A Study of the Drinking Water Supply System in K. C. A. E. T. Campus- Problems And Solutions

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PROJECT REPORT

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DECLARATION

We hereby declare that this project report entitled **"A Study Of Drinking Water Supply System In K. C. A. E. T. Campus- Problems And Solutions"** is a bonafide record of project work done by us during the course of project and the report has not previously formed the basis for the award to us of any degree, diploma, associate ship, fellowships or other similar title of any other university or society.

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Dedicated

To

Our Loving Parents

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SYMBOLS AND ABBREVIATIONS

Abbreviation	Expansion
%	Percentage
°c	Degree Celsius
b.g.l	below ground level
BIS	Bureau of Indian Standards
BOD	Biochemical Oxygen Demand
cc	cubic centimetre
CGWB	Central Ground Water Board
cm	centimetre
COD	Chemical Oxygen Demand
CWRDM	Centre for Water Resources Development and Management
DO	Dissolved Oxygen
E-coli	Escherichia Coli
g	gram
GIS	Geographic Information System
GSI	Geological Survey of India
ha	hectare
I.C.M.R.	Indian Council for Medical Research
ILWIS	Integrated Land and Water Information System
K.C.A.E.T.	Kelappaji College of Agricultural Engineering and Technology
M. cum	Million cubic meters
mg	milligram
mg/L	milligram per litre
ml	millilitre
nm	nanometre
ppm	parts per million
PWD	Public Works Department
RBF	River Bank Filtration
sq. kms	square kilometres
TDS	Total Dissolved Solids
W.H.O.	World Health Organization

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Introduction

INTRODUCTION

Human life is dependent on the presence of fresh water. Of the available 1.4 BCM of our planet water supplies, fresh water makes up less than three per cent. Most of this is tied up in the glaciers, ice caps and snow fields, particularly in Antarctica. After reaching earth as rain, water enters a supply system either by penetrating the ground and moving through subsurface channels, known as aquifers or through runoff into streams and rivers. Because of mismanagement, water becomes polluted at various stages in its movement from atmosphere to land. The type of constituents and their concentrations in water varies greatly depending on the natural phenomenon that may be involved and on other human activities around the sources.

Groundwater is the major source of drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sector. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions.

According to Global Assessment of the Problem and Options for Management, groundwater is being depleted by the demands of megacities and agriculture, while fertilizer runoff and chemical pollution threaten water quality and public health. By 2025, two-thirds of the world's population will live in a nation that is considered water-stressed.

When groundwater gets depleted day by day it becomes imperative to take proper action for its protection. For identifying those protective measures studies should have to be conducted on groundwater. Warnings of a groundwater crisis (with falling groundwater tables and polluted aquifers) have led to calls for urgent management responses. There is a need to evaluate the hard evidence of there being such a crisis and to identify the types of management responses that actually work.

1.1 Groundwater

Over half of the fresh water on Earth is stored as groundwater. As water seeps through permeable ground, it continues downward until it reaches a depth where water has filled all the porous areas in the soil or rock. This is known as the saturated zone. The top of the saturated zone is called the water table. The water table can rise or fall according to the season of the year and the amount of precipitation that occurs. The water table is typically higher in early spring and lower in late summer. The porous area between the land surface and the water table is known as the unsaturated zone.

1.1.1 Groundwater recharge

Water that seeps into an aquifer is known as recharge. Recharge comes from a variety of sources, including seepage from rain and snow melt, streams, and groundwater flow from other areas. Recharge occurs where permeable soil allows water to seep into the ground. Areas in which this occurs are called recharge areas. They may be small or quite large. A small recharge area may supply all the water to a large aquifer. Streams those recharge groundwaters are called losing streams because they lose water to the surrounding soil or rock.

1.1.2 Groundwater Discharge

Groundwater can leave the ground at discharge points. Discharge happens continuously as long as enough water is present above the discharge point. Discharge points include springs, stream and lake beds, wells, ocean shorelines, and wetlands. Streams that receive groundwater are called gaining streams because they gain water from the surrounding soil or rock. In times of drought, most of the surface water flow can come from groundwater. Plants can also contribute to groundwater discharge, because if the water table is close enough to the ground, groundwater can be discharged by plants through transpiration.

1.1.3 Groundwater Movement

Groundwater usually moves slowly from recharge areas to discharge points. Flow rates within most aquifers can be measured in feet per day, though in karsts bedrock the rate of flow can be measured in miles per hour. Flow rates are faster when cracks in rocks or very loose soil allow water to move freely. However, in dense soil, groundwater may move very slowly or not at all. Groundwater typically moves in parallel paths, or layers. Since groundwater movement is slow, it doesn't create enough turbulence to cause mixing the way surface waters mix when a river or stream empties into another water body. That is, layers of groundwater remain relatively intact. This can be an important factor in locating and determining the movements of contaminants that might enter the groundwater supply. But eventually contaminants will disperse through part or all of an aquifer. Wells affect groundwater flow by taking water out of an aquifer and lowering the nearby water table.

1.2 Perspectives of water studies

Water being the basic commodity and resource for the existence of life in various stages, requires utmost care in its maintenance and utilization. It serves mainly as for domestic needs, irrigation requirements and for industrial purposes. As the beneficiary varies in amount and satisfying condition, the quality of water also varies to satisfy the permissible standard specifications. Hence the quality of water depends on many parameters such as soil, climate, source of supply distribution systems etc. The many ways in which water promotes the economical and general wellbeing of society are known as beneficial uses. The relative importance of beneficial uses for any particular application depends on the economy of the area and the desires of the people. Many applications are restricted within narrow ranges of water quality, such as public and industrial water supply. Therefore, quality control is required to ensure that the best employment of water is not prevented by indiscriminate use of water supply. The basic information on the quality of water is an essential requirement for deciding the suitability of any source for a desired purpose.

1.3 Need for Integrated Approach

An integrated strategy to water quality based pollution control uses three approaches: control of specific pollutants, testing of effluent toxicity and biological assessment. Control of specific pollutant is done by establishing numerical limit on toxins that may affect its potability. Since quality based chemical limits are monitored by testing the water samples from different locations, proper remedial measures can be suggested.

Water in the distribution system is monitored for microbial quality by testing for coliform bacteria as indicator organisms. The number of water samples to be tested for coliform in a small public water system serving less than thousand persons in one per month.

1.4 Need for water quality monitoring

Monitoring of any system implies watching the on-going or changes of any matter to ensure no laws or rules are broken. In case of water, the monitoring generally refers to sampling, measurement and assessment of quality variables at different time and space. Some of the common objectives are classification of water resources, collection of base line data, water quality surveillance and pollution investigation, forecasting water quality and estimating waste assimilation capacity.

If water needed as a public supply, water must be treatable by conventional process to yield potable water meeting the drinking water standard. The important criteria defining quality are; dissolved oxygen, dissolved solids, coliform bacteria, toxins, pH, temperature and other parameters as necessary. Lower limits are established by various international agencies and the quality characteristics are compared with these values.

1.5 Water Budget of KCAET campus

The KCAET campus meets its water needs from pumping of the two filter point wells and an open well near the farm. It is supplied by an underground pipe line system throughout the campus and Kelappaji School which is located near the campus with an overhead tank to store the pumping water. There are two tanks in ladies hostel to meet the requirements of the hostel. These two tanks and main tank are filled in shift wise. Water for irrigation has been taking from the farm ponds and shallow tube wells. Moreover, dairy farm is also working in the campus where resources are to be properly maintained.

The present quality of water requires an urgent study on the contamination occurring in the supply system. Also irrigation water from farm ponds and wells are in threat of pollutants, which affects water quality of nearby area also. Main problem associated with drinking water supply system is that the presence of high iron content and turbidity. This is severe during summer season.

Due to high iron content in water and its use without treatment to remove the iron, it causes ugly discolouration and stains on kitchen, bathroom and laundry fixtures as well as on dishes and laundered items.

The main objectives of the study are:

- Creation of a map of KCAET campus water supply system.
- Evaluating the yield and quality of the available water sources
- To study the factors affecting the quality of water supplied in KCAET campus.
- To study the quantitative and qualitative problems of potable water in KCAET
- Finding solutions for the problems associated with KCAET water supply system.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The groundwater reservoirs gets water as a result of recharge from rainfall, rivers, streams, irrigation etc. and loses water due to regeneration in streams, movement towards other aquifers and man-made withdrawals.

The management of groundwater resources means a programme for ensuring a continual and adequate supply of water of requisite quality for varied uses without endangering the life of the reserve or the source. It implies

- Maintaining or preserving better quality water
- Controlling the use and checking abuse of these precious resources.
- Ensuring the recharge of aquifers by appropriate management of watersheds or the recharge area.

In this chapter, available literature relevant to the present study on groundwater levels and its fluctuation pattern, drawdown and recovery characteristic of wells, ground water recharge, groundwater utilization and availability and ground water quality are reviewed and presented in the subsequent head.

2.1 Ground Water Levels and Fluctuation Pattern

Beena Thomas (1996) conducted a study on monthly water balance model for lateritic hill slope. The analysis showed that minimum depth to water table is established in last July. During the first week of the rainy season, the lowest groundwater level was established and later in the season, intensive rainfall causes rapid responses. As the rain ceased, the profile dried out and the water table approaches the pre-monsoon level. And a model has been developed for estimating the weekly changes in the water level in a humid lateritic region.

Tomar *et al*. (2002) conducted study on seasonal fluctuation in groundwater table under input-intensive farming situation of Western Uttar Pradesh. The study revealed that crop diversification can reduce the rate of decline and rise in depth of water table. High water requiring crops namely sugar cane, rice & potato can be replaced with pulses and oils seed crops which require lesser amount of irrigation water and fetches higher prices in the market.

Bineesh *et al.* (2004) conducted a study on the estimation of ground water recharge in KCAET campus Tavanur Malapuram. They estimated the specific yield of lateritic formation to be in between 0.07 to 0.13 for different sites within the campus.

Deepak et al.(2007) conducted a study on ground water fluctuations and water quality analysis in K C A E T campus. The quality of ground water in terms of the physical, chemical and biological characteristics shows markable variations with water table elevations. The wells that are not using at present, are good sources of fresh water and can be made usable with minimum effort.

Lakshmi *et al.* (2009) conducted a study on temporal ground water fluctuation analysis of K C A E T campus. The study concluded that within a few years the study area is going to face an acute groundwater crisis. Sand mining carried out at river Bharathapuzha caused a fall in the groundwater levels of the study area. The absence of sand on the riverbed affects the velocity of the water flow, making it violent during monsoons.

2.2 Drawdown and Recovery Characteristics of Open Wells

Papadopoulos and Coope (1967) analysed the drawdown in a well of large diameter. Their purpose was to present an exact solution for the drawdown in and around a well of finite diameter taken into consideration the effect of water stored in it. Under some conditions, the solution may be useful in analysing pumping from a pond. A set of type curves computed from the solution permits the determination of transmissivity of the aquifer by analysis of drawdown observed in the pumping well.

Neumann (1975) analysed the pumping test data from the unconfined aquifers considering delayed gravity response. He developed two methods of analysis, one based on matching of field data with theoretical type curves and the other based on logarithmic relationship between drawdown and time. Owing to the reversible nature of the delayed response process as represented by the analytical model, he used the recovery test data to determine the aquifer transmissivity.

Bentley (1979) determined aquifer coefficient from multiple well effects at Fernandina beach in Florida. A water level recorder was used to record the changing water level following shutdown and start up. Pumping rate of well ranged from 4, 00,000 to 5, 90,000 cubic feet per day. Distance from the pumped well to the observation wells ranged from 660 to 7920 feet. Analysis of water level data was further complicated because the wells were neither turned off nor restarted simultaneously. The Copper- Jacob graphical method based on the principle of super position and using the values of specific drawdown or specific recovery (S/Q) and the weighted logarithmic mean of the distance squared divided by time (r^2/t), was applied to determine the aquifer coefficients for the upper water bearing zone of the aquifer. A transmissivity of 30,000 feet squared per day and a storage coefficient of between 2.5x 10^{-4} and 4.0x10^{-4} were computed.

