CORRELATION STUDY AMONG QUALITY PARAMETERS OF SOME WATER SOURCES

Thesis submitted in partial fulfilment of the requirement for the award of degree of

Master of Technology

In

Environmental Science and Technology

Submitted

By

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July 2013

CERTIFICATE

This is to certify that thesis entitled; **"Correlation study among quality parameters of some water sources"** by **Mr. Avinash Kumar** in partial fulfilment of the requirements for the award of **Master of Technology** degree in **Environmental Science and Technology** at **Thapar University,** Patiala (Deemed University) is an authentic piece of work carried out by him under our guidance and supervision.

To the best of our knowledge, the matter embodied in this has not been submitted to any other university/institute for award of any degree/diploma.

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DECLARATION

I, the undersigned, hereby declare that the research work present in the Master of Technology thesis entitled **"Correlation Study among quality Parameters of some water sources"** has been carried out by me under the supervision and guidance of **K. S. Babu,** Assistant Professor, School of Energy and Environment, Thapar University, Patiala

Further, I declare that no part of this thesis has been submitted for a degree or any other qualification of any other university or examination body in India/elsewhere.

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ACKNOWLEDGEMENT

First and above all, I praise God, the Almighty for providing me this opportunity and granting me the capability to proceed successfully. This thesis appears in its current form due to the assistance and guidance of several people. I would therefore like to offer my sincere thanks to all of them.

It is my extreme good fortune to associate with one impressive personality my supervisor K. S. Babu, Assistant Professor, School of Energy and Environment, Thapar University, Patiala, for his inspiring guidance, support and encouragement throughout the period of my research. He had been very kind and patient while suggesting me the outlines of this project and correcting my doubts.

I owe my sincere thanks to Dr. A. S. Reddy, Professor and Head of School of Energy and Environment, for supporting and providing me an environment to move ahead with this work.

I would like to express my deep gratitude to Dr. Anita Rajor, Assistant Professor, School of Energy and Environment, who supplied crucial information and continuous support on a variety of topics related to this project.

I cannot forget to mention the role played by non-teaching staff members of School of Energy and Environment, especially, Mr. Phoolchand, Mr. Babban Yadav and Mrs. Lalita for their generous help in various ways to complete my work.

I am also thankful to my friends, Gurpreet Singh Saggu, Satyender Chaudhary and Aman Sehgal for their help and moral support throughout this period.

Finally, I am thankful to my parents for their blessings which they bestowed upon me for the successful completion of this thesis.

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ABSTRACT

Water quality was studied by collecting samples fortnightly and analysing in the laboratory during the study period Jan- May 2013 at Patiala.

Physico-chemical tests were done for tap water, hand pump water and canal water. Hand pump water and tap water was found better.

Dependencies established through correlation coefficients revealed high positiveness between Conductivity and Dissolved Solids; Alkalinity and Hardness. The tools developed assist in decision making in Water Management Program.

CONTENTS

List of Tables

List of Figures

CHAPTER-1

INTRODUCTION

INTRODUCTION

Water is one of the aboundantly available substance in nature. It is an essential constituent of all animals and vegetable matter and form about 75% of the matter of earth's crust. Water is distributed in nature in different forms such as rain water, river water, spring water and mineral water. Over 98% of the fresh water on the earth lies below its surface. The remaining is present in lakes, rivers, streams and resources. Whether a surface water or ground water source, now-a-days, most of these are subjected to pollution.

1.1 WATER POLLUTION:

Water pollution may be defined as:

"Alteration in physical, chemical and biological characteristics of water which may cause harmful effects on human and aquatic biota".

Pollution disturbs the normal use of water for irrigation, agriculture, industrial, public water supply and aquatic life. It is considered not only in terms of public health but also in terms of conservation, aesthetic and preservation of natural beauty and resources.

Punjab state has enormous water resources. Its fertile land is irrigated by both surface and ground water. The intensive use of ground water for irrigation and other human needs has resulted in the declining of water levels. The water is also exploited in other sector such as industry. Patiala district of Punjab state lies between 29^{o} 49' to 30^{o} 40' north latitudes and 75^{o} 58' to 76^{o} 48' east longitudes. Total geographical area of the district is 3290 sq.km. The Patiala district is divided into five sub-divisions (tehsils) namely Patiala, Nabha, Ghanaur, Rajpura and Samana comprising eight-community development blocks viz. Patiala, nabha, Sanaur, Bhunerheri, rajpura, ghanaur, samana and Patran for the pirpose of administration .The district headquarter, Patiala town falls in Patiala Tehsil.

Extensive paddy cultivations, especially during summer months has declined water table, the tube wells are deepened and farmers are shifting to the use of submersible pumps in place of centrifugal pumps being used, resulting in additional expenditure and extra power consumption. This has adversely affected the socio- economic conditions of the small farmers. Fertility and plant size were the most important components of seed yield. In as much as fertility and plant size were negatively correlated, $r = -.665$, a compromise must be reached in selection for these two characters if maximum seed yields are to be obtained. The method of “path coefficients” proved useful in analyzing correlation coefficients in this system of interrelated variables **(R. Douglas Dewey and K.H. Lu, 1959)**

1.2 UTILITY OF WATER:

Water is utilised for many beneficial purposes such as domestic, industrial, agriculture, aqua farming and hydro power production. Although the domestic requirement is less, industrial and agricultural demand of water is large. In developed countries, the major use occurs for industrial production and in developing areas it occurs for agriculture.

1.3 CLASSIFICTION OF WATER:

Surface water is present in stream, river, pond, lake, ocean forms. Quality of water streams and lakes is better as compared to that of ponds and rivers. Oceanic water is exploited not yet much and is highly saline. Rivers are imponded if the flow of water is seasonal.

Ground water occurs due to infiltration of water and is present in the form of springs; wells etc., spring water are sometimes medicinal in value. Open wells are traditional and tube wells are replacing open wells now-a-days for irrigation. Water quality from shallow wells is inferior compared to deep wells.

1.4 QUALITY OF WATER:

In general ground water is purer, compared to surface water. It is dominant in gases and dissolved solids etc. Surface water on the other hand is rich in suspended sediments and sufficient dissolved oxygen. The quality of surface water within a region is governed by both natural processes such as precipitation rate, weathering processes and soil erosion and anthropogenic effects such as urban, industrial and agricultural activities and the human exploitation of water resources **(Jarvie *et al.*, 1998)**. Ground water quality has become an important water resources issue due to rapid increase of population, rapid industrialization, unplanned urbanization, flow of pollution from upland to lowland, and too much use of fertilizers, pesticides in agriculture **(Joarder *et al.*, 2008)**

1.5 DEFINING THE RESEARCH PROBLEM:

Water quality parameters are defined by regulatory boards and they are analysed in the laboratory by standard procedure (APHA, 1985). Some parameters are time consuming relatively compared to others in estimation. Two or three parameters are estimated to represents the similar type of impurity. Few parameters also show similar trend of changes. As an example, Alkalinity and Hardness are proportional. Suspended and colloidal solids are related to Turbidity. Dissolved solids dictate the Conductivity of water. To what extent and at what conditions, one influences the other is not known proper by. It is necessary to understand the significance of quality parameters, represent systematically, establish relationships existence among them. Statistical analysis of physicochemical parameters of water has been reported from the different parts of World and India **(Dewangan et al., 2010)**. Francis Galton invented the concept of standard deviation, correlation and regression.

