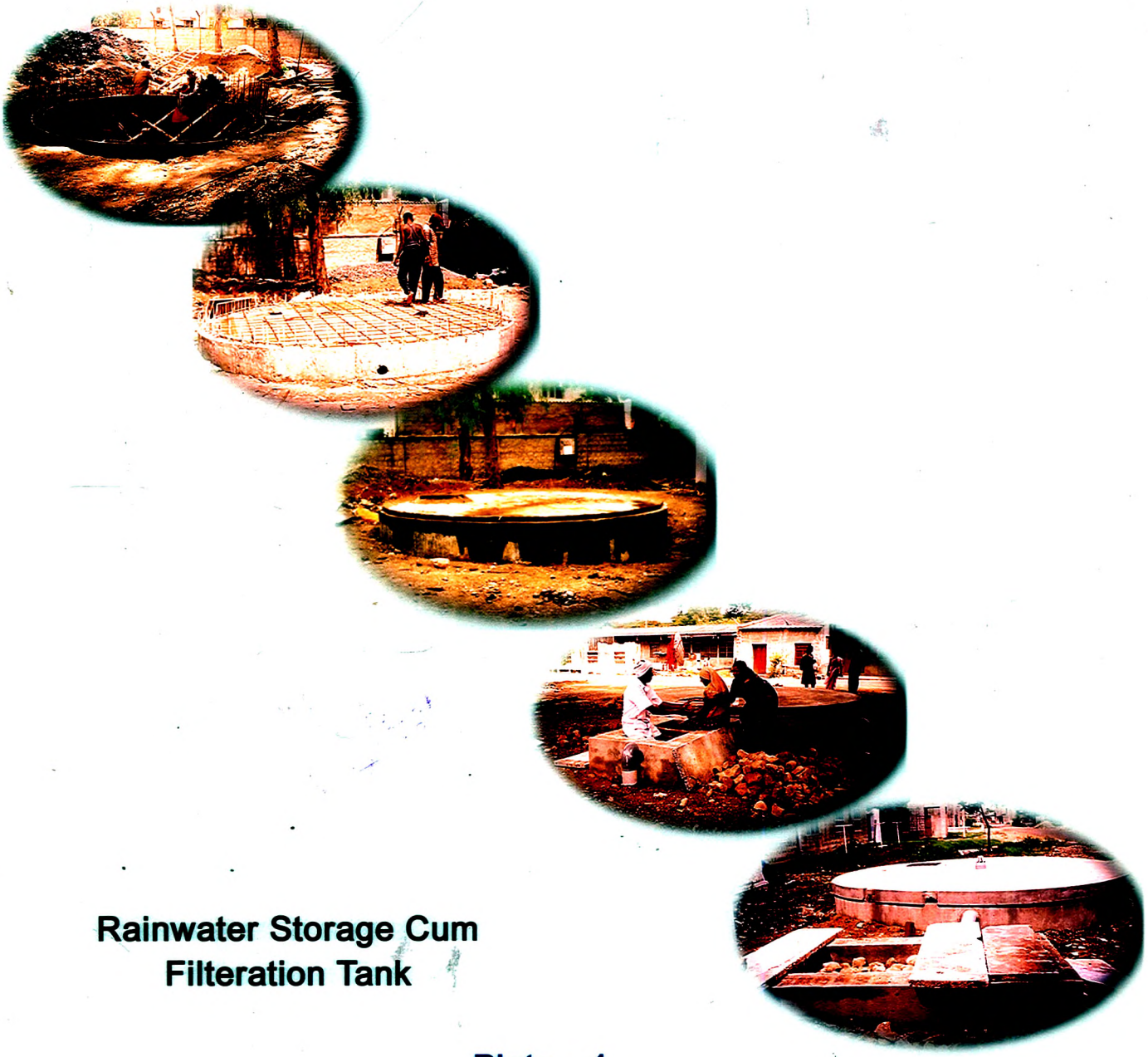
இந்த கூட்டத்தில் இணை ஹைட்ரோ ஜியாலஜிஸ்ட் வெங்கடசாமி, நாட்டு நலப் பணித்திட்ட ஒருங்கிணைப்ப ாளர் டாக்டர் வேல்மயில், பேராசிரியர்கள் ஞானசக்தி ஜெகதீசன், சித்ரா உள்பட பலர் கலந்து கொண்டனர்.

Role of Avinashilingam Deemed University in sensitisation drive

Figure 6

Borewell Recharge Point

Natural Recharge Point



Rainwater Storage Cum
Filteration Tank

Plate - 4

RAINWATER HARVESTING TECHNOLOGY OPTED IN AVINASHILINGAM DEEMED UNIVERSITY

Case study II: Project Siruthuli

Coimbatore's heritage, its once abundant water tanks and canals, its sweet Sriuvani water, salubrious climate and its reputation as the 'Poor man's Ooty' are now under threat from water mismanagement and environment abuse resulting in intolerable high temperatures and acute water scarcity with water supply made only once in 4 days..

Operation Siruthuli is a revolutionary eco-protection project initiated by a conscientious team from Coimbatore's corporate houses. In the initial phase of its activities, it aims to improve water management and distribution in the Coimbatore district by revamping 8 tanks within the corporation limits (approx 780 acres water spread area) and 2 canals (15.3 kms) at an estimated cost of Rs. 5 crores. The team comprises of a group of non-governmental like-minded Coimbatore citizens drawn from all walks of life. The specific aims of Siruthuli are:

- Revamping of water management systems
- Rain water harvesting
- Deepening and de-silting of ponds, canals and water ways
- Providing gradient to enable flow
- Clearing the water ways and reinforcing the banks
- Non-encroachment on water bodies
- Initiating projects for a greener, cleaner environment, to spread the message of 'save nature for posterity'
- Afforestation
- Garbage clearance and discouraging use of non-biodegradable wastes
- Beautification of water bodies around Coimbatore
- Sewage water management and treatment
- Encouraging community participation and social solidarity.

Siruthuli's accomplishment include desilting the encroachment of Krishnampathy Tank, Selvampathy Tank, Kumarasamy Tank and Narasampathy Tank. On-giving projects in Valankulam tank and Selva Chinthamani Kulam are carried out at a greater pace to revive the lost heritage of Coimbatore.

Approach to the initiative

It is with an integrated approach Siruthuli is progressing having the following in it's agenda.

- Awareness creation on water harvesting, sewage and garbage handling.
- Sanitation
- Hygiene
- Eco-friendly way of living
- Soil and water conservation
- Literacy movement
- Awareness campaigns through various forums which included a children's rally with 15,000 children participating and an Aadi perukku festival with 10,000 citizens witnessing have made SIRUTHULI a "People Movement".
- Siruthuli looks at its activities as a continuing process over the years to come. As mentioned earlier, after the completion of desilting and standardisation of the tanks. Planting trees and maintenance of the same are being done on a regular basis. Siruthuli is looking at the community to effectively participate in maintaining the projects in the long run. Eventually, it would also look into the prospects of employment generation for the local community in running the sewage treatment plants, compost yards, nurseries and tank maintenance.
- In 10 years from now, it is hoped that Coimbatore will witness a self-sustained community, taking care of its requirements with only optimum support from the Government and making Coimbatore a model city for the rest of the world.

Phase II: Results of the ground water quality analysis

The baseline survey gave an idea about the rainwater management practices in different areas of Coimbatore which further furnished the investigator with authentic reports for collecting the groundwater samples to carry out the water quality analysis. The survey revealed the effectiveness of the rainwater harvesting systems and its impact in alleviating water scarcity and also the steps taken by the people in maintaining water quality. The quality aspect is directly correlated to the health of the inmates. This creates an awareness about the water quality and the need for necessary steps to be taken to alleviate the situation. The results of the selected samples which were tested are presented under the following heading:

A. Areawise analysis report
B. Consolidated report of the selected sample areas
C. Nitrate, Fluoride dilution in groundwater
D. Comparison of samples for selected parameters

A. Areawise analysis report

The topography and geological conditions of the area play a vital role in creating ground water potential (Rao and Kumar, 2000). In modern times, it has led to formulation of specific standards to provide a basis for judging the quality of water. The standards are, exposure limits for bacteriological, viral, chemical and physical agents that have been adapted by government or appropriate authorities and therefore have legal force (Jee, et al., 2004).

The data of the samples tested in the year 2000 August-September were obtained from Rural Water Supply and compared with the test reports of the same source points carried out in the year 2004 July. The water quality report of the potable and non potable water of specific areas is discussed below individually. The report of the analysis of the samples collected from 20 sources which were analysed for selected parameters are presented under

1. Report of the potable water samples
2. Report of the non-potable water samples

1. Report of the potable water samples

Water quality depends mainly on the geological conditions of the source points. Water samples satisfying permissible water standards do not have parameters having excess values, hence all the areas having potable water are tabulated in Table IX and the discussion of individual water samples are presented after the Table.