Barker and Herberta (1982) conducted study on pumping tests in patchy aquifer and developed an equation describing the long-time behaviour of drawdown shows that Jacob's method can be employed to estimate the regional transmissivity from drawdown measured at any point in aquifer. These equation shows that an average storage coefficient should be calculated from drawdown measured outside the aquifer discontinuity. The results of the study support the hypothesis that the average transmissivity of the heterogeneous aquifer can be calculated from the rates of drawdown observed after long periods of pumping.

Norris (1983) conducted and analysed aquifer tests and well yield performance at Scioto river valley, Ohio. Values of drawdown measured in the observation wells at the end of constant rate pumping periods, usually of 3 days duration were used to determine the line-source distance and aquifer transmissivity based on 13 aquifer infiltration tests at 11 sites, aquifer transmissivity ranged from 17,000 to 40,000 square feet per day and the standard infiltration rate ranged from 0.06 to 0.19 million gallons per day per acre along a 7 mile reach of Scito river in south central Ohio.

Basak and Nazimuddin (1984) conducted a study on groundwater resources of Malappuram District. Results of the pumping test indicated that on an average, the wells can safely be pumped every 8-10 hrs and the wells will completely be recovered before the next pumping. The specific capacities of these coastal wells vary between 50-232 litres per minutes per meters of drawdown.

Walthall and Ingram (1984) determined the aquifer parameters using multiple piezometers. The study was being carried to evaluate the North Merseyside Permian-Triassic sand stone aquifer with particular reference to saline intrusion and water resources. The study had included a full range of hydrological investigations of which the behaviour of observation boreholes has formed an important part. In addition to water levels, these observations boreholes had been used to access the regional permeability of the aquifer, variations of the hydraulic properties over the aerial extend of the aquifer and for hydrological sampling. The use of multiple piezometers proved to be the only way of obtaining sensible results for field pumping tests and has given storage coefficient for both confined and unconfined sections of aquifer.

Rushton (1985) studied the interference due to neighbouring wells during pumping tests. An important finding of the analysis is that the distance between the test and interfering wells has a small effect during both pumping and recovery phase.

Ballukraya and Sharma (1991) suggested a method for estimating storativity using residual drawdown measurement from an observation well in confined aquifer. An equation derived from Cooper- Jacob is suggested for estimating storativity from an observation well. It may be pointed out that in cases where Cooper-Jacob's straight line method can be applied, the proposed method can be safely employed.

Avci (1992) developed a procedure that analyses step drawdown test with pumping stages of unequal time, duration was formulated and developed into computer programme. This method is applicable to confined aquifer where the water level drawdown is governed by Theis' well function. A least square fit error analysis is used in the determination of the aquifer properties and the well loss component of the drawdown. The method considers the time dependency of the aquifer loss coefficient during the collection of step drawdown data without requiring equal pumping stage duration.

Chapuis (1992) studies proposed a graphical representation for visualizing and quantifying difference between Cooper- Jacob's solution and Theis' solution. The graph of drawdown versus log time may be divided into three zones, the early one being influenced by storativity, pumping well pipe capacity and skin effects and the intermediate one by the transmissivity and storativity of the aquifer. The solution can be used when Cooper-Jacob's approximation and values does not require curve matching. Early data can be used, however to obtain a better estimate of storativity and transmissivity from drawdown data of observation wells.

Chung and Quazar (1995) made a study of Theis solution under aquifer parameter uncertainty. This study showed that drawdown is almost inversely proportional to transmissivity and also find that there is no correlation between transmissivity and storativity.

Jaganathan and Nazimuddin (1998) studied about the recovery characteristics of open wells in mid land regions of Trivandrum. The test results indicated that well tapping groundwater from alluvial and sand stone formation could be pumped out thrice or four times in a day during the end of monsoon. The time since recovery starts in ordinary scale and residual drawdown in logarithmic scale are plotted in a semi-log sheet and a straight line was obtained. The recovery trends of these wells are found at low, hence these wells can be pumped only once in a day. The wells tapping from alluvium and sandstone can be pumped 4 times in a day at the end of monsoon.

Ambili and Biju (2002) conducted a study on evaluation of aquifer parameters from pumping test data. The analysis of the data revealed that the drawdown curve for all the wells showed a linear relationship during the initial faces of pumping because of well storage. The recovery curves for all the wells were found to be similar with initial fast rate of recovery that is attributed to the steep hydraulic gradient in the beginning.

2.3 Ground Water Recharge

Langshot (1992) observed that recharge represent a major portion of rainfall and recommends further model studies to reveal the complex groundwater recharge in this region based on the studies conducted on a $600m^2$ field site in Kerala.

Ranfrez and Finnerty (1996) conducted a study on the precipitation and water table effects on agricultural production and economics. Capillary rise was modelled as a function of soil moisture content and depth to water table. The capillary rise model was used to define the sensitivity of soil moisture depletion, actual evapotranspiration and agricultural benefits to change in water table depths.

Rajan (1997) in his notes prepared for implementing groundwater estimation methodology gives two methods for the calculation of rainfall recharge and they are rainfall infiltration factor method and water table fluctuation method.

Jain and Sondhi (1998) conducted an experiment to estimate the groundwater potential of Bist Doab Tract in Punjab, through seasonal groundwater recharge and water balance studies. The results showed that the average total groundwater recharge in the area in Kharif and Rabi seasons were 28.02 % & 24.28 % of the total water inputs namely rainfall, irrigation from tube wells and canal network during the corresponding seasons. The average annual net change in groundwater storage was observed as a negative value, which indicates that the groundwater resource is over exploited.

Gaur (2001) conducted a study on groundwater recharge estimate of a small watershed. The total annual recharge was calculated as the sum of total monsoon rainfall recharge, non-monsoon rainfall recharge, non-monsoon recharge from surface sources of irrigation and potential recharges. The net utilizable recharge is taken as 85 % of gross recharge.

Rajan (2001) in his lecture notes prepared for training on water harvesting and artificial recharge-their application in drinking water supply programme gives different natural recharge estimation methods and various factors affecting natural recharge. The utilizable recharge is estimated based on premonsoon (June) to post monsoon (November) water level fluctuations for the area receiving South West monsoon. Similarly for the areas receiving North East monsoon water level fluctuation of pre-monsoon (November) and Post-monsoon (March) are to be taken into considerations.

Gitte and Pendke (2002) studied the effect of water conservation practices on hydrological behaviour, water table fluctuations and ground water recharge in water shed. They noted the seasonal water table fluctuations in premonsoon and post monsoon seasons. The ground water recharges in the study area were derived by water table fluctuation method.

Sharma (2002) conducted studies on efficient conservation and management of water resources for sustainable agriculture. For enhancing the groundwater recharge several innovative measures are suggested such as check dams on natural streams, percolation tanks, recharge tube wells, rainwater conservation in paddy field etc. It was observed that the presence of check dams in series have increased aquifer recharge from 5.2 to 38 %. Construction of percolation tank and recharge tube wells helped in an increase of 15 % of the cropped area with 30-35 % higher yields even in drought years. Studies conducted for rainwater conservation in paddy fields showed that dike heights of 22.5 cm around paddy fields were able to retain about 97 % of the rainwater.

2.4 Ground Water Utilization and its Availability

Basak and Nazimuddin (1984) carried out an intensive field research on ground water resources of Malappuram District. The study revealed that total groundwater availability in the top unconfined aquifer along the entire Malappuram coast comes out to be 62 Mcum and average utilization is in the order of 27.5 % to an estimated 3300 open wells scattered all along the coastal stretch of the district.

Rajagopalan and Narasimha Prasad(1988) conducted a study on subsurface water in river bed of the Bharathapuzha at a location near Thrithala in Palakkad District of Kerala State for a rural water supply scheme. Field data obtained through hydrologic and hydrogeologic data monitoring, geophysical and aquifer performance tests are analysed to obtain estimate the critical period of water demand when the river can be expected to be dry, saturated thickness as well as the permeability of the aquifer and gradients of subsurface flow. The feasible subsurface water withdrawal through an infiltration gallery based water supply scheme is finally estimated as $50x10^6$ lpd during periods other than critical period and $25x\ 10^6$ lpd during critical period.

Neumann (1989) presented a comparative discussion of several methods for the determination of specific yield. The specific yield values are consistent with water balance considerations when all the components of the water budget are properly taken into account. The rate at which the groundwater level fluctuates in response to pump age is controlled by the smaller specific yield that obtained from the time-drawdown analysis.

Ganapathisubrahmanian and Subramanian (1993) conducted a study on groundwater exploitation in the command area of Parambikulam Aliyar Project. The study revealed that the ground water development in the command area has reached the maximum limits. The long-term trend of discharge showed a depletion rate of 1.00 MCM per year. It amounts to mining the groundwater. It has to be controlled and regulated either by legislative acts or by indirect measures.

Kulandaivelu and Prabhakaran (1993) conducted a study on groundwater exploitation in Coimbatore taluk. This study clearly indicated that there is over exploitation of groundwater in the area for agriculture purposes. There was a decrease in groundwater table to the tune of 25.3 mm/year. Groundwater exploitation could be minimized by crop diversification.

Venugopal *et al.* (1993) conducted a study on evil effect of groundwater mining and methods for its replenishment in south interior part of Karnataka State. The study indicated that the groundwater resources had been over exploited and situation prevailing in the area warrants for taking up water conservation and better water management practices through improved methods like drip and sprinkler irrigation. Desilting of minor irrigation tanks in the area should be taken up in a phased manner. Surface dykes were also used for conserving the surface runoff.

Kumar (1998) conducted a study on spatial analysis of water balance of Northern Kerala. Water balance graphs drawn for different conditions showed that the soil moisture recharge starts in the pre-monsoon showers during May and the full soil capacity of 300 mm is reached in mid-June. The water surplus from mid-June to October is lost as surface runoff. The soil moisture utilization starts from November and it was almost completely exhausted by January leading to water deficiency from February to April.

Bhatnagar (2002) in his study on ground water utilization for irrigation, revealed that, in areas having the problems of ground water depletion, the processes of discharge needs to be augmented through artificial means. He also found that drip irrigation has a potential to save irrigation water 40-60 % along with an increase in yield by 15-25 % and improved the quality of the produce.

Sharma (2002) presented different methods for the efficient conservation and management of water resources for sustainable agriculture. This study revealed that even under relatively similar environment the level of management could cause significant changes in water productivity. He also concluded that rainwater is the primary source of all kinds of water and needs to be conserved and used most judiciously.

2.5 Ground Water Quality

Basak and Nazimuddin (1984) conducted a study on ground water resources of Malappuram District. The study revealed that in some places, ground water remains unpotable throughout the year due to high pH, high TDS, high chlorine content, high iron content etc.

Nazimuddin and Basak (1988) in their study on "Ground Water resources in Kerala with special reference to coastal shallow aquifer zone" identified low pH, high Fe, high hardness, high TDS and salinity in the study area. The results also revealed that the width of the sensitive zone for seawater in the various coastal belts vary from 100 m to 500 m from the shore.

2.6 Infiltration

Michael et al.(1973) explained the methods of increasing the yield of open wells in alluvial formations. On installing filters radially there is a significant increases in yield.

Marino (1974) studied the water table fluctuation in response to recharge. Solutions have been derived which describe the rise and fall of the water table in an extensive unconfined aquifer receiving uniform localized recharge and discharging into a surface reservoir in which water level remains equal to that of the main flow before the incidence of recharge. The solutions are expressed in terms of the head averaged over the depth of saturation and are applicable when the rise of water table is smaller than 50% of the initial depth of saturation. When prediction of future water level is desired the equation should be used in conjunction with the method of successive approximations.