Hence, the study has taken up during January to May 2013. Two work elements involved in the study are:-

-Selection of various water sources used by the city people

-Physico-chemical analysis of significant parameters of water from the sources.

-Establishing relationship through Correlation analysis.

-Understanding the need of above tools for water management programs.

CHAPTER-2

Review of Literature

REVIEW OF LITERATURE

2.1 Cited Information:

Snedecer *et al.*, (1967) revealed that if the correlation coefficient is nearer to +1 or –1, it shows the probability of linear relationship between the variables x and y . This analysis attempts to establish the nature of the relationship between the variables and thereby provides a mechanism for forecasting.

Draper *et al.*, (1981) their study was based on best subset procedure (R and F value) and assessed water quality parameters for predicting the river water quality management. Correlation analysis are developed in explaining variation in river water quality using routinely measured water quality parameters

Khan and Rao (1981) studied the potential effects of thermal pollution, nutrient enrichment in eutrophication, interaction of ions, toxic substances like heavy metals, halogens, solids, reducing agents, and radioactive wastes on aquatic communities.

Singanan *et al.*, (1995) studied that the statistical regression analysis has been found to be a highly useful tool for correlating different parameters. Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables.

Tong *et al.*, (2002) Statistical and spatial analyses were employed to examine the statistical and spatial relationships of land use and the flow and water quality in receiving waters on a regional scale in the State of Ohio.

Sinha (2002) their study was based on multivariate statistical techniques, such as cluster analysis (CA), factor analysis (FA), principal component analysis (PCA) and discriminant analysis (DA) were applied to the data set on water quality of the Gomti river (India), generated during three years (1999–2001) monitoring at eight different sites for 34 parameters (9792 observations). The multivariate statistical techniques was used for evaluation and interpretation of large complex water quality data sets and apportionment of pollution sources/factors with a view to get better information about the water quality and design of monitoring network for effective management of water resources. Three significant groups, upper catchments (UC), middle catchments (MC) and lower catchments (LC) of sampling sites were obtained through CA on the basis of similarity between them.

Awasthi and Tiwari (2004) studied the seasonal trends in abiotic factors in lake Govindgarh, Rewa, Madhya Pradesh. An inverse relationship was observed between dissolved oxygen and temperature. The lake was perennial and alkaline in nature. The parameters found to show marked seasonal variations include temperature, transparency, pH, dissolved oxygen, free carbondioxide, alkalinity, calcium, chloride, nitrite and phosphate.

Meenakshi *et al.*, (2004) determined the fluoride concentration in underground water in four villages of Jind district of Haryana state (India) where it is the only source of drinking water. Various other water quality parameters such as pH, electrical conductivity, total dissolved salts, total hardness, total alkalinity as well as sodium, potassium, calcium, magnesium, carbonate, bicarbonate, chloride and sulfate concentrations were also measured. A systematic calculation of correlation coefficients among different physico-chemical parameters was performed. The analytical results indicated considerable variations among the analyzed samples with respect to their chemical composition. Majority of the samples do not comply with Indian as well as WHO standards for most of the water quality parameters measured. The fluoride concentration in the underground water of these villages varied from 0.3 to 6.9 mg/l, causing dental fluorosis among people especially children of these villages. Overall water quality was found unsatisfactory for drinking purposes without any prior treatment except at eight locations out of 60.

Ramanaiah et al., (2006) determined fluoride concentration surface and ground water samples in eight villages of Prakasham district in India. They found that the groundwater samples contained high concentrations of fluorides compared to open well and pond water samples and Fluoride concentrations showed good correlation with TDS concentrations (R^2 of 0.61) compared to other physico-chemical parameters [EC (R^2 - 0.36), nitrate (R^2 - 0.24), total hardness (R^2 - 0.12), chloride (R^2 - 0.06) and sulfate (R^2 - $4x10^{-5}$)]

Ouyang *et al.*, (2006) analysed seasonal changes in surface water quality is an important aspect for evaluating temporal variations of river pollution due to natural or anthropogenic inputs of point and non-point sources. In this study, surface water quality data for 16 physical and chemical parameters collected from 22 monitoring stations in a river during the years from 1998 to 2001 were analyzed. The principal component analysis technique was employed to evaluate the seasonal correlations of water quality parameters, while the principal factor analysis technique was used to extract the parameters that are most important in assessing seasonal variations of river water quality. Analysis shows that a parameter that is most important in contributing to water quality variation for one season may not be important for another season except for DOC and electrical conductance, which were always the most important parameters in contributing to water quality variations for all four seasons.

Dash *et al.,* (2006-07) developed regression equations for the parameters having significant correlation coefficients can be successfully used to estimate the concentration of other constituents. A systematic study of correlation and regression coefficients of the water quality parameters not only helps to assess the overall water quality but also to quantify relative concentration of various pollutants in water and provide necessary cue for implementation of rapid water quality management programmes.

Antony (2008) analysed strong correlations among different parameters and a combined effect of their inter-relatedness indicates the water quality. Ground water quality in the industrial areas is determined by measuring the concentration of some physico-chemical parameters and comparing them with drinking water standards

Ramakrishnaiah *et al., (2009)* had assessed the Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State.

Karunakaran *et al.,* (2009) studied that the increase in temperature decreases the potability of water due to the unpleasant taste produced by CO2 and other gases. Thus, the taste of sample differs from place to place20

Kumar (2010) find an approach to water quality management through correlation studies between various water quality parameters, the statistical regression analysis for eight data points of Gagan river water of different sites at Moradabad was performed. The comparison of estimated values with W.H.O. standards revealed that water of study area is polluted with reference to a number of physico-chemical parameters studied. Regression analysis suggests that conductivity of river water is found to be significantly correlated with ten parameters out of fifteen water quality parameters studied and it is moderately correlated with other four parameters. It may be suggested that the Gagan river water quality at Moradabad can be checked very effectively by controlling the conductivity of water. Present study may be treated one stop forward towards the water quality management.