Table IX Report of the selected samples satisfying permissible standards

Parameters	Permissible standards (WHO)			Samples										
				I	II	III	IV	V	VI	VII	VIII	IX	X	XI
	Accep-table limit	Cause for rejection		Sources										
				HP	HP	BW	BW	BW	BW	HP	HP	HP	BW	OW
Turbidity FTU	2.5	10	B	0	2	0	0	0	2	1	0	1	2	1
			A	0	0	0	0	0	0	0	0	0	0	0
Electrical conductivity mS	NM	NM	B	2490	823	1205	2490	1174	1243	611	777	1202	1092	1164
			A	1243	529	935	2130	604	134	1057	917	2350	1144	1544
Total Dissolved Solids ppt	500	2000*	B	1743	576	844	1743	822	870	428	554	841	764	815
			A	870	370	655	1490	423	94	740	642	1645	800	1080
pH	7.0-8.5	6.5-9.2	B	7.98	7.45	7.1	7.98	8.0	7.95	7.68	7.98	8.10	7.98	8.20
			A	7.62	7.01	8.11	7.84	7.0	7.69	7.13	7.84	7.34	8.44	8.51
Total Hardness mg/l	200	600	B	350	210	160	350	400	160	160	250	380	290	290
			A	550	170	360	530	240	14	330	210	510	370	290
Nitrate mg/l	45	45	B	40	20	8	40	43	38	22	29	34	9	20
			A	28	14	5	45	25	27	7	14	32	11	10
Chloride mg/l	200	1000	B	650	90	230	650	105	232	127	40	238	218	236
			A	182	68	36	423	55	18	68	109	70	177	187
Fluoride mg/l	1.0	1.5	B	0	0	1.5	0	0.6	0.8	0.6	0.4	0.6	1.4	0.4
			A	0.8	0.6	1.2	1.0	0.6	0	1.0	0.4	0.4	0.8	1.4
Sulphates mg/l	200	400	B	185	85	160	185	16	32	46	18	20	32	23
			A	44	5	105	165	8	8	22	59	99	28	55
Potable/ Non-potable			B	P	P	P	P	P	P	P	P	P	P	P
			A	P	P	P	P	P	P	P	P	P	P	P

B - 2000, A - 2004; * -BIS Guidelines, HP-Hand Pump, BW-Bore Well, OW-Open Well, P-Potable. NM-Not Mentioned

I - Kannarpalayam, II - Pethikuttai, III - Vaiyalipalayam, IV - Vanjipalayam, V - Punjaithamaraikulam VI - Nachipalayam, VII - Thiruvalluvar Nagar, VIII - Somayampalayam, IX - Chandrapuram X - Malumichampatty XI - Bodipalayam.

The water quality level of 11 habitations of 9 unions in general were found to be potable with time lapse of five years. The comparison of the water sample with the water quality standards certified that all the 11 samples were potable and were not affected by the deteriorating water table level.

Sample I - Kannarpalayam - Karamadai Union

The appearance, colour and taste of the sample proved unobjectionable. Though all the parameters discussed are within the permissible limit, the levels of Total Hardness has fluctuated from 350 mg/l to 550 mg/l and the Fluoride content had raised from zero to 0.8 mg/l. These factors have to be given thought so as to keep the values within the limit or else it will lead to health effects.

Sample II - Pethikuttai - Karamadai Union

The appearance, colour and taste of the sample proved to be unobjectionable. The Turbidity levels have decreased from 2 FTU to Zero. All the parameters discussed are within the standard permissible limit except that the Fluoride content has increased from zero to 0.6 mg/l. It is a warning signal for the people to stop polluting the water so as to prevent the increase in the Fluoride content and other parameter levels leading to serious health problems.

Sample III - Vaiyalipalayam - Karamadai Union

The appearance, colour and taste of the sample proved to be unobjectionable. From the Table it can be inferred that the pH level has raised from 7.1 to 8.11. The Total Hardness has shotup from 160 mg/l to 360 mg/l. Hardness of water is caused due to the presence of Sulphates and Chlorides of Iron, Manganese and Aluminium. Water with 25 mg/l calcium

carbonate is considered soft while with 500 mg/l calcium carbonate is termed hard, the water sample thus being moderately hard. Although hardness has no adverse effect on health, an evidence was found to indicate its role in heart disease (Jeyanthi., et al., 2004). The Fluoride level has decreased from the cause for rejection level of 1.5 mg/l to 1.2 mg/l. Fluoride is responsible for dental and skeletal fluorosis, a serious health problem. Hence steps need to be taken to protect the water from getting further polluted.

Sample IV - Vanjipalayam - Avinsahi Union

The appearance, colour and taste of the sample proved unobjectionable. The table shows that only the Total Hardness level and Nitrate levels have raised from 350 mg/l to 530 mg/l and 40 mg/l to 45 mg/l respectively. Hardness of water leads to skin irritation and excess of Nitrate leads to blue baby disease. Steps should be taken to avoid further increment of these levels.

Sample V - Punjaithamaraikulam - Avinashi Union

The appearance, colour and taste of the sample proved unobjectionable. Other parameters showed a marked improvement in quality of water by reduction of levels over a period of 5 years. The quality of water has to be kept in continuous surveillance to prevent any further change.

Sample VI - Nachipalayam - Annur Union

The appearance, colour and taste of the sample proved unobjectionable. The turbidity levels has decreased from 2 FTU to zero. The other parameters have proved that the water quality standards are satisfactory without any increment in the pollution levels.

Sample VII - Thiruvalluvar Nagar - Periyanaickenpalayam Union

The appearance, colour and taste of the sample proved unobjectionable. The Turbidity levels have decreased from 1 FTU to zero.

Though the standards of Electrical Conductivity is not mentioned, it is an aspect considered in deciding the quality of water, which has raised from 611 mS to 1057 mS. Electrical Conductivity of water is due to ionization of dissolved inorganic solids and is used as a basic index in judging the suitability of water for potable properties. Likewise levels of Total Dissolved Solids have raised from 428 ppt to 740 ppt. This increase might be due to the domestic activities of the people. The total hardness value has also increased from 160 mg/l to 330 mg/l. People have to be careful not to further pollute and increase the levels thereby making the water non-potable.

Sample VIII - Somayampalayam - Periyanaickenpalayam Union

The appearance, colour and taste of the sample proved unobjectionable. A slight increase in the parameter levels like electrical conductivity (777 mS - 917 mS), Total Dissolved Solids (554 ppt - 642 ppt), Chloride (40 mg/l - 109 mg/l) and sulphates (18 mg/l - 59 mg/l) were observed. All these parameters must not be aggravated to cause further pollution.

Sample IX - Chandrapuram - Sulur Union

The appearance, colour and taste of the sample proved unobjectionable. Turbidity level shifted to zero. The parameters which showed a drastic increase was the Electrical Conductivity (1202 mS - 2350 mS), Total Dissolved Solids (841 ppt - 1645 ppt), Total Hardness (380 mg/l - 510 mg/l) and presence of sulphates (20 mg/l - 99 mg/l). The report shows the water getting slowly degraded. Steps have to be initiated to maintain the potability.

Sample X - Malumichampatty - Madukkarai Union

The appearance, colour and taste of the sample proved unobjectionable. The turbidity level has turned out to be zero from 2 FTU.

The table shows that there are certain variations in the levels of electrical conductivity (1092 mS - 1144 mS), Total Dissolved Solids (764 ppt - 800 ppt), pH (7.98 - 8.44), Total Hardness (290 mg/l - 370 mg/l) and Nitrate (9 mg/l - 11 mg/l). There is a gradual increase in level of all the above parameters which has to be subdued by practicing better water management practices.

Sample XI - Bodipalayam - Madukkarai Union

The appearance, colour and taste of the sample proved unobjectionable. The Turbidity level has ended in zero. Parameters like Electrical Conductivity has raised from 1164 mS to 1544 mS, Total Dissolved Solids have increased greatly from 815 ppt to 1080 ppt though it is within the permissible standard. pH has slightly shifted from 8.20 to 8.51 and the Sulphate level has increased from 23 mg/l to 55 mg/l. Thus this variation has to be considered while maintaining the quality of water.

2) Report of the non-potable water samples

Table X to Table XVII discusses vividly the quality levels of the selected samples, the parameters causing pollution, effects and reasons for the quality degradations.

Report of Kandankulampudur

Table X depicts the groundwater quality of Kadankulampudur of Avinashi Union.

Table X Report of Kandankulampudur

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
1584	5280	1109	3696	7.89	8.11	496	1720	43	156	266	1488	0.6	0.8	33	440	P	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Borewell, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The water was found potable in the year 2000, but due to the indiscriminate ways of people the quality has degraded and the water has turned out to be non-potable in the report of 2004 test analysis. The reasons for non-potability are Total Dissolved Solids, Total Hardness, Nitrate, Chloride, and Sulphate. Total Dissolved Solids level have exceeded the cause for rejection limit (2000 ppt) and reached 3696 ppt. Total Hardness level is 1720 mg/l, Nitrate is 156 mg/l, Chloride is 1488 mg/l and Sulphate is 440 mg/l. Increase in Total Dissolved Solids level will lead to undesirable taste and gastro intestinal irritations, Hardness of water to poor lathering and deterioration of clothes, skin irritation and degradation of food quality. Excess Nitrate will lead to blue baby disease and algal growth. Excess Chloride is very corrosive and affects then taste of the waters. Excess Sulphate leads to gastro intestinal irritation and affect taste and act as an laxative agent.

Report of Nehru Nagar

Table XI depicts clearly the groundwater quality status of Nehru Nagar of Palladam Union.