Rai *et al.* (1988) derived an approximate solution of the nonlinear Boussinesq equation which describes the water table variations in a ditch-drainage system with a random initial condition and transient recharge. The numerical results reveal that the water table variation is significantly influenced by the random initial condition and the transient rate of recharge. The amplitude of variation was maxima at the ground water divide.

Lai *et al*. (1991) compared the water table fluctuation predicted by different models. The models described in this work have been used to simulate the water table behaviour in response to subsurface drainage for climatologically and soil prevailing at sample in Haryana. A field experiment on subsurface drainage was conducted to control the water table and salinity in the water logged saline soils at sample. The experiment consists of three tile drain spacing of 25m, 50m and 75m. The average depth of tile line below ground surface was 1.75m. Two models for predicting water table namely, de Zeeuw- Hellinga and Van Schilfgaarde were selected to their field applicability by comparing the observed water table heights with the predicted water table for the period July to September 1985 for 75m drain spacing Van schilfgaarde model was found to be more satisfactory for its application in the field condition.

Zomorodi (1991) derived a new method for the elevation of the response of a simple numerical model. The model has several advantages over the traditional methods of mounting prediction. The effect of the unsaturated zone which modifies the recharge rate as compared with the infiltration rate is considered. Mounting is calculated for variable recharge rate induced by a variable infiltration rate. Also, the effect of in-transit water in reducing the tillable pore space above a rising water table is considered.

Raghu Babu et al. (2004) conducted a study on subsurface skimming techniques for coastal sandy soils. The study reveals that the system known as “Improved Doruvu technology”, works on the principle of collection of shallow depth fresh water into the well through horizontally installed collector lines.

Joseph(2011) conducted a study on radial wells for lateral storage and collection of water . He explained that radial well can be the most viable technology for tapping good quality water from the shallow subsurface soil in Kuttanadu. The model evolved based on the fact that in Kuttanadu, acidity increases as depth increases. The water quality can be ensured by tapping maximum water from near surface level rather than increasing the depth of the well.

Materials and Methods

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MATERIALS AND METHODS

This chapter deals with the water resource data of our campus and the methods of data collection and analysis.

3.1 Site and Location of Study Area

The study of water supply system was conducted at K.C.A.E.T. campus Tavanur, in Malappuram district of Kerala, situated at 10°52’30” North Latitude and 76° East Longitude in the humid tropics. The total area of the study region is about 40 ha. Bharathapuzha River forms the northern boundary of the study area.

3.2 Creation of a map of KCAET campus water supply system

A digital contour map of the study area was created from the existing drawn contour map which was modified to include the recent changes. The steps for creating and digitizing the map are given below.

The map was digitized using the software ILWIS 3.3. ILWIS is an acronym of Integrated Land and Water Information System. It is a Geographic Information System (GIS) software with image processing capabilities. ILWIS was initially developed by International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, Netherlands and is now an open source software developed by 52°North (www. 52north.org), a consortium of open source developers. As a GIS and Remote Sensing package, ILWIS allows inputting, managing, analysing and presenting geographical data. From the data one can generate information on the temporal and spatial patterns and processes on the earth surface. GIS are nowadays indispensable in applications related to spatial analysis.

The map was scanned and imported to ILWIS environment using the ‘File- import’ option of the software. To start ILWIS, double click the ILWIS icon on the desktop. After opening we can see the ILWIS main window. From this, we can start all operations. The digitized map was converted to real-world coordinates by using a set of control points with known real world coordinates (called geometric transformation). Then boundary of the study area and included buildings were digitized and segment map was generated.

3.2.1 Digitizing contour lines

(1) From the File menu of the Main window, select Map Reference. The Map Reference dialog box is opened.

(2) Expand the create item in the operation-tree and double-click New Segment Map. The Create Segment Map dialog box is opened.

(3) Type ‘Isolines’ for the name of the map.

(4) Select landuse from the list box Coordinate System.

(5) Click the Create Domain button. The Create Domain dialog box appears.

(6) Type ‘Isolines’ for the Domain Name and select domain Type Value.

(7) Type 0 and 50 in the Min, Max text boxes, and type 0.1 in the text box Precision.

(8) Close the Create Domain dialog box by clicking OK. You are now backing in the Create Segment Map dialog box. Click OK.

(9) From the Edit menu of the segment editor, select Insert Code.

(10) The Edit dialog box is opened.

(11) Type the value: 8. this will be the default value for all segments that will digitize from now on. Click OK.

(12) Digitize the contour lines with the altitude 8. After you finished digitizing each line, click OK in the Edit dialog box.

(13) Subsequently digitize a contour line of altitude 10. In the Edit dialog box, which appears after you finished digitizing the line, change the value to 10 and click OK.

(14) Continue to digitize the rest of the contour lines.

(15) Make sure to snap different parts of the same contour line.

(16) From the File menu of the segment editor, select Check Segments, Code Consistency.

(17) Accept the defaults in the Check Segments dialog box and click OK. If the program finds an error, it will indicate the place of the error with a red box and a dialog box appears stating the nature of the error: Different codes ‘value’ and ‘value’ at node. Zoom in on error

(18) Click yes to zoom in and correct the errors (if any) by recoding the wrong segments.

(19) Press the Exit Editor Button when the digitizing is finished. When the segment editor is closed, the segments are displayed in a map window; segments are displayed with system representation Pseudo.

(20) Close the map window when you have seen the result.

3.2.2 Adding the water resources and water supply system in the KCAET map

The water supply system of the KCAET campus was studied. The position of pumping wells and overhead tank were located in the map. Then pumping and supply lines routes were plotted in the map with measured values. A point map was then prepared giving labels to the overhead tanks. After that, pumping and supply lines segment map layers were created. Additional layer of point map of different valves were created. The new map of water supply system was generated by integrating these layers.

The wells were located using GPS (Global Positioning System) and field measurements. These wells were marked on a point map layer.

Then the created map was exported to bitmap format.

3.3 Study of Water Resources in K.C.A.E.T. campus

The campus has got several open wells, filter point wells and shallow tube wells as water sources for potable water in addition to ponds which are exclusively used for irrigation purposes only. The wells are located in different land slopes. Presently most of the wells lack proper development and there is no conjunctive or optimal utilization of the water resources.

The wells used for daily water supply are studied for their drawdown characteristics and also the quality of the water in these wells were analysed.

3.4 Observations on draw down and recovery characteristics of open wells

Draw down and recovery characteristics of the wells were studied by conducting pumping tests. Measurements of depth to water table were taken for every one-minute interval for the first fifteen minutes and five minutes interval for the next forty five minutes and there after one hour interval till the water table depth attained its maximum drawdown. Similarly the recuperation of water table was also recorded.

3.5 Yield Test

The following tests may be performed to get an idea of the probable yield of the well

(a) Pumping test

(b) Recuperation test

(a) Pumping Test

Pumping tests were carried out in well 5 with a 2 hp motor having a discharge of 300 lpm, in the month of October. In the pumping test, the water level in the well is depressed to a amount equal to the safe working head for the sub-soil. Then the water level is kept constant by making the pumping rate equal to the percolation into the well. The quantity of water pumped in a known time gives an idea of the probable yield of the well of the given diameter.

In hard-rock areas, if D = diameter of the well, d = depth of water column, Q = pumping rate and t = time required for emptying the well, then,

Rate of seepage into the well = $\frac{\text{Volume of water pumped out} - \text{Volume of water stored in the well}}{\text{Time of pumping}}$

$$= \frac{Qt - \frac{\pi D^2}{4} d}{t}$$

(b) Recuperation test

The different steps in pumping test include the following.

- Measure the distance from the ground level to the water level in the well.
- Operate the pump at about one-third its capacity for 1 to 4 hours.
- During the pumping, measure the yield of the pump by filling a container of known volume and recording the length of time it takes to fill it.
- At the end of the pumping period, measure the water level as soon as the pump is turned off.
- Calculate the drawdown by subtracting the original depth of the static level from the new depth.
- Calculate the "specific capacity" of this one-third drawdown point by dividing the yield (how many litres collected in the barrel in one minute) by the drawdown
- Repeat this process pumping at two-thirds of the pumps capacity and then again at full capacity.
- If water level measurements are frequently taken during drawdown and recovery, hydro geologists can use the information to calculate aquifer characteristics (transmissivity and storativity) which can be used to help develop local groundwater development plans.

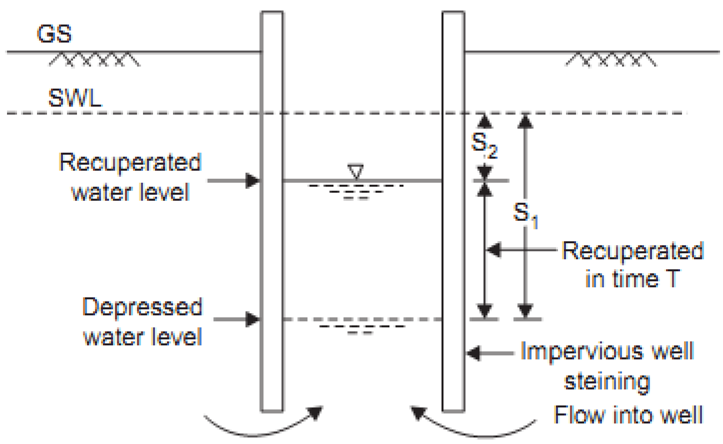

Fig. 3.1 Recuperation test in open wells

The depth of recuperation in a known time is noted from which the specific capacity of the well is calculated. If the water level inside rises from s_1 to s_2 (measured below static water level) in time t and if s is the drawdown at any time t, then specific capacity (C) of the well per unit cross sectional area per unit depression head is given by

$$C=2.303/t \log (s_1/s_2)$$

If A is the cross sectional area of the well and H is the safe working depression head then the yield of the well,

$$Q=CAH$$

3.6 Iron Testing

Yellow or red coloured water is often a good indication that iron is present. However, a testing laboratory can determine the exact amount of iron, which can be useful in determining the best type of treatment. In addition to testing for iron, it can be of value to also test for hardness, pH, alkalinity, and iron bacteria. Iron in amounts above 0.3 mg/L is usually considered objectionable. Iron levels are usually less than 10 mg/L.

3.5 Estimation of water requirement

3.5.1 Daily water consumption

The capacity of both over head tank and ladies hostel tanks were measured. Then pumping rate was calculated by measuring time required to fill these tanks. Daily water consumption is the product of pumping rate and time for which the pump is operated in a day.

3.5.2 Future water demand

A curve of population against time was drawn for the study area. The curve is then extended from present to future decades and the population after each successive future decade is read from the curve. Thus, if the average rate of demand and population are known, we can calculate the required quantity of water at any instant.

3.6 Rain water harvesting for direct use

Annual water requirement for lawn irrigation was calculated on the basis of sunny days. Average annual rainfall depth for past six year was calculated from the rain fall data obtained from a non recording rain gauge station installed at KCAET campus. Annual roof top water harvesting potential (RWHP) of the academic building was calculated using the formula

RWHP = average annual rainfall depth   roof area   runoff coefficient

The roof of academic building is concrete, so the run off coefficient value is taken as 0.8.

3.6.1 Estimation of roof area

The roof area which acts as the catchment area for rainwater collection is taken as equal to the plan area of the building. The roof area of academic building of KCAET Tavanur is 750 m^2.

3.7 Iron Testing

Yellow or red coloured water is often a good indication that iron is present. However, a testing laboratory can determine the exact amount of iron, which can be useful in determining the best type of treatment. In addition to testing for iron, it can be of value to also test for hardness, pH, alkalinity, and iron bacteria. Iron in amounts above 0.3 mg/L is usually considered objectionable. Iron levels are usually less than 10 mg/L.