Jothivenkatachalam *et al.*, (2010) analysed water's various Physico-chemical and biological parameters such as pH, Electrical Conductivity, TDS, TH, Ca^{2+}, Mg^{2+}, Cl^{-}, SO_4^{2-}, Total Acidity, Total Alkalinity and DO etc., The results are compared with standards of WHO, USPH and ICMR. A systematic correlation and regression study showed significant linear relationship among different pairs of water quality parameters.

Daphne *et al.*, *(2011)* established the correlation between TSS and turbidity to offer more efficiency in predicting total suspended solids concentration in river streams of Singapore. A positive relationship between total suspended solids concentration and turbidity level suggested that the measurement of turbidity is possibly the most economic option for estimating total suspended solids concentration in a river.

Daraigan *et al*., (2011) did linear correlation analysis study of drinking water quality data for Al-Mukalla city, Hadhramout, Yemen and showed that all the physicochemical parameters of drinking water in Mukalla city are more or less correlated with each other.

Rastogi and sinha (2011) established fact that clean water is absolutely essential for healthy living. Adequate supply of fresh and clean water is the basic need for all human beings on the earth, yet it has been observed that millions of people world-wide are deprived of this. Water caused health problems are mostly due to inadequate and incompetent management of water resources. A number of water quality physicochemical parameters were estimated quantitatively in water samples following methods and procedures as per W.H.O. guidelines. Water Quality Index (W.Q.I.) is regarded as one of the most effective way to communicate water quality in a collective way regarding water quality parameters. The WQI of water samples were also calculated. The Statistical Regression Analysis has been found to be highly useful tool for correlating different parameters. To find an approach to water quality management through correlation studies between various water quality parameters, the statistical regression analysis for twelve data points of underground drinking water of different hand pumps at Moradabad, India was carried out in the year 2009. The comparison of estimated values of different water quality parameters with W.H.O. drinking water standards revealed that water of study area is polluted and quality management is needed. Regression Analysis of the data suggests that conductivity of underground water is significantly correlated with all the eighteen water quality parameters studied. The correlation of calculated values of W.Q.I. with conductivity is also found to be significantly correlated. It may be suggested confidently that the underground drinking water quality of study area can be checked effectively by controlling the conductivity of waters. The present study may be treated one step ahead towards the water quality management.

Bi-Hsiang et al., (2011) investigated on sampling and analyzed water quality in water reservoir & water tower installed in two kind of residential buildings and school facilities. Data of water quality was collected for correlation analysis with frequency of sanitization of water reservoir through questioning managers of building about the inspection charts recorded on equipment for water reservoir. Statistical software packages (SPSS) were applied to the data of two groups (cleaning frequency and water quality) for regression analysis to determine the optimal cleaning frequency of sanitization. The correlation coefficient (R) in this paper represented the degree of correlation, with values of R ranging from +1 to -1.After investigating three categories of drinking water users; this study found that the frequency of sanitization of water reservoir significantly influenced the water quality of drinking water. A higher frequency of sanitization (more than four times per 1 year) implied a higher quality of drinking water. Results indicated that sanitizing water reservoir & water tower should at least twice annually for achieving the aim of safety of drinking water.

Arora *et al., (2011)* did the correlation analysis of drinking water in rural areas of Chandigarh. They collected eight samples from the various locations to analysis, various physical and chemical parameters, such as pH, turbidity, chlorine, carbonates, bicarbonates, total hardness, calcium, Magnesium, Fluorides, Nitrates, Sodium, and Potassium. The results were compared with Indian standards and WHO. Correlation and Regression analysis showed the significant linear relationship among different parameters. This study revealed that water of the area is much polluted and quality management is urgently needed.

Saleem *et al.*, (2012) studied that groundwater is a major source of municipal and private water supply in Gulbarga city. Water samples were collected from spatially referenced bore wells located in various wards of the city. 150 bore well water samples were analyzed for electrical conductivity (EC), pH, total dissolved solids (TDS), total hardness (TH), Ca^{2+},

Mg^{2+}, Na^{+}, K^{+}, HCO_3^{-}, CO_3^{2-} Cl^{-}, SO_4^{2}- ,NO_3^{-}, F and Fe. All tests were performed as per standard methods and water quality was compared for both Indian and WHO drinking water standards. Significantly positive correlation at 1 and 5% was found between many parameters. EC prediction with multiple R2 value of 0.999 indicated that 99.9% variability in observed EC could be ascribed to Cl^{-} (76%), HCO_3^{-} (12.5%), NO_3- (10.3%) and SO_4^{2-} (1.1%). Multiple regression models can predict EC at 5% level of significance. Nitrate, chlorides, TDS and fluoride concentration exceed permissible level of drinking water in 75, 41, 95 and 3.33% of the samples respectively. It is recommended to treat groundwater prior to domestic use.

Florence *et al.*, (2012) analysed groundwater samples of bore wells (BW), open wells (OW), Hand Pumps (HP), lakes, falls and streams collected from different locations in Yercaud Taluk in Salem District, Tamil Nadu for their physicochemical characteristics. The ground water samples were studied during pre-monsoon and post-monsoon seasons from 25 different villages. The present study was undertaken to characterize the physicochemical parameters such as temperature, pH, Total Alkalinity, Electrical Conductivity, salinity, Calcium Hardness, Magnesium Hardness, Total Hardness, Total Dissolved Solids, Total Suspended Solids, Total Solids and fluoride. Each parameter was compared with its standard permissible limit as prescribed by World Health Organization. The Water Quality Index (WQI) reflected that most of the samples are of good and excellent quality. The Karl Pearson Correlation matrix has approved the influence of CH on EC, Salinity and TDS with significantly positive correlation. The study reveals that all the villages have hardness within the desirable limit prescribed by WHO.

Saha (2012) had assessed the water quality characteristics of River Ganga at Kolkata Region, India using water quality index and ANN simulation method.

Sohrab *et al.*, (2012) had studied the Water quality index as a simple indicator of watersheds pollution in southwestern part of Iran and from this study it is revealed that quality declined significantly during the dry season.

Sirajudeen *et al.*, (2013) The physico-chemical status of water samples from five major part of locality in Karur and Tiruchirappalli cities, Tamil Nadu was assessed. The sampling points were selected on the basis of their importance. The physicochemical parameter like, temperature, pH, electrical conductivity (EC), total dissolved solids (TDS), dissolved oxygen (DO), total hardness (TH), calcium (Ca) magnesium (Mg), sodium (Na), potassium (K), nitrate (NO_3) sulphate (SO_4) and phosphate (PO_4) of ground water was determined. The results were compared with standards prescribed by WHO (2003). It was found that the ground water was contaminated at few sampling sites namely Mayanur, lalapet and Petavaithalai. While the sampling sites showed physicochemical parameters exceed the water quality standards and the quality of water is bad and it is not fit for drinking purpose. For the statistical analysis, correlation co-efficient (r) were also calculated for these water quality characteristics.