Table XI Report of Nehru Nagar

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
3400	706	2300	494	7.32	7.68	710	230	150	47	340	109	2.0	0.6	550	9	NP	P
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Borewell, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The water was non potable during the year 2000 due to higher levels of Total Dissolved Solids, Nitrate, Sulphate, Fluoride and Total Hardness. All these parameters have serious effect on health like gastro intestinal

irritation, skin irritation, blue baby diseases, dental and skeletal fluorosis, non-skeletal manifestation. The other effects of this water is that it causes undesirable taste, poor lathering of soap, decreases the food quality, initiates algal growth, and produces laxative effect .It was interesting to note that due to the better water management practices and adopting rain water harvesting practices the ill effects of the parameters have greatly reduced and the water has now turned out to be potable. Thus it is clear that by proper water management, the quality of water can be upgraded.

Report of T.Vadugapalayam

Table XII depicts the groundwater quality status of T.Vadugapalayam of Sulthanpet union.

Table XII Report of T.Vadugapalayam

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
921	4080	645	2856	8.09	8.3	320	1200	45	228	44	965	0.7	0.4	41	275	P	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Borewell, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The water which was potable during the year 2000 has turned out to be non-potable due to excess Total Dissolved Solids level, Total Hardness and Nitrate level. This has affected the health of the people and has resulted in the incidence of gastro intestinal irritation, undesirable taste and odour, skin irritation, symptoms of blue baby disease and algal growth. All these reasons are due to improper water management and pollution of both the water and the ground by the people. Solid waste management is not properly done leading to the poor ground water quality.

Report of Bogampatty

Table XIII clearly depicts the groundwater quality of Bogampathy of Sulthanpet union.

Table XIII Report of Bogampatty

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
1221	4510	855	3157	8.20	7.18	360	840	12	14	200	792	1.0	1.4	20	825	P	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Open well, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The groundwater was potable in the year 2000. The test report of the recent analysis (in the year 2004), has certified that the water has turned out to be non-potable due to excess Total Dissolved Solids, Total Hardness and Sulphate level. These parameters have led to the incidence of gastro intestinal irritation, undesirable taste, poor lathering of soap, deterioration of clothes, skin irritation. Water added to milk and food cooked with this water gets spoilt and resulting in poor quality of the food. The main causative factor for such a critical scenario is extreme groundwater extraction and poor environmental consciousness.

Report of Selekarachal

Table XIV clearly shows the groundwater quality of Selekarachal of Sulthanpet union.

Table XIV Report of Selekarachal

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
2300	2240	1610	1568	8.15	7.79	600	590	42	13	400	91	0.6	0.8	120	770	P	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Hand pump, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The water was potable during the year 2000. Followed by the severe drought and improper water management ground water has depleted considerably. In addition to this state a large amount of groundwater has been extracted illegally leading to depletion of groundwater tabel. These situations have led to the depletion of water quality standards and in the recent test it was also proved that the water was non potable. The parameter which exceeded the standard limit was Sulphate. This led to the incidence of gastro intestinal irritation and taste in water.

Report of Venkittapuram

Table XV shows the groundwater quality status of Venkittapuram of Sulur union.

Table XV Report of Venkittapuram

Electrical conductivity mS		Total Dissolved Salts ppt		P^H		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
3180	1360	2226	7952	8.15	8.02	790	2500	21	219	636	2598	0.4	1.2	118	1430	NP	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Borewell, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

Groundwater quality was not upto the standards during the year 2000 due to the presence of Total Dissolved Solids and Total Hardness in excess. Proper steps to avoid this quality depletion could have been taken. But negligence in proper water management has led to the increase of the other parameters causing extreme poor water quality. The other parameters which exceeded the standard limit during the year 2004 test includes Total Dissolved Solids, Total Hardness, Nitrate, Chloride and Sulphate. All these parameters have led to the incidence of gastro intestinal irritation, skin irritation, blue baby diseases, algal growth, corrosive effect and unpleasant taste.

Report of Kalangal

Table XVI shows the groundwater quality status of Kalangal of Sulur union.

Table XVI Report of Kalangal

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
298	2360	209	1652	7.97	8.38	100	510	3	7	18	137	0.0	1.4	8	715	P	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Hand pump, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The analysis presents a very drastic change in water quality parameters tested in the year 2000 and in the year 2004. Though all the parameters are within the standard acceptable limit, only the Sulphate has exceeded the standard limit, making the water non-potable leading to the incidence of gastro intestinal irritations. The taste is affected and has an laxative effect. If proper water management is given consideration , this parameters can be kept under control.

Report of Kallipalayam

Table XVII shows clearly the groundwater status of Kallipalayam of S.S. Kulam union.

Table XVII Report of Kallipalayam

Electrical conductivity mS		Total Dissolved Salts ppt		PH		Total Hardness mg / l		Nitrate mg / l		Cloride mg / l		Fluoride mg / l		Sulphate mg / l		P/NP	
B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
798	6535	559	4575	7.43	7.92	240	1460	12	24	96	1542	0.8	0.6	45	770	P	NP
NM		500* 2000**		7.0 -8.5* 6.5 - 9.2**		200* 600**		45* 45**		200* 1000**		1.0* 1.5**		200* 400**		-	

Source point : Hand pump, B - Year 2000, A - Year 2004, P - Potable, NP - Non Potable

* - Water standard - acceptable limit ** - Water standard - Cause for rejection, NM - Not mentioned

The quality of groundwater has degraded from the year 2000 and has reached non-potable state at present. The parameters which led to the poor water quality status are Total Dissolved Solids, Total Hardness, Chloride and Sulphate. Due to this exceeded limit there are chances for the incidence of gastro intestinal irritation, skin irritation, corrosive effect and unpleasant taste.

B. Consolidated report of the selected samples

Water samples were collected from 20 areas covering 9 unions during the year 2004. The test report of the sample collected from Chinnamathampalayam was found to be potable. Due to non availability of the year 2000 test report for the year 2000, comparison of the sample was impossible and omitted in the consolidated report. The overall report of the 20 samples is given in Appendix VII. Table XVIII presents the consolidated report of the water quality report for potability and non-potability of the selected samples.

Table XVIII Consolidated report of potable and non-potable water

	P/NP- Before (Year 2000)				Total	
	NP		P		No.	%
	No.	%	No.	%		
P/NP - After (Year 2000)						
NP	1	50	7	41	8	42
P	1	50	10	59	11	58
Total	2	100	17	100	19	100

P - Potable, NP - Non-potable

Table XVIII clearly picturizes the status of the groundwater quality of the selected samples collected during the year 2000 and the year 2004 from 19 locations of the nine unions in Coimbatore. Of the 19 water

sample source points, two sources were detected non-potable during the year 2000. It was encouraging to note that among the two non-potable sources, one source has become potable due to proper water management. But among the 17 potable water sources collected during the year 2000, only 10 have retained it's parameters within standard limit. Remaining since water sources have become non-potable due to improper water management. On the whole, the tests done on water quality in the year 2004 report that 11 water source (58 per cent) are potable and eight water source (42 per cent) is non- potable. The non-potability is due to several parameters like Total Dissolved Solids, Total Hardness, Nitrate, Chloride and Sulphate, etc. The chemical substances present in water will affect the health. The health problems like fluorosis, blue baby diseases, diarrhoea, dysentery, cholera, typhoid, jaundice etc., are associated with the parameters affecting the water. Besides, the water works structures, distribution pipes, and storage structures may also be affected.

C. Nitrate, Fluoride dilution in groundwater

Non-potable water on addition with rainwater losses its hardness. The water quality parameter level decreases with increase in addition of rainwater, thereby converting non-potable water to potable water. In order to confirm this theory and further emphasize the effect of harvesting rainwater towards enhancing the quality of water the following procedure was opted and the results presented in Table XIX proved the theory.

Table XIX Nitrate, Fluoride dilution in groundwater

Parameters →	Nitrate mg / l			Fluoride mg / l		
↓ Habitations	Year 2000	Year 2004 - July	Year 2004 - August	Year 2000	Year 2004 - July	Year 2004 - August
Nehru Nagar	150	47	8	2.0	0.6	0
T. Vadugapalayam	45	228	12	0.7	0.4	0

Table XIX clearly depicts the effect of addition of potable water or rainwater to the water sample with substandard quality. Nitrite and Fluoride are two main parameters which has very serious health effects like blue baby disease and dental, skeletal fluorosis respectively. Two water samples from Nehru Nagar and T. Vadugapalayam whose nitrate and fluoride content were not upto the standard quality level was considered. To this water samples, equal amount of potable water was administered for six times in a day. After the dilution the samples were tested for the presence of Nitrate and Fluoride content. It was proved that the Nitrate content of the water sample collected from Nehru nagar which was 47 in 2004 July had decreased to 8 mg/l and the Fluoride content ended bringing the level to zero. The water sample from T. Vadugapalayam after subjecting to analysis also had only trace levels (12 mg/l) of Nitrate and zero level of Fluoride content.