Results and Discussion

RESULTS AND DISCUSSION

The present study aims at assessing the quantitative and qualitative aspects of the household water supply system in the KCAET campus. The salient features of water resources viz. the drawdown and recovery characteristics of wells, natural ground water recharge, ground water availability, its extend and pattern of utilization and the water quality are determined. This chapter illustrates the results of the study on the above-mentioned aspects of the water supply system of KCAET, Tavanur.

4.1 Study of ground water resources

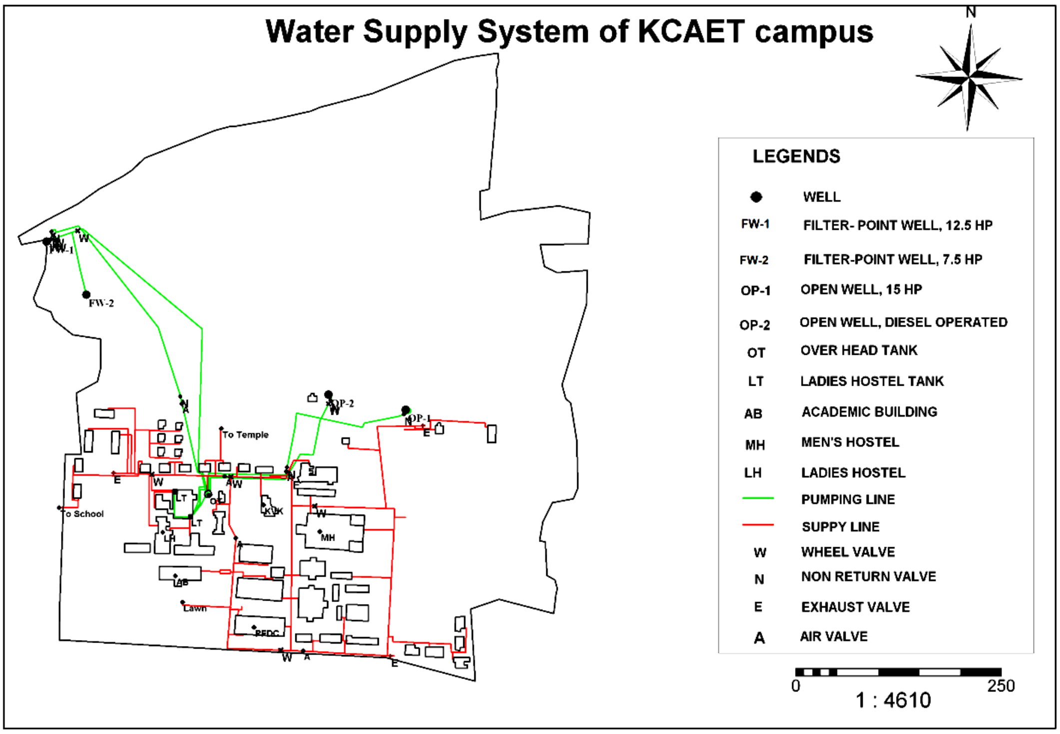

Fig.4. 1. Water Supply System of KCAET campus

Table 1. Well location

Well no.	Type	Location
W1	Open well	Near Kelappaji's house
W3	Filter point well	North-West corner of the boundary
W4	Filter point well	Near coconut farm(N-W corner)
W5	Open well	Near farm building
W6	Open well	Near coconut farm

The campus has got abundant water resources as open wells, filter point wells and shallow tube wells. There are mainly 17 open wells in the campus, of which two are used for pumping. Most of the wells have less storage capacity and are usually dry during the summer season. Keeping this in view and from the previous studies, the open well which is usually pumped is selected for the yield study. At present two filter point wells are pumped for supplying water to the campus. There are about five ponds in the farm, from which water is being used for irrigation purpose. Most of the open wells being left as such and no further conservation steps are taken, the estimation of recharge and discharge will not represent the true scenario. However there is scope for efficient development since the unconfined coastal aquifer can contribute ground water at shallow depth. The locations of wells are given in fig 4.2 and details in the table 1.

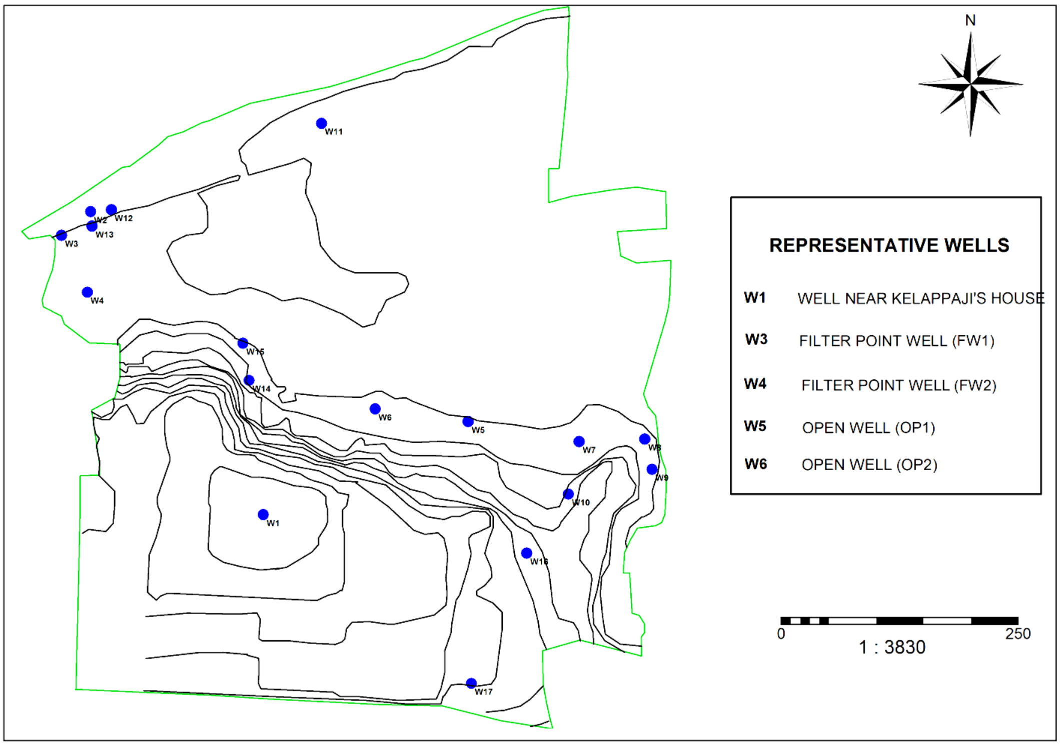

Fig. 4.2 Location of wells on the Contour map of the K C A E T campus

4.2 Yield and quality of the available water sources

The draw down and recovery response for the well (w5) is presented in the fig 4.3 - 4.6

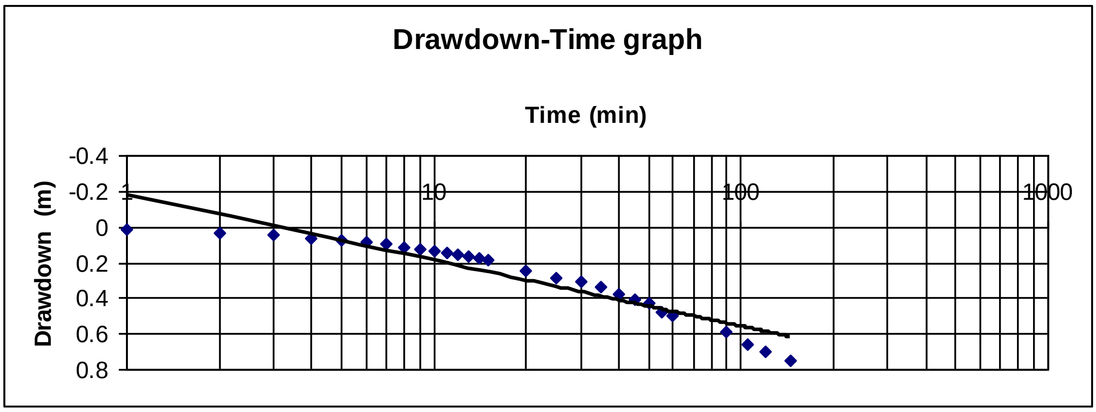

Fig.4.3. Drawdown response of the open well, w5 (July)

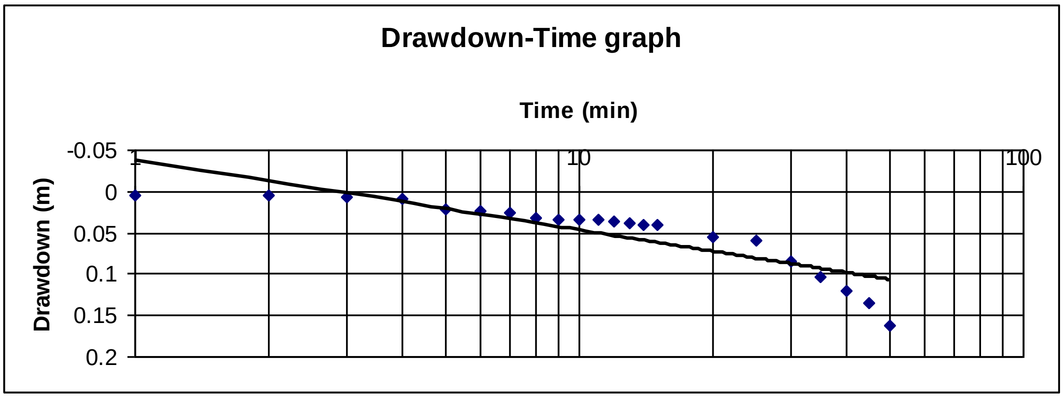

Fig.4.4. Drawdown response of the open well, w5 (October)

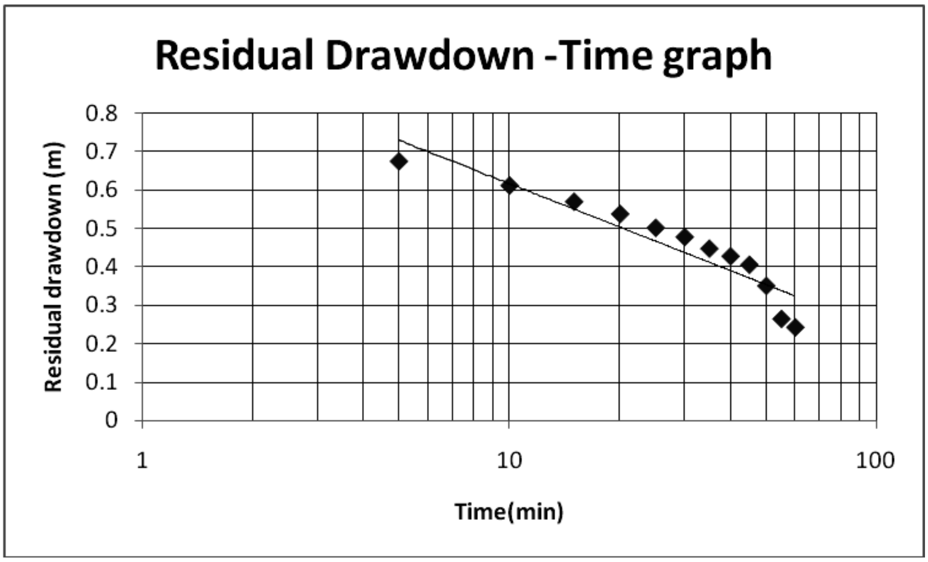

Fig.4.5. Recovery response of the open well w5 (July)

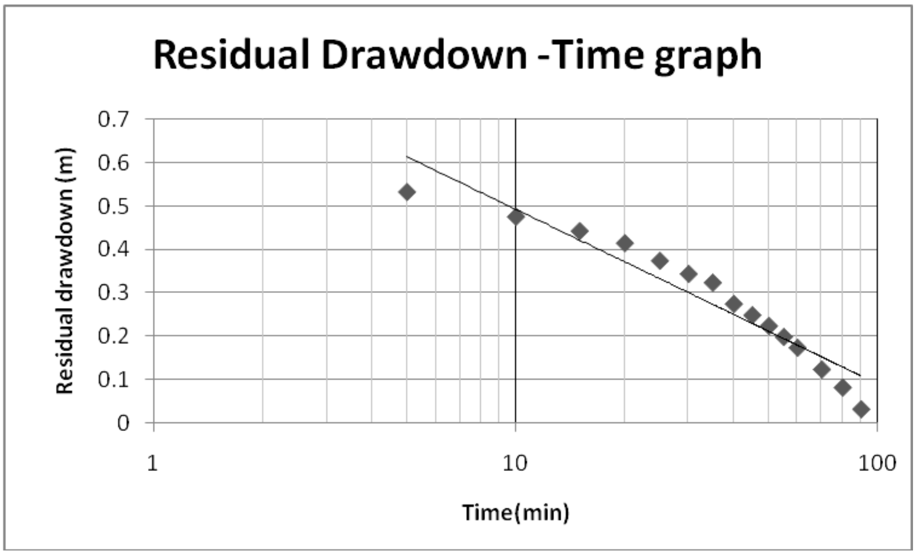

Fig.4.6. Recovery response of the open well w5 (October)

Yield Test

Pumping test

Rate of seepage into the well W5 was found to be 281.6 and 200.2 lpm respectively in July and October.