Heydari *et al.*, (2013) a statistical regression analysis method of twenty one data points of drinking water at five fields (21wells) for Kashan city (Iran) with hot and dry climate. found that most of the water samples are not potable. They used Piper diagram indicate that in most part of this city, the chemical character of water is dominated by NaCl. All samples showed sulphate and Sodium ion higher and K+ and F- content lower than permissible limit. Highly positive correlation is observed between TDS and EC (R=0.995) and between Ca^{2+} and TH (R=0.948). The results showed that regression relations have the same correlation coefficients, as: (I) pH and TH, EC and TH (R=0.520), (II) $NO3^-$ and pH, TH and pH (R=0.520), (III) Ca^{2+} and SO^{2-}, TH and SO^{2-}, Cl^- and SO^{2-} (R=0.630).

The literature collected and presented above shows that relationships exist among several water quality parameters. Although the biological information is described, similar trends may also exist among physical and chemical characteristics. The trends are popularly known as correlation.

2.2 Need for Correlation:

The water quality parameters vary from source to source and also undergo spatial and temporal variations. Hence one the parameters are identified, it is necessary to establish some kind of relationship. Once the degree of relationship among the variables is established, for the value of one variable given, the value of another variable can be found out. The correlation analysis also contributes to the understanding of economical and technical behaviour, aids in locating critically important variables on which others depend. Progressive development in the correlation methods increases the knowledge of relationships and arriving at multiplicity of interrelated forces. The effect of correlation also reduces the range of uncertainty.

CHAPTER-3

Materials & Methods

MATERIAL & METHODS

This chapter discusses the materials used and techniques followed during the study.

- Chemicals- Chemicals used were of analytical grade with sufficient purity.
- Instruments- All instruments with accuracy procured from authorized dealers were employed for measurement of sample characteristics.
- Calibration Curves- They were prepared from Stock solution, before estimating the unknown parameters (F^- etc.) and were used throughout the study.

3.1 SELECTION OF SOURCES:

A preliminary study was made at Patiala for several water sources and finally three sources were selected by keeping the accessibility and convenience. The sources of water selected were:-

i. Tap water at TU Campus
ii. Hand pump water near TU Campus
iii. Surface water at Bhakra Canal.

Samples were collected fortnightly throughout the study period Jan 2013- May 2013.

3.2 SAMPLE COLLECTION:

The water sources are being used by citizens of Patiala for drinking and other domestic uses, irrigation respectively. Samples were collected so as to be representative. Water was collected from the tap after discarding the stagnant water where as it was after sufficient wastages from hand pump. At the canal, representative sample was obtained at 40-60 cm depth below surface. Plastic Jerry cans and glass bottles of 1-2 litres thoroughly rinsed were used for collection.

3.3 SAMPLE HANDLING AND PRESERVATION

From the time of sample collection to the time of actually analyses, many physical, chemical and biochemical reactions would change the quality of the water sample, therefore to minimize this change the sample were preserved soon after the collection. The water samples were preserved by adding chemical preservatives, lowering the temperature or by the combination of both the method. The analysis of parameters was completed within 2 days of sample collection in the laboratory.

3.4 METHODS OF ANALYSIS:

The water samples collected from different sources were analysed in the laboratory for various Physico-chemical characteristics with the procedure as recommended by standard method of examination and wastewater (APHA, 1985)

3.5. PARAMETERS OF WATER QUALITY:

i. pH Measurement

The pH of the sample was determined by digital pH meter with an accuracy of ± 0.01. The buffer solution of pH 4.0, 7.0 & 9.2 is used for standardization.

ii. Electrical Conductivity

Electronic Conductivity was determined by using Conductivity meter, Model: EQ – 510. Conductivity may be defined as the measure of ability of aqueous medium to carry on electric current. Conductivity is totally dependent upon concentration and number of ions.
The results are measured at 25^0C

First the conductivity cell is rinsed by 0.01 M KCl solution. Temperature of solution is adjusted to 25^0 C. After that the cell is rinsed with sample and put into the sample and noted the reading in mho/cm.

iii. Total Solids

Total solids were determined by using gravimetric technique. A well mixed sample was evaporated in weighed beaker and dried to constant weight in an oven at 103^0 to 105^0 C. The increase in weight over that of empty beaker represents the total solids (TS).

iv. Dissolved Solid

Dissolved solids are the solids present in water in the dissolved state and are determined as the residue left after evaporation of filtered water at 103^0C.

v. Suspended Solids

Suspended Solids= Total Solids – Total Dissolved Solids

vi. Total Alkalinity

Total alkalinity is the measure of the capacity of the water to neutralize a strong acid. The alkalinity in the water is generally imparted by the salt of the carbonates, bicarbonates, phosphates, nitrates, borates, silicates, et c. together with the hydroxyl ions in the Free State. Total alkalinity, carbonates and bicarbonates can be estimated by titrating the sample with an acid (H_2SO_4), first to pH 8.3 using phenolphthalein as an indicator and then further to pH between 4.2 and 5.4 with methyl orange or mixed indicator. In first case, the value is called as phenolphthalein alkalinity (PA) and in second case; it is total alkalinity (TA). Values of carbonates, bicarbonates and hydroxyl ion can further be computed from these two types of alkalinities.

Calculation for alkalinity

$$\text{PA as } CaCO_{,} \text{ mg/l} = \frac{\text{A X N of HCl X 1000 X 50}}{\text{ml of sample}}$$

$$\text{TH as } CaCO_3\text{, mg/l} = \frac{\text{B X N of HCl X 1000 X 50}}{\text{ml of sample}}$$

Where

A = ml of HCl used with only phenolphthalein

B = ml of total HCl used with phenolphthalein and methyl orange,

PA = phenolphthalein alkalinity

TA = total alkalinity

vii. TOTAL HARDNESS

Ethylene diamine tetra acetic acid (EDTA) and its sodium salt form a chelated soluble complex when added to a solution of certain metal cations. Additional of small amount of a dye such as Erichrome Black T to an aqueous solution of calcium and magnesium ions of pH 10.0, turns the solution wine red. When EDTA is added as titrant, the calcium and magnesium get complexed and the colour of the solution turns from wine red to blue, marking the end point of the titration.

viii. TURBIDITY

It is the resistance offered by a sample to the passage of light. In the Nephelo turbidity meter, the received light is read in perpendicular direction to the incident light. The meter was calibrated between 40- 400 NTU of formazin and the readings of the unknown samples were noted down.

3.6 Correlation

To understand the relationship between different water quality parameters analysed from different sources, statistical parameters were calculated using Microsoft Office Excel 2007.