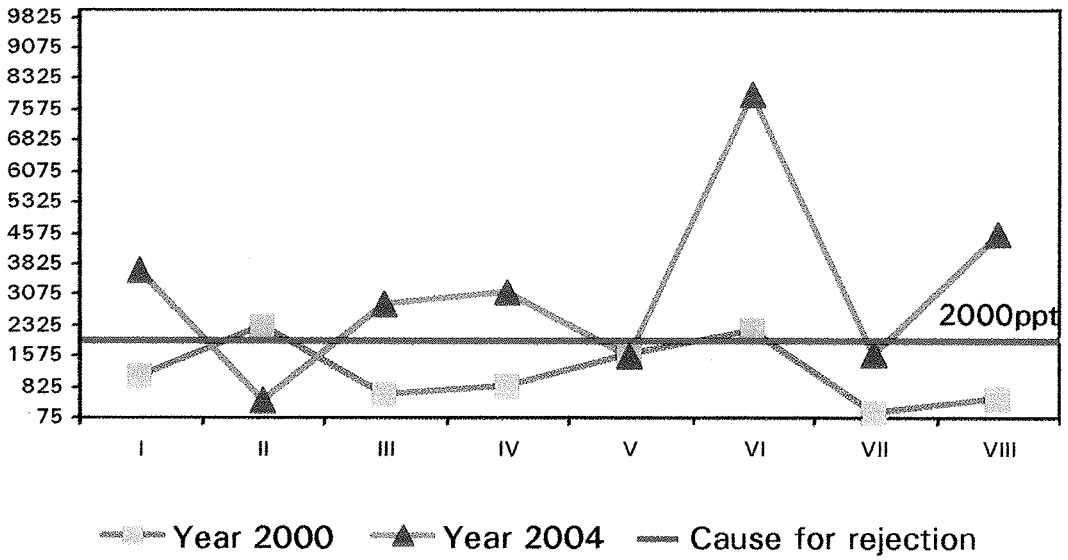
Thus it is clear from the table and result that addition of potable water to a contaminated water reduces the non potable features and reduces the adverse effect of the parameters Nitrates and fluoride. This is a clear evident to prove the efficiency of harvesting rainwater towards increasing the quality of ground water.

D. Comparison of samples for selected parameters

The comparison for selected parameters namely Total Dissolved Solids, Total Hardness, Nitrate, Fluoride, Chloride and Sulphate of the samples are presented below. The test reports of the selected samples for two years over a period of five years duration were compared for its quality status (Year 2000 and Year 2004).

Total Dissolved Solids

Figure 7 presents the level of Total Dissolved Solids in the selected samples.



I - Kandankulam pudur
II - Nehru Nagar
III - T.Vadugpalayam
IV - Bogampatty
V - Selekarachal
VI - Venkittapurm
VII - Kalangal
VIII - Kallipalayam

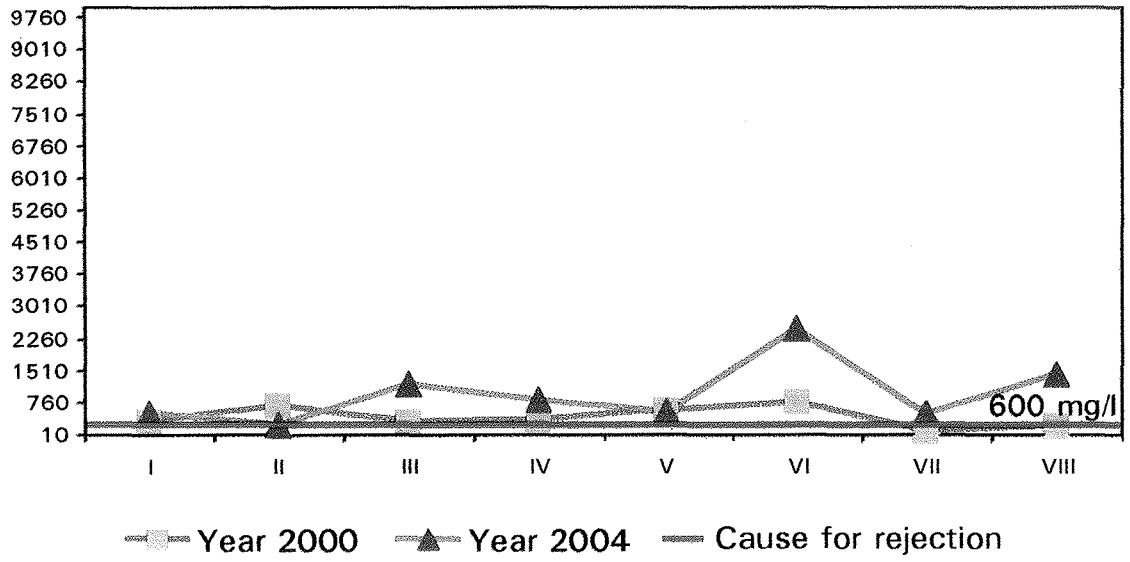
Total Dissolved Solids (ppt)

Figure 7

It is clear that seven samples have Total Dissolved Solids levels above the level indicated for the cause for rejection (2000 ppt).

Total Hardness

Figure 8 presents the level of Total Hardness in the selected samples.



I - Kandankulam pudur
II - Nehru Nagar
III - T.Vadugpalayam
IV - Bogampatty
V - Selekarachal
VI - Venkittapurm
VII - Kalangal
VIII - Kallipalayam

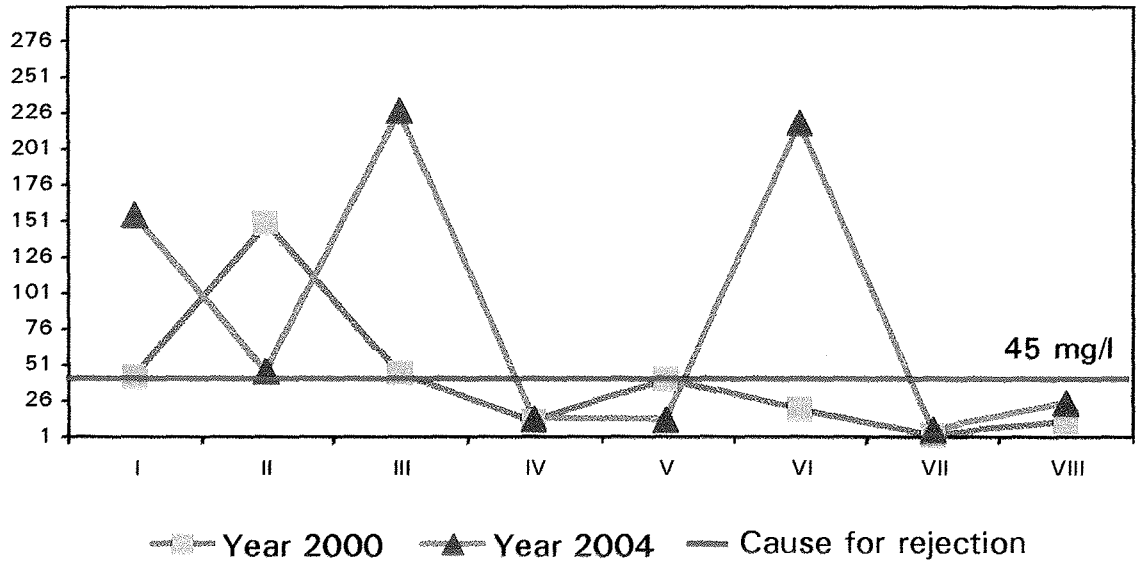
Total Hardness (mg/l)

Figure 8

It is clear that seven samples have Total Hardness levels above the level indicated for the cause for rejection (600 mg/l).

Nitrate

Figure 9 presents the level of Nitrate in the selected samples.



I - Kandankulam pudur
II - Nehru Nagar
III - T.Vadugpalayam
IV - Bogampatty
V - Selekarachal
VI - Venkittapurm
VII - Kalangal
VIII - Kallipalayam

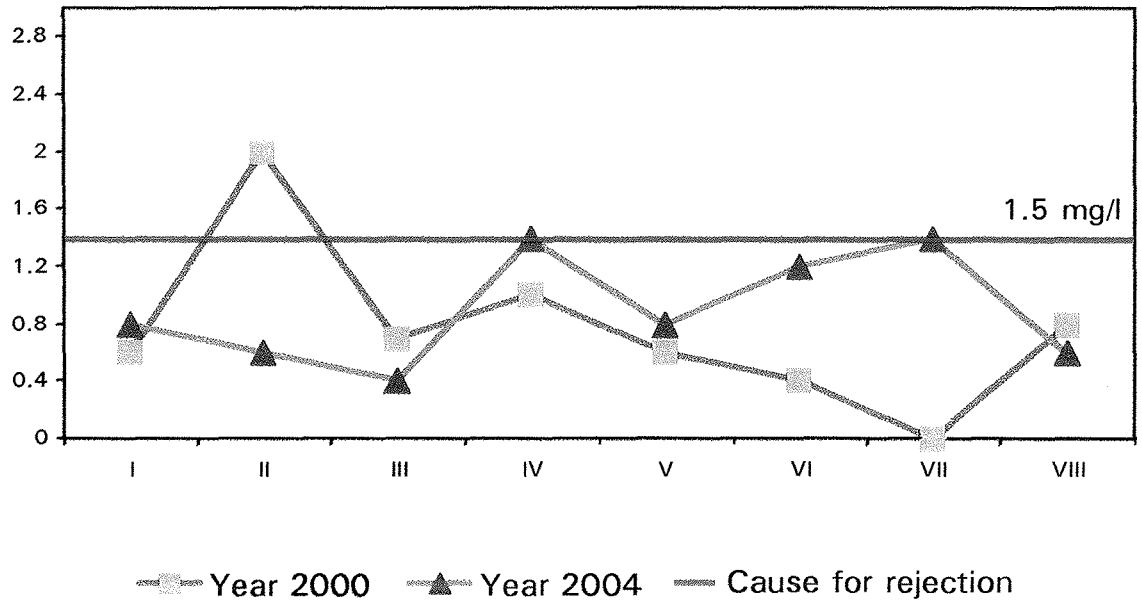
Nitrate (mg/l)

Figure 9

It is clear that four samples have Nitrate levels above the level indicated for the cause for rejection (45 mg/l).