Recuperation test

The recuperation test in open well (w5) in the month of July gave a specific capacity of 0.76 and a safe yield of 81 m^3/h. When the test was carried out in October the specific capacity and safe yield were 0.47 and 33.9 m^3/h respectively.

Quality analysis

Sl No	Parameters	Concentration	Desirable limit (BIS)
1	pH	6.36	6.50- 8.50
2	Electrical Conductivity, µS/cm	76.60	……
3	Colour, Hazen	ND	5.00
4	Turbidity, NTU	5.40	5.00
5	Total Dissolved Solids, mg/l	54.60	500.00
6	Total Hardness, mg/l	16.0	300.00
7	Total Alkalinity, mg/l	19.39	200.00
8	Chloride, mg/l	16.0	250.00
9	Sulphate, mg/l	6.80	200.00
10	Calcium, mg/l	6.40	75.00
11	Magnesium, mg/l	ND	30.00
12	Iron, mg/l	0.048	0.30
13	Total Coliform, MPN/100ml	Absent	10
14	E. Coli, MPN/100ml	Absent	Absent

Table 2: Water Analysis Report of OP1

Parameter	Value
Appearance	Clear with brown sediments, colourless, odourless
pH	7.0
Electrical conductivity	0.2 m.mhos
Alkalinity	56.0 (ppm)
Chlorides	12.0 (ppm)

Nitrates	Trace
Sulphate	Nil
Oxygen absorbed	0.1
Ammonia-free& saline	Nil
Dissolved solids	110.0
Total hardness	50.0 (ppm)
Iron	10.0 (ppm)
Presence of lactose-fermenting organism	100
M.P.N.	Nil

Table 3: Analysis of filter point well water (FW 1)

4.3 Factors affecting the quality of water supplied in KCAET campus

The report of water quality analysis was compared with drinking water quality standards and it has been found that all the limits are in tolerable limit for OP 1 well. But in case of filter point well iron content is the only parameter which exceeds the safe limit

4.4 Analysis of the water demand with respect to the available yield

Forecasting results of the water requirement for future years shows an increase in water demand. The variation of this water demand is given in fig. 4.7. Details are given in appendix 5.

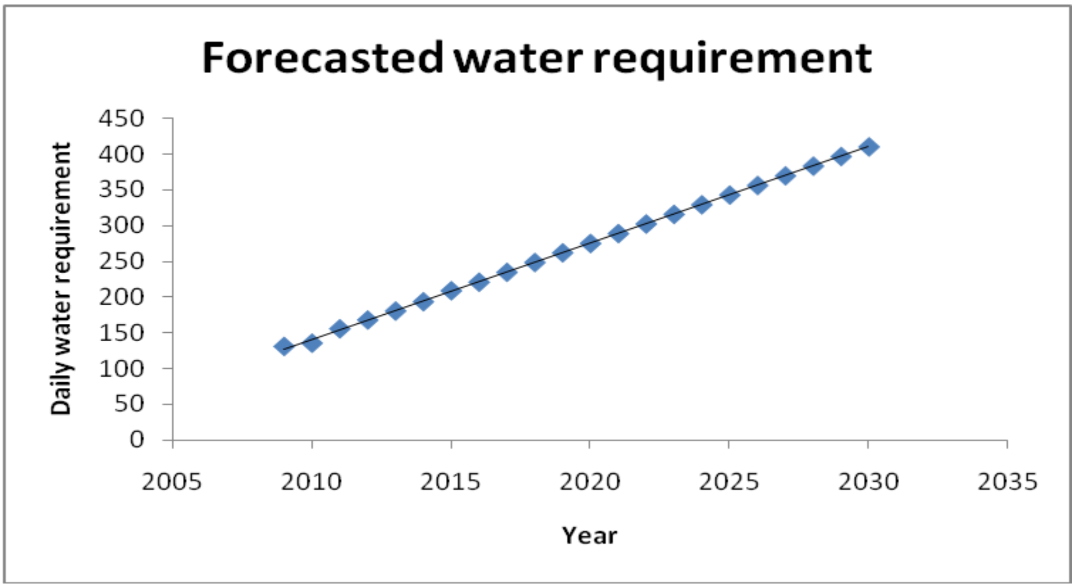

Fig. 4.7. Water Requirement of the K.C.A.E.T campus

Fig 4.7 shows that the current water requirement is 150 m^3/day. By comparing this result with the safe yield of W5, it is clear that it can not met the daily water requirement during summer season. Thus during summer we depend mainly the filter point well for meeting water requirement. Hence the total water requirement of the campus can be met by the existing sources, but the quality of water from the filter point well remains major issue which is to be highlighted.

4.4.1 Daily water consumption

Capacity of ladies hostel tank is 50, 000 litre and that of over head tank is 65, 000 litre. Duration for which pump operated for filling the tanks is 3.8 hour. Pumping rate is calculated as 30 m^3/h. Pump is operated for 6.5 hours per day, thus daily water consumption is 200 m^3. By comparing the result with the safe yield of W5, it is clear that it can not met the daily water requirement during summer season.

4.5 Solutions for the problems associated with KCAET water supply system

From the detailed analysis, it is clear that the problem associated with the KCAET water supply system is the high iron content in the ground water. By considering the future demand time is near to take a curative action. The most common method for controlling iron in water is water treatment. In some circumstances, another alternative is to use a different water source that is low in iron, such as a public water system or well drawing water from a different water-bearing formation. In some cases, a new source may be an option; however, it is difficult to predict what the iron concentration will be. Neighbouring wells may be an indicator, but the iron content of two nearby wells may be quite different. Thus the possible solutions are :

4.5.1 Treating the presently supplied water sources

The quality of filter point well can be improved by water treatment. Treatment of water containing iron depends on the form of the iron present, the chemistry of the water, and the type of well.

4.5.1.1Filter unit

Water filters are the most widely used equipment in removing iron. Its popularity comes from its versatility due to the various media products available and the process involved with each media. Most iron filtration systems operate on the principal of oxidizing the iron (oxidation) to convert it from a ferrous (dissolved or soluble) to a ferric or undissolved state. Once in the ferric state, iron can be filtered. The most common reasons for filter failure are a lack of flow in backwash or a lack of frequency of regenerations. Low pH levels when using filters are another reason for unsatisfactory results.

Each type of treatment has its own strengths and weaknesses. As in the selection of equipment, it is important to follow manufacturers' recommendations and note any application limitations such as water temperature, pH, alkalinity and dissolved oxygen content to get the best result. Filtration using various means of oxidation is the most common method of iron removal. Depending on the media selected, other common processes such as ozone, aeration, chlorine or peroxide injection may be used to boost the oxidizing properties of the water being treated.

Since the filter has to work with huge amount of water and high iron content (10 ppm) regular backwashing and media replacement is needed. High cost of media and filter unit and regular maintenance make the water treatment uneconomical.By providing an aeration tank prior to the filter unit makes it economical and more economical if the pressurised aeration system is used.

When aeration is used as a pre-oxidizer it is generally done with either an air inductor or an air pump. An air inductor is a venturi installed inline. The water flowing through the inductor creates a vacuum and sucks air into the water line. The faster the water flows, the more air induced into the water. Watch for pressure drop and perform routine maintenance of the inductor, as they will clog with iron over time. The air pump method allows more air induced into the water, as a mechanical pump is used to force air into the water. A contact tank is often used. This method has proven effective with the only cautions being maintenance to the pump and injection fittings. The recommendable filter unit components are given in appendix 7.

4.5.2Revitalization of good quality water source

Quantity problem of good quality source can be reduced by adopting revitalization methods. We were examined that wells except OP1 and OP2 bear not sufficient water to supply the system. They were left as useless nowadays. But they can be put as recharge wells. OP2 well is currently not using due to damage of pumping line. It is connected to a diesel engine operated pump for lifting the water. The water is safe for consumption but it is not sure to meet the water demand during summer season. It shows the same condition as that of OP1 which is near to OP2 and both are located at same contour. OP1 well is currently using. Water quality analysis report shows that the parameters are in a safe limit.

Revitalization methods like radial wells and vertical boring can be implememted on both OP1 and OP2. But the success of these methods depends on presence of barriers and development of fractures in the substrata.

The following are the common methods adopted to increase the yield of open wells:

(i) Deepening of wells to tap potential water-bearing formations adequately.

(ii) Providing one or more vertical bores at the bottom of existing wells to penetrate potential water bearing layers lying below it.

(iii) Providing horizontal bores along the sides of wells below the water table, or installing filters radially in potential aquifers.

(iv) Rescheduling of pumping time into convenient block periods.

(v) Increasing ground water recharge in the vicinity of open wells.

(vi) Hydraulic fracturing

Procedures for deepening wells and installing vertical bores at the bottom of open wells (dug-cum-bore wells) have been discussed in preceding sections.

4.5.2.1Deepening of wells

Deepening of wells with soil at the bottom can be accomplished manually, whereas for wells with hard rock at the bottom deepening requires blasting and removal of the rock.

4.5.2.2 Providing one or more vertical bores at the bottom

Vertical bores can be made at the bottom of the well using drilling equipment so that the effective depth of the well increases.

4.5.2.3 Horizontal Boring in Open Wells

Studies have shown that in many ground water regions, especially in semi-consolidated and hard rock formations, the yield of existing open wells can be increased substantially by drilling horizontal bores below the water table. These borings, sometimes called revitalization holes, open the paths of flow in water-bearing formations, which may otherwise be restricted. They also function as miniature horizontal wells or infiltration galleries leading to the main well, thus increasing the well discharge. Since a good part of the ground water in hard ruck areas is stored in cracks and fissures of rocks, the lateral flow of water may often be slow. At a certain distance from a well which has gone dry. The water table may be considerably higher than that in the well itself. Because of this hydrostatic head, water often comes out of revitalization holes by its own pressure

Sometimes underground barriers (dykes) obstruct the flow of water into hard rock wells, from upstream. In such a situation, horizontal boing to pierce the barrier layer may greatly increase the yield of the wells. However it is feasible only if the barrier is of narrow width and lies close to the well.