Relationship between the parameters (Correlation)

Any relationship between the two variables is known as correlation. If one variable increases or decreases with a corresponding increase or decrease of the other variable, a direct positive correlation exists between the two variables. If one variable decrease with an increase in the other variable, then there is a negative or inverse correlation. There are two different methods to study correlation

Graphic method

It is the simplest method of showing the relationship between two variables. In this one variable is represented on X-axis and other variable on Y-axis on graph paper. Data corresponding to X and Y axis were plotted in form of dots. And then estimated lines joining first and last points were drawn on the graph paper to find out correlation.

Correlation coefficient

The graphic method indicates the existence of a correlation. To find the relationship between two parameters x and y, the Karl Pearson's correlation coefficient, r is used and it is determined as follows:

$$r = \frac{n \sum x y - \sum x \sum y}{\sqrt{[n \sum x^2 - (\sum x)^2][n \sum y^2 - (\sum y)^2]}} \quad (1)$$

here, n = number of data points ; x = values of x–variable ; y = values of y–variable

To evaluate the straight–line by linear regression, following equation of straight line can be used –

$$y = ax + b \quad (2)$$

here, y = dependent variable ; x = independent variable ; a = slope of line; b = intercept on y–axis

$$a = \frac{n \sum x y - \sum x \sum y}{n \sum x^2 - (\sum x)^2} \quad (3)$$

$$\text{and} \quad b = \bar{y} - a\bar{x} \quad (4)$$

here, $\bar{x}$ = mean of all values of x ; $\bar{y}$ = mean of all values of y

CHAPTER-4

RESULTS & DISCUSSION

RESULTS AND DISCUSSION:

The result of study performed and discussion on results are presented in this chapter.

4.1 Selection of water sources during the study

After preliminary investigation of the sources, finally three were selected by keeping in view the accessibility and convenience. The selected water sources were:-

1. Tap water at TU campus
2. Hand pump water at TU campus
3. Surface water at bhakra canal

The water at TU campus is supplied after pumping the ground water two an elevated storage tank. There may /may not be any chlorine added. The hand pump water is used directly obtained from ground after operating the handle. Surface water flowing in the canal was filled in to bottles.

Selection of water source is crucial in water supply systems to decide the cost of conveyance, cost of treatment, types of units to be installed. In general ground water is superior to surface water. Causes of pollution of surface sources are many were as they are limited in ground water. Surface water once contaminated is seen and travels fast down streams. The contaminated ground water due to less velocity takes several years to travel downward further.

Draper *et al* (1981) made his study based on river water quality and Antony (2008) established the interrelatedness for ground water.

4.2 Physico-chemical analysis of water from different sources:-

Physico-chemical analysis of water was done, and the significant parameters are represented in Table 4.1-4.3. Parameters shown are pH, conductivity, alkalinity, total hardness, turbidity, total solids, dissolved and suspended solids.

Table 4.1 Analysis of Tap water

Sr.No.	Parameters	Jan		Feb.		Mar.		Apr.		May	
1	pH	7.1	7.2	7.2	7.1	7.3	7.2	7.3	7.2	6.9	7.1
2	Conductivity (mho/cm)	0.826	1.058	0.752	0.589	0.502	1.261	0.515	0.628	0.593	0.396
3	Alkalinity (mg/l) of $CaCO_3$	67	54	45	57	42	78	20	32	34	41
4	Total Hardness (mg/l) of $CaCO_3$	302	334	310	290	320	324	120	234	297	234
5	Turbidity (NTU)	15.6	16.8	20	19.1	21.3	14	16.3	11.2	5.5	17.4
6	Total Solids (mg/l)	308.3	346.7	285.7	298.6	301	355.9	285.7	331.2	342.4	132
7	Dissolved Solids (mg/l)	288.4	241.6	306	267.6	265.7	311.6	256.7	265.3	233	65.3
8	Suspended Solids (mg/l)	19.9	5.1	19.7	31	35.3	9	29	15.9	29.4	26

Table 4.2 Analysis of Hand Pump Water

Sr.No.	Parameters	Jan		Feb.		Mar.		Apr.		May	
1	pH	7.4	6.9	7.1	7.1	6.9	7.2	7.3	7.1	6.9	7.6
2	Conductivity (mho/cm)	0.912	1.132	0.81	0.682	0.676	1.152	0.576	0.717	0.653	0.356
3	Alkalinity (mg/l) of $CaCO_3$	95.9	98	100	98.3	120.1	38	46	57	40	64
4	Total Hardness (mg/l) of $CaCO_3$	320	301	270	290	150	170	240	350	297	234
5	Turbidity (NTU)	27	17	19	18	17	8	19	15	15	17
6	Total Solids (mg/l)	428	327	307	297	312	250	291	332	239	245
7	Dissolved Solids (mg/l)	188.4	185.6	266	256.4	275.7	219.5	196.7	419.5	203	273
8	Suspended Solids (mg/l)	26.6	15.4	41	29.4	46.3	30.5	34.3	66.7	22.6	82.9

Taple-4.3:- Analysis of Surface Water

Sr.No.	Parameters	Jan		Feb.		Mar.		Apr.		May	
1	pH	7.5	7.2	7.3	7.3	9.0	7.6	7.5	7.4	7.9	7.6
2	Cond. (mho/cm)	0.852	0.588	0.362	0.512	0.943	0.721	0.656	0.222	0.355	0.324
3	Alkalinity (mg/l)	60.9	40	44	98.3	164	72.8	56	66	90	94.6
4	Total Hardness (mg/l)	220	201	270	290	150	220	240	397	118	134
5	Turbidity (NTU)	40	47	39	18	27	28	29	35	49	37
6	Total Solids (mg/l)	495.3	492.3	338.8	276.2	251.2	281.6	308.6	396.1	367.4	258
7	Total Dissolved Solids (mg/l)	311.8	213	258	235.6	215.8	392.5	245.4	339.9	421.5	432.6
8	Total Suspended Solids (mg/l)	73.8	69.7	80.8	40.6	35.4	89.1	63.2	56.2	55.6	72.4

pH represents the intensity of acidity and the water from all the three sources has pH 7.0 to 9.0, which is desirable for drinking.

Conductivity is ability of a sample to carry electrical currents and this varies with type and number of ions. For distilled water, it is low and it varies depending on water source. As the ground water contains mainly dissolved salts, it would have more conductivity. The conductivity of wastewater is always large

Alkalinity measures the ability of a sample to neutralise an acid and in this case alkalinity values are reasonably low. The highest value is 164 mg/l of $CaCO_3$ with surface water. Alkalinity data is generally considered in water treatment operations.

Hardness is the resistance of water to produce lather with soap and the values obtained are higher for tap and hand pump water compared to surface water. Though it is problem in industries for drinking hardness is not considered to be serious.