Fluoride

Figure 10 presents the level of Nitrate in the selected samples.



I - Kandankulam pudur
II - Nehru Nagar
III - T.Vadugpalayam
IV - Bogampatty
V - Selekarachal
VI - Venkittapurm
VII - Kalangal
VIII - Kallipalayam

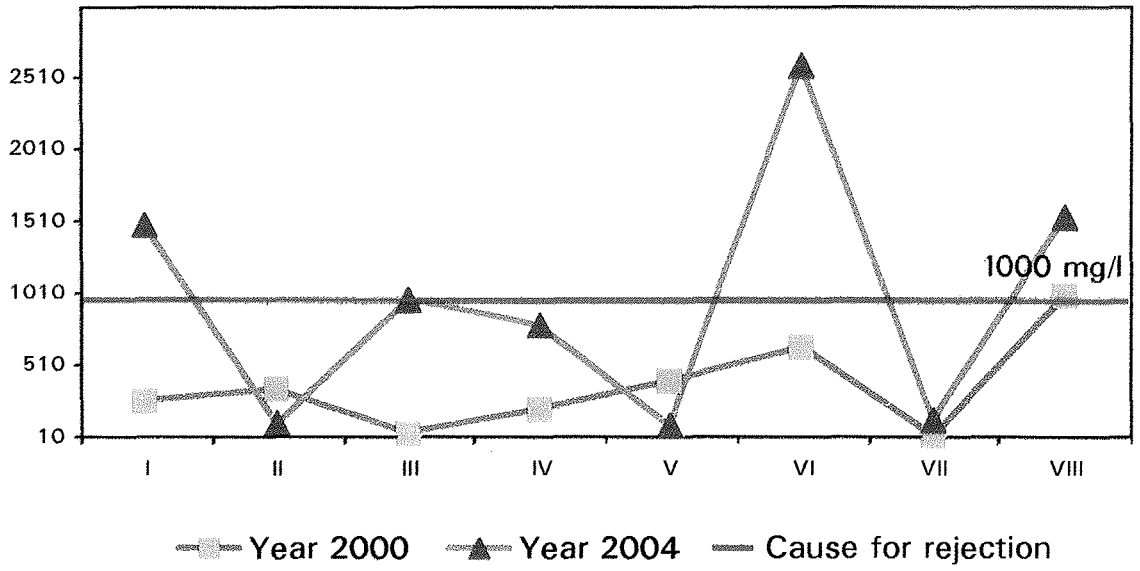
Fluoride (mg/l)

Figure 10

It is clear that one sample have Fluoride level above the level indicated for the cause for rejection (1.5 mg/l).

Chloride

Figure 11 presents the level of chloride in the selected samples.



I - Kandankulam pudur
II - Nehru Nagar
III - T.Vadugpalayam
IV - Bogampatty
V - Selekarachal
VI - Venkittapurm
VII - Kalangal
VIII - Kallipalayam

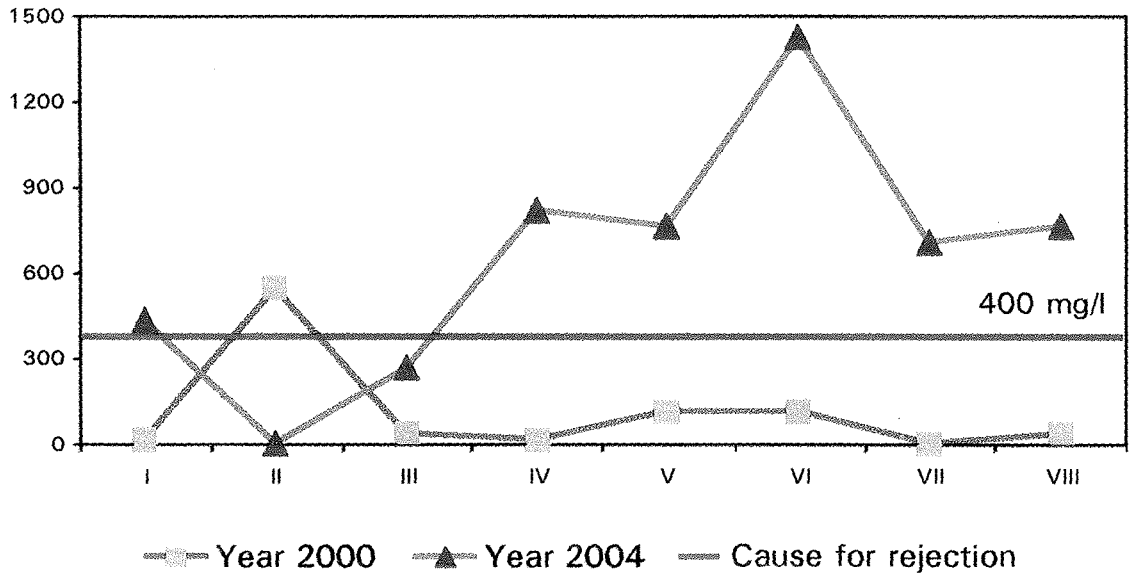
Chloride (mg/l)

Figure 11

It is clear that three samples have chloride levels above the level indicated for the cause for rejection (1000 mg/l).

Sulphate

Figure 12 presents the level of sulphate in the selected samples.



I - Kandankulam pudur
II - Nehru Nagar
III - T.Vadugpalayam
IV - Bogampatty
V - Selekarachal
VI - Venkittapurm
VII - Kalangal
VIII - Kallipalayam

Sulphate (mg/l)

Figure 12

It is clear that seven samples have sulphate levels above the level indicated for the cause for rejection (400 mg/l).

Summary and Conclusion

V SUMMARY AND CONCLUSION

Water, the elixir of life has become scarce. The originality of mother earth has disappeared due to man's cruel crunch of exploitation resulting in water scarcity. Water has become more complex technically, environmentally and economically (Subramanian, 2002). The exponential increase in population rate further increments this critical situation. Saving water is the need of the hour. The major step towards this direction is to harvest rainwater and augment the groundwater reserve (Agarwal, et al., 2001). Since, people have to play their part in rehabilitating the environment, effective planning and management of water sources is required.

The people have a major responsibility in maintaining the quality of natural water (Ghanta and Rao, 1998) Much of the ill health which affects humanity, especially the developing countries can be traced to lack of safe and wholesome water supply. Water must be easily accessible, adequate in quantity, free from contamination, safe and readily available. Water is an integrated component of health, education, food and nutrition. Thus, there can be no state of positive health and well being without safe water (Park, 2000).

In order to understand the extent of groundwater depletion, a study was carried out on "Assessing the Ground Water Quality in Coimbatore, with the following objectives:

- To assess the impact of the rainwater harvesting units put up at households
- To analyse and compare the status of groundwater

- To promote and create awareness of water conservation and
- To increase consciousness of groundwater quality

The outcome of results are summarised under two major phases.

Phase I : Impact of the awareness creation campaign on water conservation

A. Response of the awareness campaign

The investigator executed an awareness campaign to educate the people on the importance of water, need for water conservation, method of rainwater harvesting, status of ground water quality and measures to improve the groundwater. The different sectors of people included, students, rural mass, and the urban community. The investigator conducted meeting, organised exhibition, presented lectures and demonstration on RWH model unit and conducted rallies as part of the awareness campaign. The investigator organised meetings, developed charts, prepared booklet and leaflet for enriching the focus on the sensitisation drive. A total of 366 participants from various sectors attended the awareness campaign. The people expressed their realization in understanding their key role in conserving water and augmenting groundwater table. The sensitisation drive was timely and resulted in a positive impact. Construction of Rain Water Harvesting units in households were major outcome of the campaign.

B. Outcome of the household survey

Household survey was carried out in 100 households in selected rural areas in Coimbatore. Interview schedule was the tool used for gathering information. The major aspects included in the survey were the socio economic profile of the respondents, details on water management practices and general details on quality of rainwater and its effect.

The findings of the survey are as follows

- The socio economic profile indicated that joint family system constitute 54 per cent and nuclear family system 46 per cent, which clearly shows the trend in slow transition of the joint family system to nuclear family system.

- The impact of the Family Planning Programmes of the Government had an effort on the size of the family. Large size family is vanishing at a greater extent leading to small (47 per cent) and medium size family (53 per cent) respectively.

- When considered with male and female ratio, the male dominated compared to females. With regard to age male and female in middle adulthood (66.9 per cent) were higher followed by early adulthood (59.5 per cent) and old age (31.1 per cent).

- Majority (74 per cent) of the heads of the families were literate while 69 per cent of the home makers were literate. Thirty one per cent of the female population were illiterate. National Literacy programme need to be more effective and strengthened for improving the literacy level of the female population.

- The employment status revealed that 93 per cent of the male population and 81 per cent of the female population had better job security. Due to the awareness of the need for literacy, a noteworthy improvement in occupational status was evident. Economic necessity was the basis for taking up job.

- The family income varied between Rs. 1250 and Rs. 4450 and above. With 43 per cent having an income between Rs. 1250 and Rs. 2650, and 36 per cent between Rs. 2650 and Rs. 4450.