4.5.2.4 Installation of Radial Filters in Wells in Alluvial Formations

Studies on the methods of increasing the yield of open wells in alluvial formations have indicated significant increases in yield on installing filters radially (Khepar and Sondhi, 1973). Unlined radial bones, however, are not feasible in these wells since they will be blocked by the collapse of the unconsolidated aquifer material. Filters can be installed through suitable radial boring equipment. Jackscrew based manually operated, radial-boring equipment is suitable for installing filters radially in open wells.

Any common type of filter pipe used in shallow tube wells can be used. The size of the filter pipe ranges from 2.5 to 6 cm in diameter. They are available in lengths ranging from I to 3 m. The dive end of the filter is provided with a conical metal point. The base of the conical bit is kept slightly larger than the filter diameter.

To install the filters, the water level in the well is lowered to the desired depth by continuous pumping. Points are then marked on the well wall, where the filters are to be installed. The equipment is lowered into the well and properly installed with reference to the point where the filter is to be located. The steining of the well is broken at the point marked. The filter is then loaded in the jack block and locked. It is driven into the formation in suitable lengths. When the full length of a filter has been penetrated, another piece is screwed in and the procedure repeated. The length of filter is usually limited to 3-5 m when manually operated jack blocks are used.

Radial Boring in Open Wells in Semi-Consolidated Formations Using Manually Operated Augers

The yield of open wells in semi-consolidated formations can often be improved through radial bores which usually extend 15-25 m into the water bearing formations. Boring is done with a twisting and reciprocating motion of the auger set. While making horizontal bores, the water level in the well is kept below the level of work. This is done by pumping or employing one or more animal-operated water lifts, like leather buckets. A suitable thumb rule for locating the points for radial boring in semi-consolidated formations is to follow the track of water oozing out of the crevices.

Horizontal Water Wells or Radial Collector Wells

"Radial collector well" consists of a caisson, or large water tight concrete vertical tube, usually constructed from the surface down into the groundwater aquifer and then from 4 to eight radial wells (or more) are drilled out of the base of the caisson. The wells flow into the caisson where a large pump is used to withdraw the water. When pumping, the lowered water level in the caisson induces more supply from the radial wells in the aquifer, which is very quickly recharged by the surface water in the river when the well is adjacent to a river, which is most of the time.

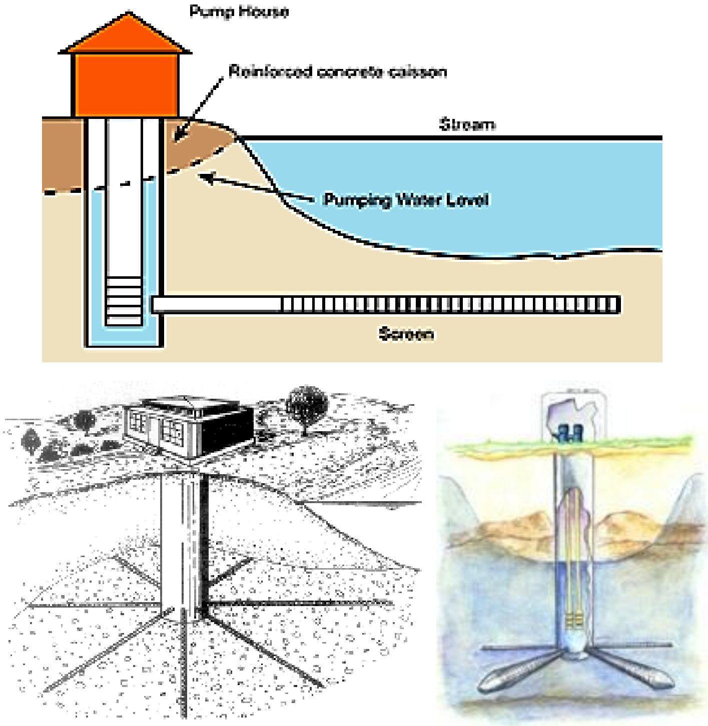

Fig 4.8. Radial Collector Wells

Visvesvaraya's Collector well for Water Supply to Sukkur in Sind on the Banks of River Indus (1895)

Mokshagundam Visvesvaraya did the construction of water works at Sukkur in Sindh (which was then a part of the Bombay Presidency) which earned him recognition both from within and outside India. The job was to supply drinking water from the river Sindhu. In Visvesvaraya's own words from his Memoirs, "the Sukkur Water Works Water, which had to be supplied from the river Indus into the town water-works system, had to be pumped into a reservoir on top of the Edinburgh Castle Hill close to the river bank." The water of the Indus River, always muddy and discoloured had to be filtered and purified before distribution to the city. At that time the City Municipality of Sukkur was not in sufficiently affluent circumstances to spend money on filter-beds. As an alternative, I decided to excavated circular well in the river-bed itself close to the river bank to obtain spring water by percolation. The supply from this well was found insufficient, so a tunnel had to be driven from the bottom of the well for some distance under the flowing river. This tunnel brought a sufficient supply of pure water which was conveyed by a pipe into the engine sump well of the pumping station on the river bank. The water was then pumped into the pure water reservoir constructed on top of the Edinburgh Castle Hill."' Visvesvaraya's ingenuity saved a lot of money needed for filtering the muddy Indus water. The then Governor of Bombay, Lord Sandhurst, the Sukkur Municipal Board and the Government of Bombay recorded their appreciation of the extraordinary abilities of Visvesvaraya as an Engineer. Subsequently, Visvesvaraya carried out similar water supply works to carry water from Tapti River to Surat. The circular well-tunnel combination used by Visvesvaraya is now known as "**collector well**" in modern textbooks.

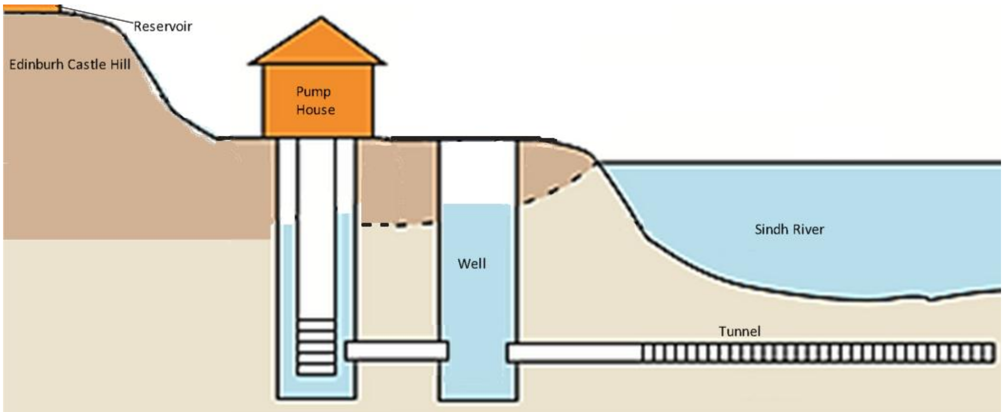

Fig 4.9. Visvesvaraya's Collector well

Radial collector wells to overcome water quality constraints: case studies

<u>Improved Doruvu Technology: skimming well technology for coastal sandy soils</u>

Fig 4.10. Improved Doruvu Technology

A total of 1.74 lakh ha of sandy soils along the sea coast of Andhra Pradesh have shallow water table varying from 0.5 to 3.0 m. The installation of shallow as well as deep tube wells is constrained with shallow depth of good quality of water, poor recharging rate and occurrence of clay in deeper layers. The traditional technique of drawing water manually that collects in dug out conical pits locally called as Doruvus has major drawbacks of wastage of about 20% of land towards Doruvus, high evaporation losses, higher costs of irrigation involving manual splashing and caving in of sands etc. To improve the situation, a Sub surface Skimming Well System (SSSWS) has been evolved by the AICRP–Saline Water Scheme, Bapatla centre. The system popularly known as "Improved Doruvu technology", works on the principle of collection of shallow depth fresh water into the well through horizontally installed collector lines (Raghu Babu et al, 2004). This technology is also used for drinking water purpose under rural water scheme at G.N. Palem and Alkapuram.

Radial Wells for lateral storage and collection of water in Kuttanadu.

Radial Well is the most viable technology for tapping good quality water from the shallow subsurface soil in Kuttanadu, part of the Ramsar Vembanadu wetland area, where acidity and presence of soluble salts increases as depth increases.

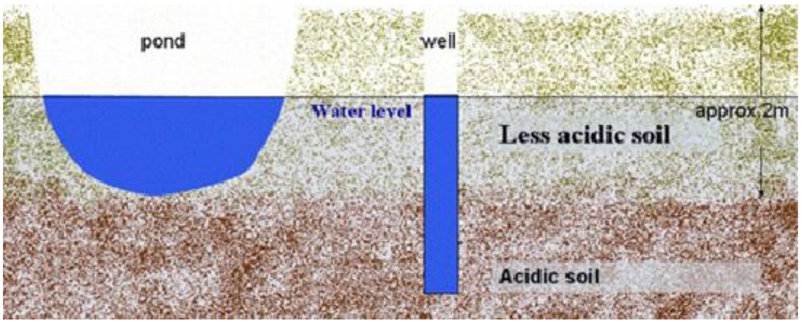

Fig 4.11. Variation of acidity in Kuttanad soils

The water quality can be ensured by tapping maximum water from near surface level rather than increasing the depth of the well. The technology involves making underground radials or filter paths towards the well at a depth in which soil is comparatively less acidic. The sand filled radials serve as earthen sponges which absorb rain water and thus improve the fresh water zone of the area.

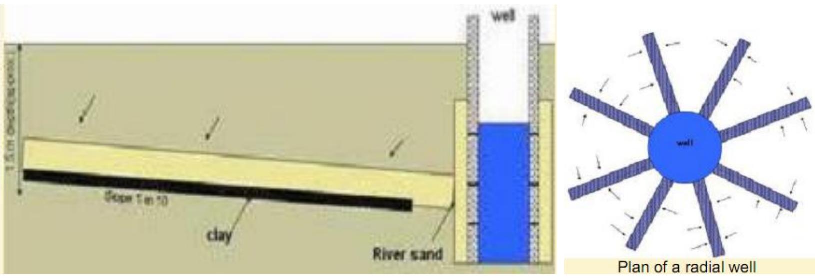

Fig 4.12. Radial wells used in Kuttanad

Advantages

- Lesser investment than a pond while meeting its functional utility
- Great saving in the area which would have been required for the pond
- Easiness in construction and faster construction time (about a week only)
- Abandoned wells can be easily converted to radial wells

Ranney collector well (Ranney well/ Ranney collector)

A Ranney collector is a patented type of radial well used to extract water from an aquifer with direct connection to a surface water source like a river or lake. It is a variation of strainer well; in this case the strainers are driven horizontally in the water-bearing strata, radiating from a central sump or tube well enabling the tapping of a shallow depth of aquifer. The amount of water available from the collector is typically related more to the surface water source than to the piezometric surface of the aquifer. This water collector is constructed as a dug well from 3.5 to 5 m in diameter that has been sunk as a caisson near the bank of a river or lake. Screens are driven radially and approximately horizontally from this well into the sand and the gravel deposits underlying the river.