Total solids represent the residue obtained after evaporation at 103-105^{0}C and the samples have recorded values upto 500mg/l.

Dissolved solids represent an important constituent. They cause saline taste and change the quality of industrial product. Not much variation is observed with dissolved solids in water at different sources.

Suspended solids (>1 μm) doesn't allow the light too pass through the water and bring sedimentation of river beds. Suspended solids are more in the case of water from Bhakra Canal compared to other water.

Turbidity is the resistance to the passage of light and for drinking of water it should be <10 NTU. High values of turbidity are seen with surface water.

Physico-chemical properties of water change from season to season. As an example, due to runoff more sediment may be contributed thus increasing turbidity and suspended solids. Rains aids in diluting the pollution aspects also. Summer or winter brings stratification in water body, thus affecting nutrient exchanges at various depths. Similar type of variations of analysis values and observed from the data during the study.

Awasthi and Tiwari (2004) have studied the seasonal variations of lake waters at Madhya Pradesh. Maruthanayagam *et al* (2003) reported zooplankton variations in pond in various season at Tamilnadu.

4.3 Statistical summary of quality parameters and establishing correlation:

Table 4.4-4.6 represents the statistical summary of physico-chemical parameters of samples analysed. They are calculated by Microsoft Office Excel 2007. Min. And Max. Values are:

Taple-4.4:- Statistical summary of physicochemical parameters of tap water

Parameters	Min. Value	Max. Value	Mean	Std. Deviation
pH	6.97	7.33	7.16	0.1074
Conductivity	0.396	1.261	0.712	0.2697
Alkalinity	20	78	47	17.314
Total Hardness	120	334	276.5	64.925
Turbidity	5.5	20	15.72	4.631
TS	132	355.9	298.75	63.91
DS	65.3	311.6	250.12	69.69
SS	5.1	35.3	22.03	9.883

Taple-4.5:- Statistical summary of physicochemical parameters of hand pump water

Parameters	Min. Value	Max. Value	Mean	Std. Deviation
pH	6.93	7.61	7.17	0.214
Conductivity	0.356	1.152	0.76	0.245
Alkalinity	38	100	75.73	29.893
Total Hardness	150	350	262.6	64.098
Turbidity	8.7	27.1	17.417	4.537
TS	239	428.5	302.85	55.491
TDS	185.6	419.5	248.38	70.009
TSS	15.4	82.9	39.57	20.856

Taple-4.6:- Statistical summary of physicochemical parameters of surface water.

Parameters	Min. Value	Max. Value	Mean	Std. Deviation
pH	7.3	9.02	7.65	0.526
Conductivity	0.222	0.943	0.553	0.240
Alkalinity	40	164	78.6	36.16
Total Hardness	220	397	224	83.19
Turbidity	18	49.2	35.087	9.5895
TS	251.2	495.3	346.55	90.59
DS	213	432.6	306.61	85.470
SS	35.4	89.1	63.68	17.022

The mean and standard deviations of sample values obtained during the study are shown above:

Data are analysed statistically if it is extensive. Minimum and maximum values are reported in the case of temperature measurement and meteorology related parameters. Averages may be made on arithmetic basis or geometric basis. It is reported that arithmetic averages project the value on lower side whereas geometric average project on higher side. As an example, arithmetic average is used for population projection of developed city and geometric average is used for developing city. Standard deviation indicates the deviation of a value from the average.

From the Tables, the alkalinity for tap water, hand pump water and surface water are 47, 75 and 79 mg/l of $CaCO_3$. This indicates the mean behaviour that occurred during the study period.

During the analysis of water, dissolved solids and conductivity, alkalinity and hardness, turbidity and suspended solids are reported in practice. When two parameters are representing the similar behaviour, is it necessary to perform analysis of both? Can't it be treated as overlap? Is it not the wastage of time? Hence correlation analysis was done for similar quality parameters and the results are given in Table 4.7-4.9

Taple-4.7:- Correlation analysis for tap water

Parameters	Jan.		Feb.		Mar.		Apr.		May	
Conducti. (X)	0.862	1.058	0.752	0.589	0.502	1.261	0.515	0.628	0.593	0.396
TDS (Y)	288.4	278.6	306	267.6	265.7	311.6	256.7	265.3	233	250

r= 0.750653

Parameters	Jan.		Feb.		Mar.		Apr.		May	
TA (X)	67	54	45	57	42	78	20	32	34	41
TH (Y)	302	334	310	290	320	324	120	234	297	234

r= 0.700526

Parameters	Jan.		Feb.		Mar.		Apr.		May	
TU (X)	15.6	16.8	20	19.1	21.3	14	16.3	11.2	5.5	17.4
TSS (Y)	19.9	5.1	19.7	31	35.3	9	29	15.9	29.4	26

r= 0.150187

Taple-4.8:- Correlation analysis for hand pump water

Parameters	Jan.		Feb.		Mar.		Apr.		May	
Conduc. (X)	0.912	1.132	0.81	0.682	0.676	1.152	0.576	0.717	0.653	0.356
TDS (Y)	275.7	360	256.4	219.5	203	419.5	188.4	226	196.7	185.6

R= 0.919884

Parameters	Jan.		Feb.		Mar.		Apr.		May	
TA (X)	95.9	88	100	98.3	120.1	38	46	57	40	64
TH (Y)	320	301	320	290	350	170	240	210	220	234

R= 0.945149

Parameters	Jan.		Feb.		Mar.		Apr.		May	
TU (X)	27.1	17.2	19	18	17	8.7	19	15.2	15.5	17.4
TSS (Y)	26.6	15.4	41	29.4	46.3	30.5	34.3	66.7	22.6	82.9

R= 0.4592

Taple-4.9:- Correlation analysis for surface water

Parameters	Jan.		Feb.		Mar.		Apr.		May	
Conduc. (X)	0.852	0.588	0.362	0.512	0.943	0.721	0.656	0.222	0.355	0.324
TDS (Y)	311.8	213	258	235.6	215.8	392.5	245.4	399.9	421.5	432.6

R= 0.977492

Parameters	Jan.		Feb.		Mar.		Apr.		May	
TA (X)	60.9	40	41	98.3	164	72.8	56	66	90	94.6
TH (Y)	210	201	270	290	150	220	240	397	118	134

R= 0.979484

Parameters	Jan.		Feb.		Mar.		Apr.		May	
TU (X)	40.17	47.2	39	18	27	28.7	29	35.2	49.2	37.4
TSS (Y)	73.8	69.7	80.8	40.6	35.4	89.1	63.2	56.2	55.6	72.4

R= 0.975112

The data shows that the correlation regression coefficient (r) is high (upto 0.979) between Conductivity and DS, TA and TH for hand pump and surface water whereas it was low (0.750) for tap water. This indicates that this sample requires better care in analysis.