- The major source of water in the rural area is the open well (76 per cent) followed by borewell (57 per cent). Fifty seven per cent and

43 per cent were provided with individual pipelines (Athikadavu and Siruvani schemes) to have the water supply from these two schemes, while 21 per cent who were also beneficiaries were supplied by water tankers. The quality of water is also at stake leading to hardness of water to be higher in 128 sources. The remaining 126 source of water was found to be soft in nature.

- Majority of the RWH units constructed comprised of recharging the groundwater (93 per cent) followed by directing the water to the borewell or openwell (56 per cent) consequently recharging the ground water. Roof top harvesting was practiced by 16 per cent.

- Ninety seven per cent of the households completed the construction work within two days followed by 61 per cent who required three days and more.

- It was encouraging to know that 86 per cent of the households added bleaching powder and 83 per cent of the households chlorinated the stored rainwater periodically by adding smaller dosage to maintain and enhance the quality of stored rainwater. Thirteen per cent of the households adopted the filtering method. Awareness campaign had proved fruitful impact.

- Majority of the respondents (94 per cent) complained of white deposits caused by salts on the vessels and PVC pipes. Seventy six per cent complained about difficulty in soap lathering. Food spoilage (57 per cent) and growth of algae (51 per cent) were also mentioned as major problems. Bad odour (23 per cent) and horizontal brownish streaks on teeth (23 per cent) were also expressed as problem faced due to poor quality of water. Potable need to be cautioned on the ill effects of poor quality water. People also have to be encouraged to play effective role in protecting the water quality.

- It was recorded that majority of the households had been affected by diarrhoea (46 per cent) followed by dysentery (31 per cent) and skin diseases (29 per cent). Typhoid, tuberculosis and jaundice were the other water-borne diseases reported.

- The total number of participants who attended the awareness campaign were 366. Lecture cum discussion and demonstration were the methods carried out with model RWH unit. Charts and posters were prepared by the investigator on relevant information to be conveyed. Tamil leaflet regarding the key points on saving water was published and distributed to different sectors. The participants were greatly benefitted and had a clearcut vision on the role of water in man's life.

C. Report of the case study

Efforts of Avinashilingam Deemed University in implementing RWH structure.

In order to mitigate the water problems faced by the campus, augmentation of the groundwater with the run-off water and the roof top water was planned. As an initiative the University identified a number of bore well points with installed recharge structures at various places. In addition five tanks with filtration tanks were constructed to collect the roof top water. Large pits were dug in specific water clogging areas and was filled with filtering media, which served as natural recharge areas. Thus, the efforts of the University to harvest rainwater will achieve its target, making the campus self sufficient with water.

Project Siruthuli

Siruthuli is an integrated project progressing with an aim to improve water management and distribution thereby reviving the lost heritage

of Coimbatore. Siruthuli's accomplishment include desilting the Krishnampathy tank, Selvampathy tank, Kumarasamy tank and Marasampathy tank. On-going projects in Valankulam tank and Selva Chinthamanikulam are carried out in a greater pace. These projects coupled with awareness campaigns at different areas is sure to make Coimbatore a self-sustained community and a model city to the rest of the world.

Phase II: Results of the analysis of the selected sample

The report of the analysis of the samples collected in the year 2004, July from 20 sources were analysed for selected parameters. (Turbidity, Electrical Conductivity, Total Dissolved Solids, pH, Total Hardness, Nitrate, Chloride, Fluoride and Sulphates). The water quality test reports of the samples collected in the Year 2000 from Rural Water Supply further enriched the study. Comparison between the Year 2000 and the Year 2004 was carried out to understand the water quality status in Coimbatore. With regard to potability of water of the 20 samples tested in the Year 2000, 17 were potable and 2 samples were non-potable. The test conducted now in the Year 2004 have shown that 11 samples are potable and 8 samples are non-potable.

a. Areawise analysis report

- Water samples collected from Kannarpalayam, Pethikuttai, Vaiyalipalayam, Vanjipalayam, Punjaithamarikulam, Nachipalayam, Thiruvalluvar Nagar, Somayampalayam, Chandrapuram, Malumichampatty and Bodipalayam proved to be potable during the year 2000 and the year 2004. Even though there is fluctuation in the samples between the year 2000 and the 2004, the water quality parameters are within permissible level.

Hence the water samples were found potable and needs to be maintained with the same features.

- Groundwater sample from Kandankulampudur was potable in the year 2000 and became non-potable in the year 2004. Test reports have revealed high level of Total Dissolved Solids, Total Hardness, Nitrate, Chloride and Sulphate.

- Groundwater sample from Nehru Nagar was found non-potable in the year 2000 due to excess Total Dissolved Solids, Nitrate, Sulphate, Fluoride and Total Hardness, but better water management practices has turned out to be potable, as per test report of the year 2004.

- Groundwater sample of T.Vadagapalam was potable during year 2000 and has found to be non-potable during the year 2004 due to excess Total Dissolved Solids, Total Hardness and Nitrate.

- Groundwater sample of Bogampatty which was potable during the year 2000 has turned out to be non-potable due to excess Total Dissolved Solids, Total Hardness and Sulphate.

- Groundwater sample of Selekarachal was potable during the year 2000 and has because non-potable in the year 2004 due to excess Sulphate.

- The groundwater sample of Venkittapuram reported non-potability during the year 2000 and the year 2004. The parameters which was excess during the year 2000 was Total Dissolved Solids and Total Hardness. Due to poor water management, the water quality was further deteriorated. Results revealed excess Total Dissolved Solids, Total Hardness, Nitrate, Chloride and Sulphate.

- The groundwater sample of Kalangal was potable during the year 2000 and has turned out to be non-potable during the year 2004 due to excess sulphate level.

- The groundwater sample of Kallipalayam was potable during the year 2000 and has turned out to be non-potable during the year 2004 due to excess of Total Dissolved Solids, Total Hardness, Chloride and Sulphate level.

Mismanagement of water had led to the status of non-potability of water, hence steps and initiatives have to be taken to improve the water quality status by encouraging to set up more rainwater harvesting units and hygienic way of disposing water both solid and liquid.

B. Consolidated report of the selected samples

Of the 19 water-sample source points, two sources were detected non-potable during the year 2000. Among those two non-potable sources, one source has turned out to be potable and the other has remained non-potable for ever. But among the 17 potable water sources (during the year 2000) only 10 has retained its parameters within standard limits. Remaining seven water sources have become non-potable. This features the careless action of man exploiting the water resource and environment of groundwater.

C. Nitrate, fluoride dilution in groundwater

Nitrate and fluoride are the two important parameters which when excess leads to severe health problems. It was noted that substandard water having excess Nitrate and Fluoride level when treated with potable water for six times in a day, considerably decrease in the level of these two parameters. Thus it was evident from the analysis that rainwater and potable water can decrease the seriousness of pollution in water and improve the quality of water.

Recommendations

- Water resource management should become the watchword for the future.
- Economy in the use of this scarce and precious resource and the conservation of available supplies will have to be central in planning.
- Traditional systems of water management need to be strengthened. This must be the "thrust area" in future planning.
- Full participation of the people and the NGO's with a good record of social mobilization should be ensured.
- Access to water has to be recognised as a basic human right. The rights of the community over common resources, environmental water right and the water rights of the river itself for the maintenance of its quality and integrity also need to be recognized and strengthened.

Conclusion

The natural resource, **water** has to be safe guarded for the present and future generations through careful planning and management. We need today to arise, awake and share what belongs to all through social justice.

References

REFERENCES

Abbasi, S.A., (1998). "Water Quality – Sampling and Analysis", Discovery Publishing House, "New Delhi, P. 125.

Agarwal, A., and Narain, B., (1997). "Dying Wisdom", Centre for Science and Environment, New Delhi, Pp. 11-36.

Agarwal, A., Narain, S., and Khurana, J., (2001). "Making Water Everybody's Business", Centre for Science and Environment, New Delhi, Pp. 242, 246-253, 262-263, 271, 273, 293-312, 329-335, 448-455

Agarwal, S.K., (2002). "Environmental Biotechnology", A.P.H. Publishing Corporation, New Delhi, Pp. 46-48.

Andrew, R.W., and Jackson, J.M., (1996). "Environmental Science – The National Environment and Human Impact", Longman Group Limited, England, P. 296.

Anjaneyalu, Y., (2002). "Environmental Impact Assessment Methodologies", B.S. Publications, Hyderabad, Pp. 63, 65, 68, 87, 89.

Bali, G., Rallapalli, R., Sallier, S.B., Shiralipau, A., and Kastury, S., (2002). "Environmental Biotechnology", A.P.H. Publishing Corporation, New Delhi, Pp. 98, 107, 108, 113, 142, 143.

Ball, P., (2004). Nature News Service /Mac Millan Magazines Ltd.

Bhushan, L.S., Abrol, I.P., and Rao, M.S.R.M., (1998). "Soil and Water Conservation – Challenges and Opportunities", Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, Pp. 736, 883, 894, 933.

Boniface, D. P., (1995). "Environmental Design and Statistical Methods", Chapman and Hall Publishers, New Delhi, P. 127.

Bryce and Susan (2001). "The Privatisation of Water: Nexus Magazine 8.3 at www.nexusmagzine.com.

Chand, D., (2002). Kurukshetra, Vol. 50, No. 9, Pp. 28-30.

Chand, D., (2002). Kurukshetra, Vol. 50, No. 12, Pp. 33-37.