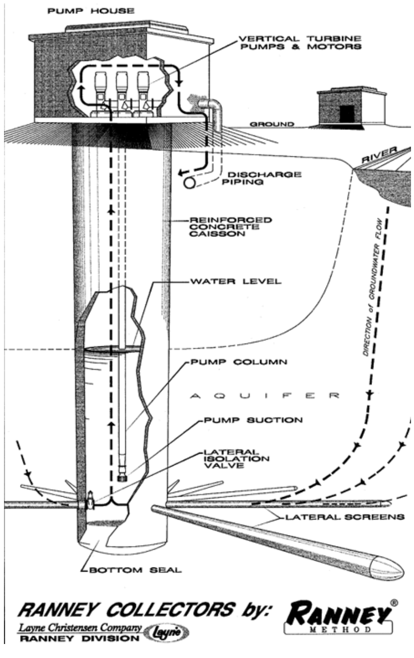

Fig 4.13. Example of a radial well with patented technology

4.5.2.4Rescheduling of Pumping Time

Studies at the Institute of Hydraulics and Hydology, Poondi (Tamil Nadu), have shown that the gross yield of open wells in a given time period can be increased substantially by rescheduling the pumping time in suitable block periods. The drawdown and recuperation pattern of open wells in hard rock areas have specific characteristics. When a well is pumped to its fully capacity, the recuperation rate is high at the beginning, due to the steep hydraulic gradient. It gradually reduces, as the static water table depth approaches. Hence, intermittent pumping would result in a greater rate of recuperation or increase in yield of the well in a given time. Table 3.2 presents typical pumping test data for a well in a hard rock area, in which pumping was conducted in suitable block periods.

4.5.2.5Increasing Ground Water Recharge

Open wells usually derive their supplies from shallow water bearing formations. Hence, their yield capacity is proportional to the extent of ground water recharge in the area contributing the flow into the well. Any method of increasing ground water recharge will improve the performance of the well. Soil and water conservation measures, including land levelling, contour bunding and terracing, will greatly increase ground water recharge. The objective is to retard the rainfall runoff water and allow a longer time for infiltration. Construction of earth dykes or bunds downstream of the well will provide for the ponding of runoff water from the surrounding catchment, which eventually gets recharged into the ground water basin. Bunds are aligned along the contour. The size of the bund will depend on the amount of runoff to be intercepted. In copped fields, this will depend on the extent of ponding that can be tolerated by the crop. It may often be necessary to provide an erosion-proof outlet (masonry structure or grassed outlet) for the safe disposal of excess runoff.

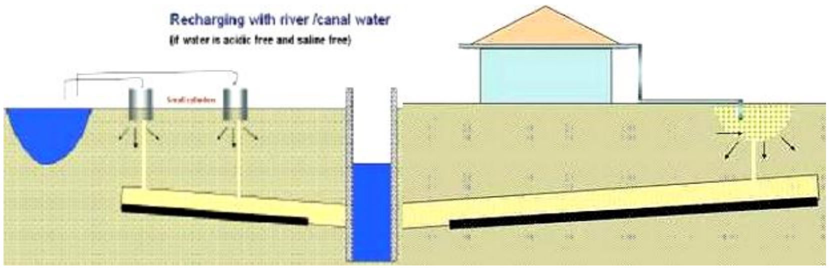

Fig 4.14. Recharging of radial collectors

4.5.2.6 Hydraulic fracturing

Hydraulic fracturing is the propagation of fractures in a rock layer caused by the presence of a pressurized fluid. Hydraulic fractures may form naturally, as in the case of veins or dikes, or may be man-made in order to release petroleum, natural gas, coal seam gas, or other substances for extraction, where the technique is often called fracking or hydrofracing. This type of fracturing, known colloquially as a frack job (or frac job), is done from a wellbore drilled into reservoir rock formations. The energy from the injection of a highly-pressurized fracking fluid creates new channels in the rock which can increase the extraction rates and ultimate recovery of fossil fuels. The fracture width is typically maintained after the injection by introducing a proppant into the injected fluid. Proppant is a material, such as grains of sand, ceramic, or other particulates that prevent the fractures from closing when the injection is stopped. One huge difference is that the public supply wells are not fracked. These are typically sand and gravel (alluvial) wells that need no propping or chemical treatments to produce water. Fracking a public water supply well, tend to produce copious amounts of water. The Olathe, KS well in Kansas, United States of America has been fracked and approved for 7,300 AF per year from a single radial well.

The technology was invented in the 1920's for the oil industry, but the first public water supply use was in 1933 in London, England of all places. The first US application was in 1936. With such enormous amounts of water being produced, the irrigation industry is going to express their interest probably when crop prices become high enough to cover the significant cost of these hydro-engineering marvels.

4.5.3Establishment of new good quality source

4.5.3.1 Collector wells

As an alternative to conventional vertical wells, collector wells are used. These wells are generally comprised of a vertical reinforced concrete shaft with horizontal lateral well screens projected out into the aquifer to collect and filter the groundwater. Typically installed in alluvial aquifers close to a dependable surface water source, these wells take advantage of a natural filtering process referred to as River bank Filtration (RBF). This natural filtration can simplify treatment and ensure the owner of high quality and high capacity water production. These Collector Wells can also be used for developing moderate to high capacity groundwater supplies.

Collector well can be established near Bharathapuzha river for tapping more water. But the yield depends upon saturated thickness of river bed, depth of well and size of collector arms.

4.5.3.2 Infiltration galleries

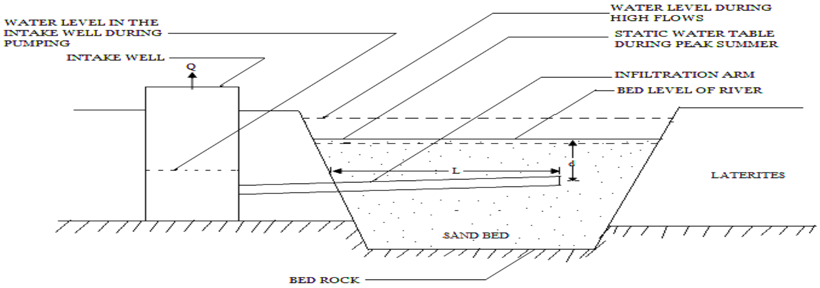

Fig. 4.15. Schematic sketch of water extraction scheme

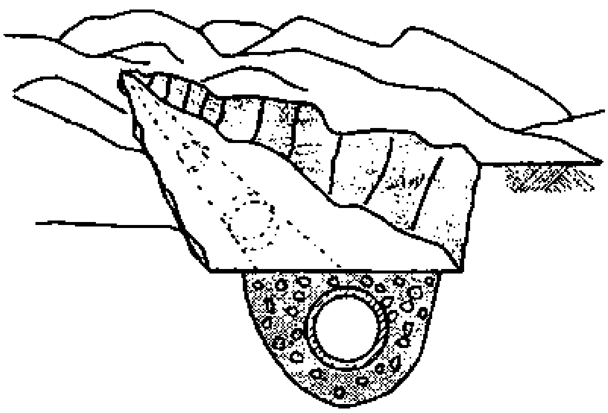

Fig 4.16. A trench infiltration gallery

An infiltration gallery can be installed in the Barathapuzha river bed. The Ground water withdrawal predominantly depends on the subsurface storage with in the river bed. The water level in the intake well is to be kept at a level below the water table in the river bed by pumping from the intake well. The infiltration arm then functions as a gravity drainage system and contributes water into the intake well. However any sand mining activities at the lower reaches will in all probability affects the performance and sustainability of infiltration galleries on the upstream portion. It taks the advantage of river bed filtration.

Limitations of infiltration galleries compared with dug or drilled wells include an higher initial cost of construction than dug wells or drilled wells, depending on the depth and method of excavation; and, a greater requirement for access to land than dug wells and drilled wells, which may cause problems with land tenure. A significant challenge to infiltration galleries in certain streams is preventing the perforated pipes from becoming blocked with fine sediment.

4.6. Rain water harvesting

For garden purpose, 1m^3 of water is required per day. Harvesting tank can be constructed above academic's car porch. Calculations of tank specifications are given below. Thus, the rain water harvested from the academic car porch can be efficiently utilized for the garden purpose. Annual rainfall and sunny days for last 6 years is given in figures 9 and 10 and corresponding values are given in appendix 6.

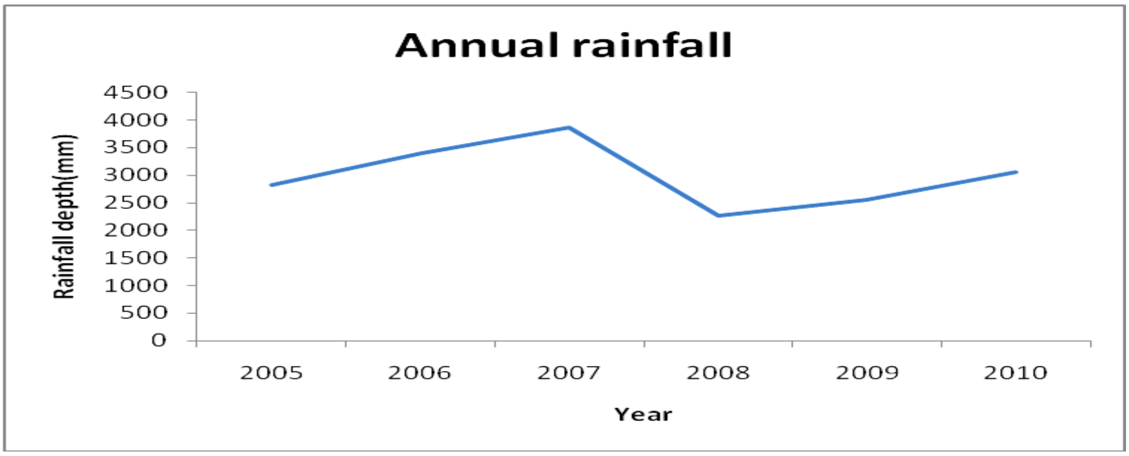

Fig.4.17. Data of annual rainfall

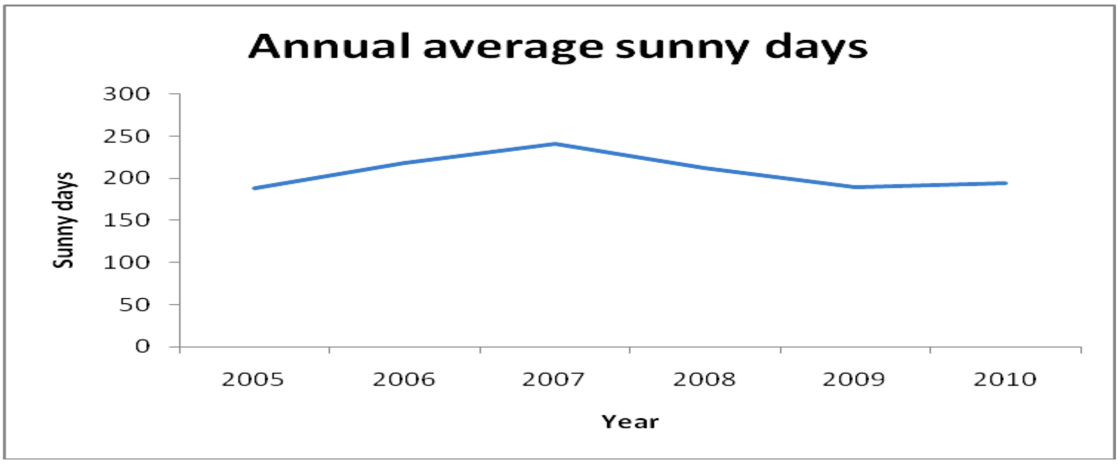

Fig.4.18. Data of sunny days

Water requirement per year = 120 m^3

Roof area of academic building = 750 m^2

But, average annual rainfall = 2.99 m

Effective roof area required for water harvesting = 52 m^2

Thus the lawn water requirement can be met by academic building itself. Storage tank can be constructed above the carporch.The storage tank dimensions are given below.

Useful area above the car porch = 30 m^2

Therefore, tank height required = 4 m

Similarly, if such rain water harvesting structures are constructed in KVK trainees' hostel, quarters etc. we can retard water scarcity to some extent.

as that of OP1 which is near to OP2 and both are located at same contour. OP1 well is currently using. Water quality analysis report shows that the parameters are in a safe limit. The water analysis report is shown in the table 2.