Correlation regression coefficient (r) was high (0.975) for surface water between Turbidity and suspended solids. This was followed by the decreasing values of 0.459 and 0.150 for hand pump and tap water.

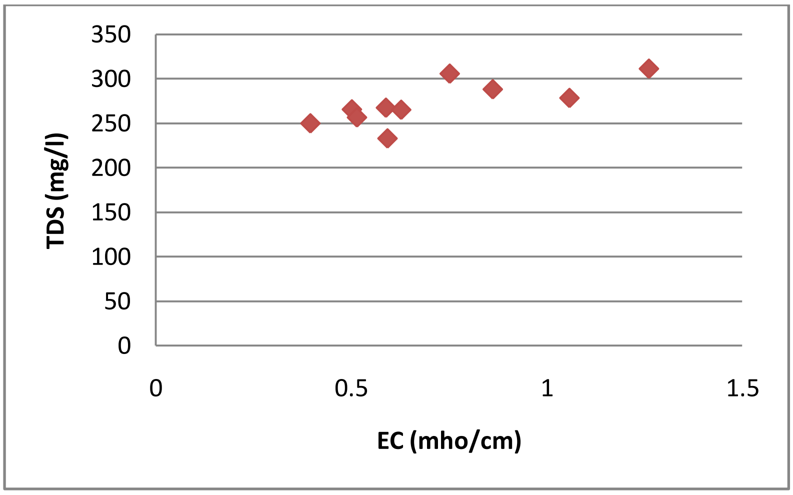
It is worth mention that all the parameters are positively correlated, meaning that the increase of one parameter influences the increase of the other.

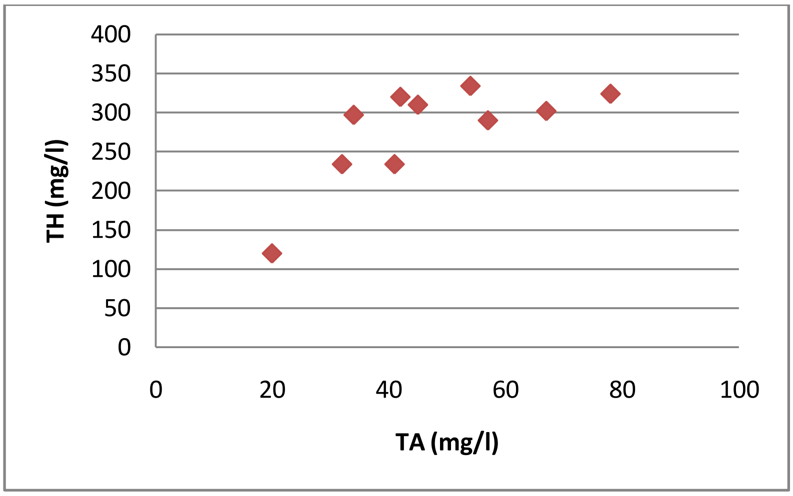
4.4 Need of tools developed for water Quality Management:

The tools developed in the study are mainly Arithmetic average, Standard deviation and correlation coefficient. They may be considered for selection of pipe materials and design, feasible location and treatment unit operation.

Scatter diagrams showing correlations are shown in Fig. 4.1-4.3

Figure 4.1 Scatter diagrams showing correlation of tap water.





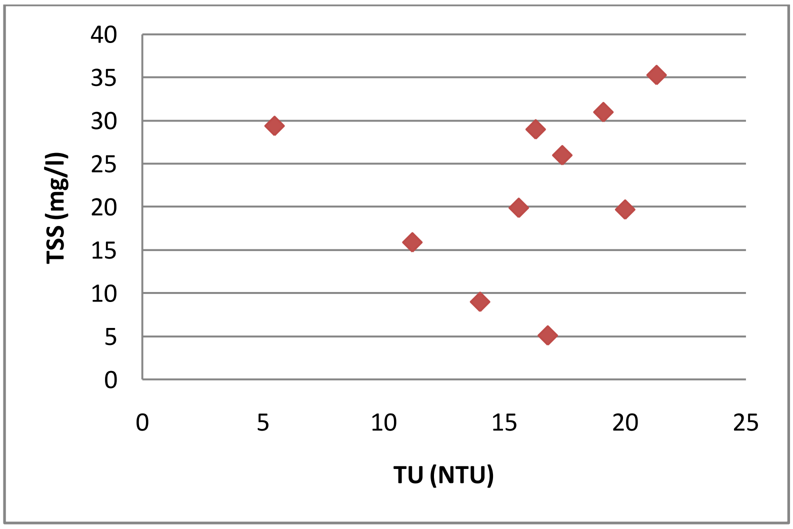
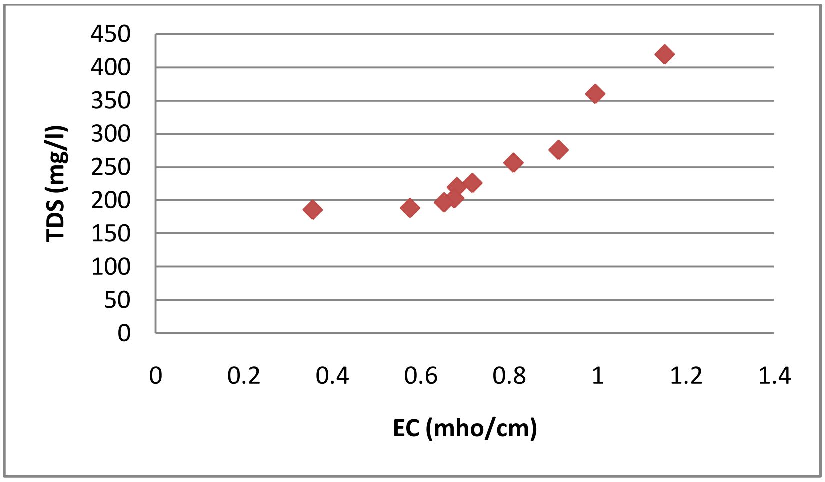
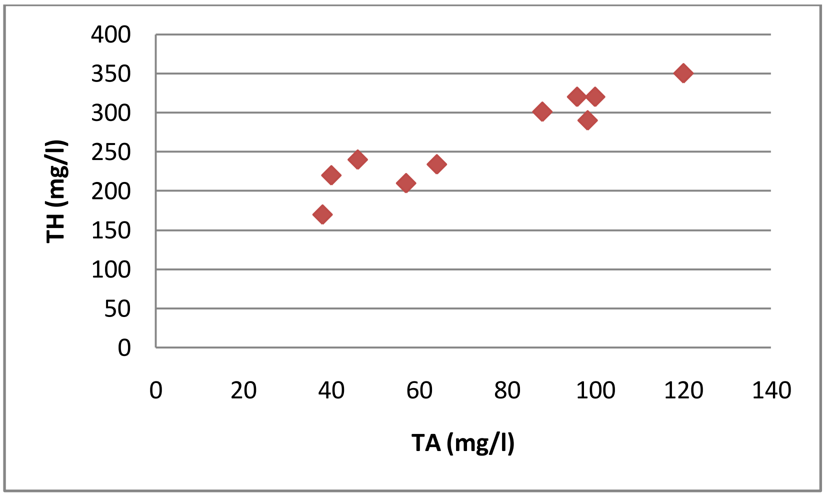


Figure 4.2 Scatter diagrams showing correlation of hand pump water.