Chandola, R.P., (1995). "Environment and Life", RBSA Publishers, Jaipur, Pp. 78, 81, 82.

Chary, S.N., and Vyasalu, V., (2000). "Environmental Management – An Indian Perspective", Mac Millan India Ltd, New Delhi, Pp. 164-165.

Chaurasia, B.P., (1992). "Environmental Pollution –Consequences and Measures", Chugh Publication, Allahabad, Pp. 192, 207-209.

Chhatwal, C.R., Satake, S., Katyal, M., Mehra, M.C., Katyal, T., and Nagahiro, T., (1999). "Encyclopaedia of Environmental Pollution and its Control", Anmol Publications Pvt. Ltd., New Delhi, Pp. 1, 2, 9, 10, 14, 29, 41, 42, 99, 170-174.

Choudhry, C. M., (1991). "Research Methodology" RBSA Publishers, Jaipur, Pp. 53, 61, 129.

Colwell, R.R., et al., (2003). "Reduction of Cholera in Bangladesh villages by Simple Filtration", Proc.Natl Acad Sci., Mac Millan Magazines Ltd.

Compendium of Environment Statistics (2000). Central Statistics Organisation, Ministry of Statistics and Programme Implementation, Government of India, New Delhi, P. 204.

Cunnigham, W.P., and Saigo, B.W., (1995). "Environmental Science-A Global Concern", WMC Brown Publishers, London, Pp. 403, 413, 421, 444.

Devi, A.K., and Kumari, O.P., (2003). Kisan World, Vol. 30, No. 5, Pp. 33-34, 44.

Dhameja, S.K., (2000). "Environmental Engineering and Management", S.K. Kalaria and Sons, New Delhi, Pp. 50-61, 76-69.

Gadgil, A., (1998). "Annual Review of Environment and Resources", Vol. 28, Pp. 275-314.

Garg, M.R., Bansal, V.K., and Tiwana, N.S., (1995). "Environmental Pollution and Protection", Deep and Deep Publication, New Delhi, Pp. 155-157, 168-177.

Ghanta, R., and Rao, D.B., (1998). "Environmental Education – Problems and Prospects", Discovery Publishing House, New Delhi, Pp. 56, 86, 163-166.

Ghosh, S., and Verma, H.N., (2002). Kurukshetra, Vol. 50, No. 3, Pp. 10-14.

Gleik, P.H., (2000). "Pictures of the Future –a Review of Global Water Resources Projections In the World's Water 2000-2001" ed.PH Gleik:, Washington DC.Island, Pp. 39-61.

Government of India., (2002). The National Water Policy, Ministry of Water Resources, New Delhi.

Ground Water Year Book of Tamil Nadu and Union territory of Pondicherry (2000-2001), South Eastern Coastal Region , Chennai, July 1999, Pp. 2, 4, 6, 9.

Gupta, A., Dey, M., and Bhattacharjee, P.R., (1996). "Our Environment", Assam University, Silchar, Pp. 52, 54.

Gupta, C.B., (1995). "Management Theory and Practices", Chultan Chand and Sons, New Delhi, Pp. 2, 11.

Gupta, S., Gupta, M., (1997). "Water and Basic Environmental Technology – Resource Management and Pollution Control, Anmol Publication Pvt. Ltd., New Delhi, Pp. 137-138.

Handa, B.K., (1997). "Environmental Pollution and Protection", Deep and Deep Publication, New Delhi, P. 118.

Huang, J.W., Poynton, C.Y., Kochian, L.V., and Elless, M.P., (2004). "Environmental Science and Technology", Advance Online Publication, Macmillan Magazines Ltd.

Humphrey, C.R., Lewis, T.L., and Buttel, F.M., (2002). "Environment, Energy and Society- A New Synthesis", Wadworth/Thomson Learning, USA, Pp. 115, 116.

Ignacimuthu, S., (1998). "Environmental Awareness and Protection", Phoenix Publishing House Pvt. Ltd., New Delhi, Pp. 108, 110, 120, 121, 129, 130, 141-144, 147, 148, 274, 275.

Jee C., Diwan, P., Anamika., Rao, Y.B., Ramakrishnaiah, S., and Venmathi, A., (2004). "International Conference WATER INDIA-4 Water Resources Development – Flood Control, Irrigation, Drinking Water, Water Ways, Hydro Electric Power and its Transmission. System 3-4, Vol. I & II, International Publications and Information Services, New Delhi, Pp. 330-332, 31-32.

Jeyanthi, G.P., Bhuvaneswari, V., Hemaprabha, J., (2004). "Quality Evaluation of Potable Water on Treatment with Selected Medicinal Plant Products", The Indian Journal Of Nutrition and Dietetics, Vol. 41, No. 5, Pp. 187-197.

Jogi, K.S., (2000). "Encyclopaedia of Energy Resource Management", Sarup and Sons, New Delhi, Vol.2, Pp. 342-345, 373.

Kalayanaraman, S., (2002). Kisan World, Vol. 29, No. 12, P. 23.

Kannan, K., (1997). "Fundamentals of Environmental Pollution", S. Chand and Company Ltd., New Delhi, Pp. 248, 280, 281

Khopkar, S.M., (1998). "Environmental Pollution Analysis", New Age International Pvt. Ltd., New Delhi, Pp. 83-112.

Kishore, K., (2004). Kisan World, Vol. 31, No. 2, Pp. 17,18.

Kothari, C.R., (2001). "Research Methodology-Methods and Techniques", Wishwa Prakashan, New Delhi, Pp.149, 150.

Krantz, D., and Kifferstein, B., (2003). "Water Pollution and Society", Nature News Service / Macmillan Magazines Ltd.

Kudesia, V.P., (1998). "Water Pollution", Pragati Prakashan, Meerut, Pp. 6-19, 593-607.

Kudesia, V.P., (2000). "Pollution (Everywhere)", Pragat Prakashan, Meerut, Pp. 51, 57, 58, 297-299.

Kumar, A., and Varma, M.C., (2004). "Environmental Pollution and Health Hazards", A.P.H. Publishing Corporation, New Delhi, Pp. 109, 110.

Kumar, R., (2001). "Encyclopaedia of Environmental Science and Technology", IVY Publishing House, New Delhi, Pp. 550, 584, 611.

Linter, S., (1997). "Environment Matters", The World Bank Group and the Environment Fiscal, Washington, Pp. 48, 49.

Magdolena, S., et al., (2003). Critical Review in Environmental Science and technologies, CRC Press LLC.

Majumdar, D.K., (2000). "Irrigation Water Management – Principles and Practice", Prentice – Hall of India Pvt. Ltd., New Delhi, Pp.51-55, 62-64.

Manavalan, S., (1998). "Water Resources and Water Needs of Tamil Nadu", Kisan World –Special issue, Pp. 57-61.

Manivasakam, N., (1995). "We Breathe and Drink Poison", National Book Trust, New Delhi, Pp. 26-34.

Mason, C.F., (1993). "Biology of Fresh Water Pollution", Longman Scientific and Technical, New York, Pp. 1, 13, 15.

Mathew, A.C., and Senthilvel, S., (2003). Kisan World, Vol. 30, No. 3, Pp. 50, 51.

Mayer, J.R., (2001). "Connection in Environmental Science – A Case Study Approach", Mc Graw Hill Companies Inc., New York, P. 63.

Mitchell and Paul (2000). "World Water Commission Recommends Privatisation of Water Supplies", in www.org/articles.2000/mar2000/wat-m20.shtml.

Murthi, C., (2004). "Population Growth and Environment", Vol. 31, No. 5, Pp. 25, 26.

Murty, J.V.S., (1994). "Watershed Management in India", Wiley Eastern Limited, New Delhi, Pp. 55-73.

Nadakavukasen, A., (1995). "Our Global Environment. A Health Perspective", Waveland Press, Inc, Ilinos, Pp. 4-8.

Ou, H.W., (2001). "Possible Bands on the Earth's Surface Temperature from the Perspective of a Conceptual Global-Mean Model", Journal of Climate, 14-2976-2988. Mac Millan Magazines Ltd.

Palanisami, K., Kumar, D.S., and Chandrasekaran, B., (2001). "Watershed Management-Issues and Polices for 21st Century", Associated Publishing Company, New Delhi, Pp. 16-25, 136-147.

Panneerselvam, A., Ramakrishnan, M., (1996). "Environmental Science Education", Sterling Publications Private Ltd, New Delhi, Pp. 14, 15, 75.

Park, K., (2000). "Park's Textbook of Preventive and Social Medicine", M/S Banarsidas Bhanot Publishers, Jabalpur, P. 483.

Perman, R., Ma, Y., and Mccilvray, J., (1996). "Natural Resources and Environmental Economics Addition Wesley Longman Ltd., New York, Pp. 44, 319.

Pickering, K.T., and Owen, L.A., (1994). "An Introduction to Global Environmental Issues", Routledge, London, PP. 133, 135, 138, 141, 156.

Prabhakar, V.K., (2001). "Health and Environment", Anmol Publication Pvt. Ltd., New Delhi, Pp. 1, 2, 178, 190-192, 241, 246-248.

Prabhakar, V.K., (2001). "Prevention and Control of Pollution", Anmol Publication Pvt. Ltd., New Delhi, P. 78.

Ramesh, et al., (1998). "Environmental Education – Problems and Prospects", Discovery Publishing House, New Delhi, Pp. 103-107.