Summary and Conclusion

SUMMARY AND CONCLUSION

The major issues associated with the use of water by humans are quantity and quality. Within limits water quantity is more important than water quality in determining the extent and type of development possible in a given location. But the quality of water depends on many parameters such as soil, climate, source of supply, distribution system etc. If water needed as a public supply the water must be treatable by conventional process to yield potable water meeting the drinking water standard. Since ground water is the common source of irrigation, water is lost by consumptive use, evapotranspiration and surface runoff, while level of ground water is dropping. At the same time, the concentration of impurities in the ground water is increasing because of evapotranspiration, leaching of salts from soil, and the application of fertilizers. It increases during summer and is significantly reduced during the monsoon due to dilution by rain water.

The study about drinking water problems and its remedies of K.C.A.E.T campus during the study period leads us to the following conclusions.

The quality of ground water in terms of the physical, chemical and biological characteristics shows markable variations with water table elevations. The net variations in pH, acidity, sulphates and nitrates were found to be negligible during the study period. But for iron, there is slight increase in value for the higher elevated wells.

Earlier results shows that the presence of oxygen content and micro-organisms were also present in the well water. The change in water table elevations in the farm wells show that the storage capacity should be increased for maintaining groundwater availability. The wells that are not using at present are good sources of fresh water and can be made usable with minimum effort.

Water from the supply system is found to be turbid along with presence of iron content, clearly indicating the presence of suspended particle. The high pumping rate from the filter point well is the main cause for sedimentation of solids in water. Pumping test is to be done for scheduling the safe pumping rate and pumping duration.

Future line of study

For the effective utilization of water resources, the necessary treatments are to be taken as the first step in remedial measures. Proper top covering should be provided for drinking water sources. Since water table fluctuation is high in summer season and some of the wells are seemed to be dried, recharge to the shallow aquifer should be accelerated by utilizing soil and water conservation measures. For providing safe drinking water, the well development is to be done for the pumping wells. The pump should be selected according to the expected yield of well and the storage tank should be cleaned in regular intervals. And also for avoiding drinking water scarcity in coming future, we have to suggest for infiltration galleries, rain water harvesting structures, horizontal wells, collector wells etc. Quality of the drinking water can be improved by the installation of iron filters in the system or sedimentation followed by aeration.

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Appendices

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Appendix 1

Drawdown response of the open well, w5 (July)

Time (min)	Drawdown (m)
1	0.01
2	0.03
3	0.045
4	0.06
5	0.07
6	0.086
7	0.098
8	0.112
9	0.122
10	0.135
11	0.148
12	0.156
13	0.166
14	0.178
15	0.188
20	0.25
25	0.29
30	0.308
35	0.338
40	0.378
45	0.408
50	0.43
55	0.478
60	0.5
90	0.59
105	0.66
120	0.7
145	0.75

Appendix 2

Drawdown response of the open well, w5 (October)

Time (min)	Drawdown (m)
0	0.000
1	0.004
2	0.005
3	0.007
4	0.009
5	0.021
6	0.024
7	0.026
8	0.031
9	0.033
10	0.034
11	0.035
12	0.037
13	0.039
14	0.0395
15	0.041
20	0.055
25	0.059
30	0.085
35	0.103
40	0.121
45	0.135
50	0.162
55	0.177

Appendix 3

Recovery response of the open well w5 (July)

Time (min)	Residual Drawdown (m)
5	0.675
10	0.612
15	0.57
20	0.538
25	0.502
30	0.478
35	0.448
40	0.428
45	0.406
50	0.351
55	0.265
60	0.243

Appendix 4

Recovery response of the open well w5 (October)

Time (min)	Residual Drawdown (m)
0	0.649
5	0.5325
10	0.4758
15	0.4425
20	0.415
25	0.374
30	0.344
35	0.324
40	0.275
45	0.249
50	0.224
55	0.199
60	0.174
70	0.124
80	0.0825
90	0.0325

Appendix 5

Water Requirement of the K.C.A.E.T campus

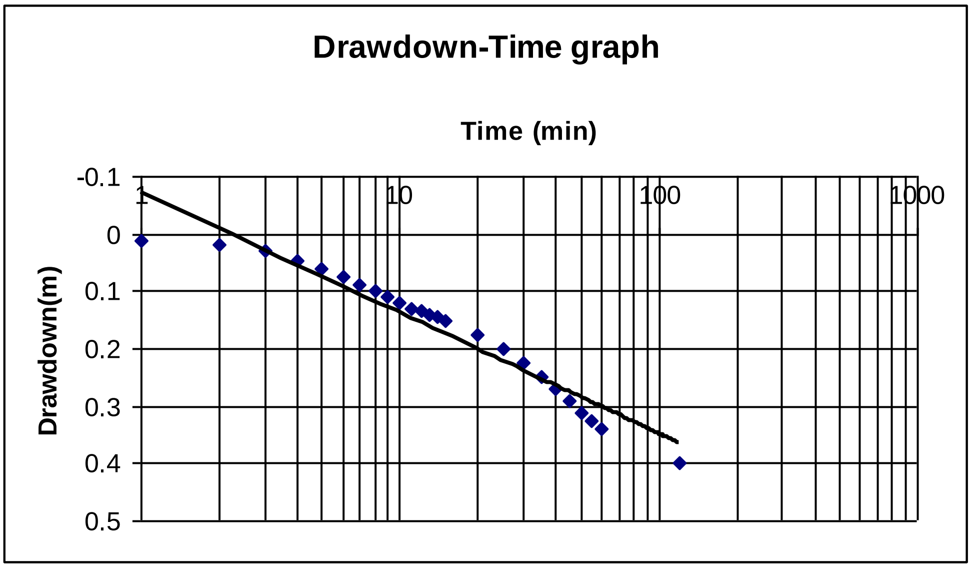
Year	Population		Demand (L per capita)		m^3 per day
	Permanent members	Part time members	Permanent members	Part time members	
2009	290	150	400	100	131
2010	300	156	400	100	135.6
2011	350	156	400	100	155.6
2012	380	160	400	100	168
2013	410	165	400	100	180.5

Appendix 6

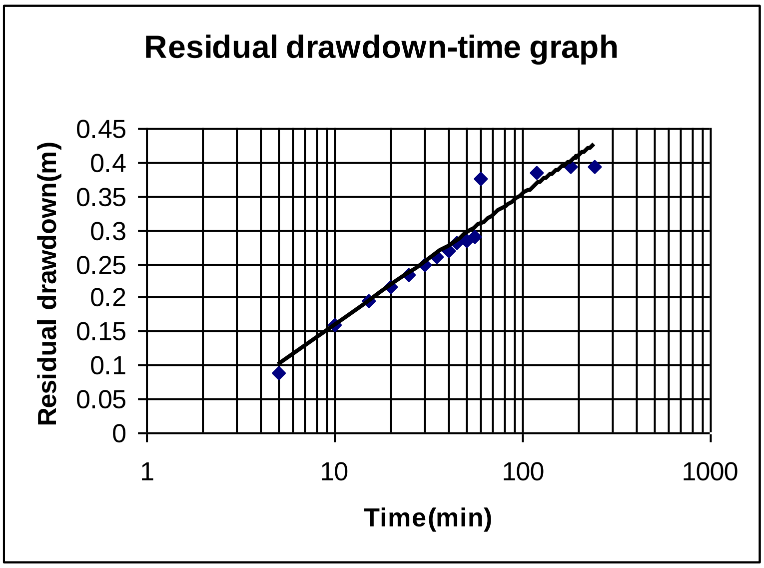
Annual rainfall and Average sunny days in the year

Sl. no.	Year	Annual rainfall(mm)	Sunny days
1	2005	2826.4	188
2	2006	3396.4	218
3	2007	3865.6	241
4	2008	2272.3	212
5	2009	2558.6	189
6	2010	3056.1	194
Average		**2995.9**	**207**

Appendix 7
Drawdown- Time graph of W6 well



Appendix 8
Residual drawdown – Time graph of W6



Appendix 9

Filter unit

Equipments Required

1. Collection cum aeration cum settling tank with conical bottom from top. Construction Brick masonry with cement plastering.

2. Air blower 2HP -1no.

3. Sludge pump 1hp -1No

4. Clear water pump 1HP -1No

5. Dosing pump -1No

6. Pressure Sand filter -205lit volume –1No

7. Filter with oxidizing media 205lit volume - 1No

8. Activated Carbon filter 205 lit Volume

9. Treated water tank.50, 000 lit capacity

10. Treated water transfer pump 1No

Cost estimation of Filter unit

PRESSURE SAND FILTER

Technical Data

Brand Name	:	**Aqua Water Purifier**
Model	:	PSF- 1000/D
Vessel	:	Composite FRP Vessel
Size in mm	:	1000 Ø x 1850 H
Maximum Working Pressure	:	3.5 Kg/cm^2
Minimum Working Pressure	:	1.5 Kg/ cm^2
Maximum Flow	:	10 m^3/Hr
Filter Media		Coarse Silex, Fine Silex, Quartz Sand, Fine Sand, Everzit (Iron Removal Media)

ACTIVATED CARBON FILTER

Brand Name	:	**Aqua Water Purifier**
Model	:	ACF 1000/D
Vessel	:	Composite FRP Vessel
Size in mm	:	1000 Ø x 1850 Hos
Maximum Working Pressure	:	3.5 Kg/cm^2
Minimum Working Pressure	:	1.5 Kg/ cm^2
Maximum Flow	:	10 m^3 /hr
Filter Media	:	Coarse Silex, Fine Silex, Activated Carbon IV 1050 -8/12 Mesh

AUTOMATIC ELECTRONIC DOSING SYSTEM FOR ALUM DOSING

Model: Akash pumps/Chemidose
Capacity: 6 Liters/Hr.

AUTOMATIC ELECTRONIC DOSING SYSTEM FOR CHLORINATION/DISINFECTION

Model: Akash pumps/Chemidose
Capacity: 4 to 5 Liters/Hr.

Raw Water Feed Pump:-

Make	:	Kirlosker/Crompton
HP	:	7.5

Inter connecting Pipeline with Valves:- One lot.

PRICE:- Rs. 4,70,000/- (Rupees Four Lakhs Seventy Thousand only)

Chemical Usage:-

Chlorine:- 10 Liters/Month, Alum - 7.5 kg/Month , Lime-5 kg/month

Drinking water problems in KCAET campus and their solutions

By

AISWARYA, M. V.

ARCHA DEVARAJAN

BINCY, A.L.

NISHA, V. S.

Abstract of the Project Report

Submitted in partial fulfillment of the
requirement for the degree

Bachelor of Technology
In
Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Land and Water Resources and Conservation Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR – 679573, MALAPPURAM

KERALA, INDIA

December 2011

ABSTRACT

A short term study on “A study of drinking water supply system in K C A E T campus- problems and solutions” was conducted. The main objective of the study was to find out appropriate measures to mitigate current water quality and quantity problems considering the economy and underground characteristics. For this, first we incorporated water supply system in the existing map of the study area and it was digitized. Quality analysis was done by collecting sample from the representative well. The result shows that the parameters are with in the safe limit. Pumping test was carried out to determine the yield of the representative well. But the yield is insufficient to meet the water requirement especially during summer. Thus we depend on filter point well for meeting the daily requirements. Early quality analysis studies shows that the water present in the filter point well contains high iron content which is severe in summer season. Installation of filter unit or aeration sump can mitigate the iron problem in the water. With the proximity of river and ground water characteristics of the campus, infiltration galleries and collector wells are good choice. Also the yield of the existing wells can be increased by revitalization methods and rescheduling of pumping time. Rain water harvesting methods are suggested for meeting the part of water requirement with the consideration of future water requirement.