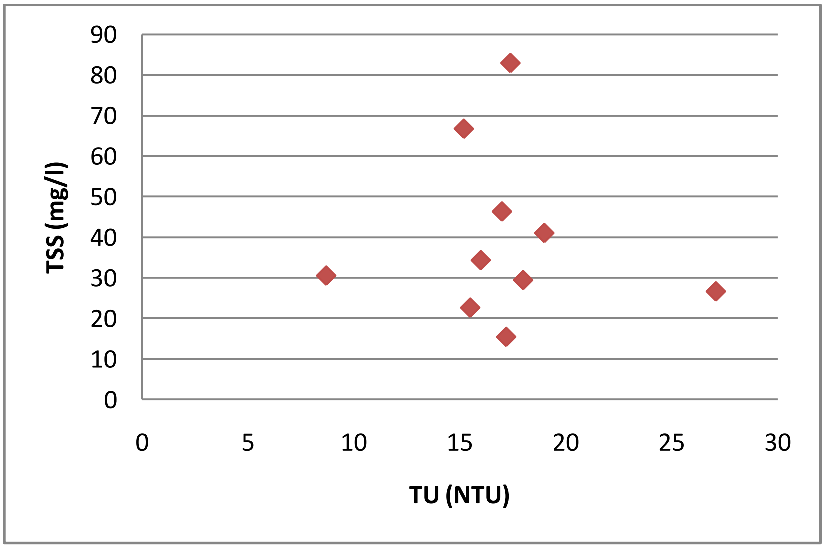
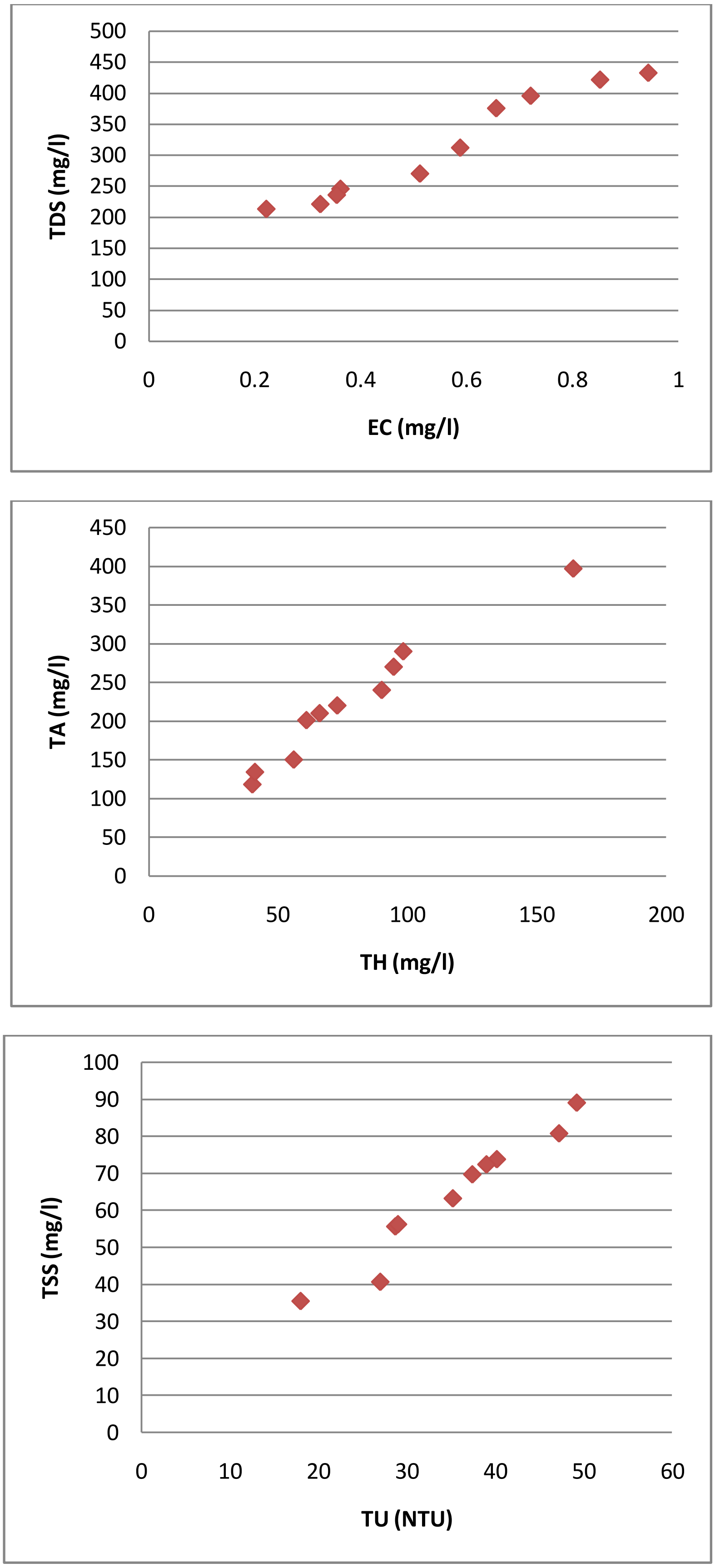


Figure 4.3 Scatter diagrams showing correlation of surface water.



CHAPTER-5

CONCLUSION

CONCLUSION

Based on the study performed, the results and discussion made the following conclusions are drawn.

- Tap water source is easy to access and convenient to handle compared to hand pump, Surface water at canal. The utility of water is also different for these sources (from drinking to irrigation).
- Most of the parameters analysed were in higher ranges for surface water. The values were lower for hand pump water; followed by tap water this indicates the suitability of tap water for a designated use of drinking.
- All the parameters subject to correlation analysis showed positive correlation with each other. Conductivity and DS; Hardness and Alkalinity was highly correlated (r = 0.97) compared to Turbidity and Suspended solids (r = 0.15)
- The correlation relations developed are promising tools for water management program.

Future Scope:

The statistical tools developed are preliminary. Further studies are required:

i. In proposing Water Quality Models.

ii. The study may be extended to larger areas covering several water sources.

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