Randhawa, N.S., and Sarma, P.B.S., (1997). "National Water Policy – Agricultural Scientists Perceptions", National Academy of Agricultural Sciences, New Delhi, Pp. 54-55, 57, 60, 64, 66-68, 81, 39, 139, 193, 204-220, 227, 357, 368, 389.

Rao, C.S., (1997). "Environmental Pollution Control Engineering", New Age International (P) Ltd., Publishers, New Delhi, Pp. 277, 288, 308

Rao, V. K., and Kumar, T. V., (2000). "Ground Water Recharge", Kisan World, Vol. 27, No. 5, Pp. 45, 46.

Raphael, J.C., (2002). Kurukshetra, Vol. 50, No. 11, Pp. 37-40.

Ravi, N., (1995). "The Hindu Survey of the Environment 1995", National Press, Chennai, P. 122.

Reddy, A.A., (2001). "Extension Education", Sree Lakshmi Press, Bapatla, Pp. 44 -107.

Sabri, M.A., (2004). "Environmental Education", Kurukshetra, Vol. 52, No. 8, Pp. 7 -11.

Samra, J.S., Sharila, V.N., and Sikka, A.K., (1996). "Water Harvesting and Recycling-Indian Experiences", Central Soil and Water Conservation Research and Training Institute, India, Pp. 7 -16.

Sastri, M.N., (1996). "Introduction to Environment", Himalaya Publishing House, Mumbai, Pp. 35, 44, 47.

Satake, M., Mido, Y., Sothi, M.S., and Iqbal, S.A., (1994). "Environmental Chemistry", Discovery Publishing Home, New Delhi, P. 51.

Saxena, M.M.N., (2003). Yojana, Vol. 47, No. 6, Pp. 7, 8, 10, 12-16.

Schmitz, R.J., (1996). "Introduction to Water Pollution Biology", Gulf Publishing Company, Texas, Pp. XIII, 19, 20.

Schwab, O., Fangmeier, D., Elliot, W.J., and Frevert, K., (1996). "Soil and Water Management Systems", John Wiley and Sons, Inc, New York, Pp.162-165.

Sharma, B.K., and Kaur, H., (1995). "Water Pollution", Krishna Prakashan Media (P) Ltd., Merrut, Pp. 24-31, 142-146, 149-154, 3-8, 17, 24-31.

Sharma, M.R., (2004). "Pollution Research" Vol. 23(1) Enviromedia, India, Pp.131, 132, 134.

Shastree, N.K., (1997). "Environmental Resource Management", Anmol Publications Pvt. Ltd., New Delhi, Pp. 75, 77, 80-98, 293.

Singh, P., (1992). "Indian Environment", Ashish Publishing House, New Delhi, P. 5.

Singh, R., (2001). Kurukshetra, Vol. 49, No. 3, Pp. 41-43.

Singh, R., (2002). Yojana, Vol. 46, No. 2, Pp. 9-15.

Singha, A.K., Khan, B.N., Kumar, A., and Shukha, G., (1999). "Human Health and Environment", A.P.H. Publishing Corporation, New Delhi, Pp:13-26

Sinha, M., (2003). Social Welfare, Vol. 50, No. 4, Pp. 2, 3.

Sivanappan, R.K., (1999). "Soil and Water Conservation and Water Harvesting", Tamil Nadu Afforestation Project, Chennai, Pp. 92-97.

Sivanappan, R.K., (2003). Kisan World, Vol. 30, No. 4, Pp. 37-40.

Sivanappan, R.K., (2003). Kisan World, Vol. 30, No. 8, Pp. 27, 28, 29.

Sodhi, G.S., (2000). "Fundamental Concepts of Environment Chemistry", Narosa Publishing House, New Delhi, P. 364.

Sravanavel, P., (1999). "Research Methodology", Kitab Mahal Agencies, New Delhi, Pp. 142, 143.

Subramaniam, V., (2002). "Text Book in Environmental Science", Narosa Publishing House, New Delhi, Pp. 43-52, 55-57, 63, 65-71.

Trivedi, P.R., and Raj, G., (1992). "Environmental Problems – Impact Assessment", Akashdeep Publishing House, New Delhi, Pp. 83, 93, 97-99.

Trivedi, P.R., and Raj, G., (1996). "Environmental Water and Soil Analysis", Akashdeep Publishing House, New Delhi, Pp. 3-12, 26.

Trivedi, P.R., and Singh, U.K., (1994). "Environmental Protection and Law", Common Wealth Publishers, New Delhi, Pp. 4, 31, 46-48, 234, 235.

Vaidyanathan, A., (2003). "Catch Water-The CSE Campaign for People's Water Management", Vol. 4, No. 5, Excellent Printing Home, New Delhi, Pp.1-15.

WAPCOS 2002. Frame Work for Action – Indian Water Vision 2025. Indian Water Partnership, P. 4.

Appendixes

APPENDIX IV

INTERVIEW SCHEDULE TO ELICIT DETAILS ON RAIN WATER HARVESTING UNITS AND WATER MANAGEMENT

Name of the Interviewer :

Name of the Interviewee :

A. General information :

1. Address :

2. Type of Family : Joint ☐ Nuclear ☐

3. Size of the family : Small (1-3) ☐

Medium (4-6) ☐

Large (>6) ☐

4. Family background :

S.No.	Name	Age	Education	Occupation	Income

B. Details on rainwater management practices :

1. Sources of Water

Well ☐

Borewell ☐

Metro water ☐

Water tanker ☐

Hand pump ☐

2. Quantum of water procured?

source:

Normal ☐ Deficit ☐ Surplus ☐

3. Year of establishing RWH units

4. Installed by

   Private engineer ☐

   Local mason ☐

5. Method of harvesting

   Roof top harvesting ☐

   Recharge to borewell / well ☐

   Percolation pit ☐

   Recharge Trench ☐

6. Cost of construction

7. Duration of construction

C. Details regarding the quality aspect of rain water

1. Nature of Water

   Soft ☐ Hard ☐

2. Purpose of utilisation of rain water

   Drinking ☐

   Cooking ☐

   Washing clothes ☐

   Cleaning utensils ☐

   Gardening ☐

D. Soil condition

1. Type of soil

2. Nature of soil

   Water absorbent ☐

   Non water absorbent ☐

3. Is the quality of water affected by the nature of soil

4. Period of storage of rain water

5. Problems experienced due to storage

Bad odour	☐
Soap not lathering	☐
Food becomes poor in quality	☐
Nuisance of algae/growth of weeds	☐
White deposits on vessels and pipes	☐
Horizontal brownish black streaks on teeth	☐
Rotten egg smell from water	☐

6. Health problems suffered

Cholera	☐	Tuberculosis	☐
Typhoid	☐	Jaundice	☐
Dysentery	☐	Poliomyelitis	☐
Diarrhoea	☐	Skin Diseases	☐

7. Methods of improving the quality of water

Chlorination	☐
Bleaching Powder	☐
Filtering	☐

8. Have you analysed the water for its quality? If yes. Where

Private laboratory	☐
TWAD laboratory	☐

E. General impression about RWH

General view of the efficiency of rainwater harvesting units and the quality of rainwater.

APPENDIX V

Guidelines on collection, preservation and testing of water samples

Collection procedure:

- Water for testing should be collected in a clean, 2 litre polythene or plastic containers.
- The water to be tested should be from a regular use and has to be adequately flushed out before collection.
- The container should be washed thoroughly with the same water two or three times.
- Water should be filled completely in the container without leaving any air space and has to be closed air tight.
- The container should be labelled with all required source particulars
- The water sample has to be delivered in the lab within 24 hours from the time of collection.
- TWAD Board can be approached with regard to bacteriological examination.

Source particulars for sample:

Location and address of the sample, location of source (if it is away from the sampling point), type of source, date of collection, pollution to source if any, tests to be conducted, purpose of testing etc., should be clearly indicated on the label.

Water preservation:

Within a period from the collection of sample upto analysis, water properties, especially those of surface water and wastes can change due to chemical, physical and biological reactions. Sample analysis cannot be always carried out immediately or within a short time after sampling. Therefore, the sample preservation is necessary to inhibit the reactions in the sample to laboratory and proper storage can reduce unfavourable changes, since no simple universal method to preserve the water sample composition has been established yet.

Testing of water samples:

- Contact local or state departments of public health or certified private laboratories for more information on water quality.
- The directions must be carefully followed and must be use only sterile containers.
- The containers must be rinsed only with the sample water or else the result will come negative.
- Any water contamination should be reported immediately to the local board of health if contamination is confirmed for further treatment of water supply and for understanding the effect of the contaminants.
- Water must be tested frequently (i.e., twice a year) if the contamination is confirmed.
- Test annually for coliform bacteria and nitrates.
- Test once every three years for sodium, sulphates, iron, manganese and lead.

- Testing for nitrates is recommended in the early months of pregnancy and again after the baby is born.
- If the water source is located near industrial sites, water should be tested for toxic metals such as lead, mercury, arsenic, and nickel.
- A total coliform bacteria test is recommended after replacing the old pipes or immediately after any construction work.
- If the taste, odour or colour of the water changes or if any recurrent gastro intestinal illness is experienced then water should be tested.
- Water must be tested before purchasing a new home or after any remodelling or construction work.
- After the water sample is tested the lab will return a report containing a list of the parameters tested, concentration of contaminants and in some cases highlights any problem contaminants that exceed the State Drinking Water Standards.