USE OF GIS IN THE ASSESSMENT OF GROUNDWATER QUALITY IN THE COMMAND AREA OF SINGANALLUR TANK, COIMBATORE

DECLARATION

Hereby it is declared that the project report titled **"USE OF GIS IN THE ASSESSMENT OF GROUNDWATER QUALITY IN THE COMMAND AREA OF SINGANALLUR TANK, COIMBATORE"** submitted to the Institution of Engineers (India), Kolkata, India, is an original work carried out by the following students, who finished their B.E degree program in May 2007.

- S. Suresh
- S. Kanagaraj
- M. Naveen Venkat
- D. Vimal Raj
- R. Sunil Kumar
- S. Sivaraj

Babu W
R. Ca... Sep. 13, 2007

Research Supervisors

Head of the Department

Principal i/c
13/9/7

KUMARAGURU COLLEGE OF TECHNOLOGY
CHINNAVEDAMPATTY
COIMBATORE - 641 006

TABLE OF CONTENTS

ACKNOWLEGDMENT

The authors wish to acknowledge the financial help given by the Institution of Engineers (India) to carry out this project. Also technical support given by the PWD Assistant Executive Engineer Er. R. Elangovan is very much appreciated. Moreover, they like to thank the staff and management of KCT for their help in completing this project work.

ABSTRACT

Due to its irregularity, both in quantity and frequency, rainfall cannot be relied on to raise crops. Though there are many factors that affect the yield of crops that are high in quality, irrigation plays a major role. In fact, more than 75% of crops are produced from irrigated areas, which are about 40% of the total cropped area. Tank irrigation is one of the ways with which crops can be irrigated. Even though tanks are great sources of water, if not properly protected, they will aid in polluting both surface water and groundwater, since water stored in the tanks is taken to the fields through canals and also it infiltrates into the ground and reaches the groundwater reservoir. Nowadays, in all countries, there are regulations that control the discharge of effluents into public water bodies and over the land surface. However, people are still, knowingly or unknowingly, letting wastewater get into surface water as well as groundwater. The polluted water, when used for irrigation, affects not only the crops but also the land. Geographical Information System (GIS) softwares are today widely used in management of natural resources. The GIS has been found to be very effective to assess the groundwater quality. The main objective of this study is to compute the variation of water quality parameters over time and also to find the zone of concentration of each parameter in and around Singanallur tank, which is located in South East part of Coimbatore.

I. INTRODUCTION

I.1 General

Land and water are two broad components on which the entire biotic community thrives. Groundwater and surface water have always been useful and are unique sources of fresh water for domestic, industrial and agricultural purposes. The available surface water resources are inadequate to the entire water requirements for all purposes, so the demand for groundwater has increased over the years. The importance of groundwater has long been recognized, but the potential for groundwater to become contaminated as a result of human activities at or near the land surface has only been recognized in recent years. Of the population served by public water supplies, approximately 50 percent depend on groundwater (http://www.in.gov/dem/water/index.html). Groundwater being hidden is more vulnerable to hidden threats of contamination and depletion. Urban growth and rapid increase in population has induced tremendous pressure on natural resources, resulting in impermeabilisation of a significant proportion of land surface, and contamination of groundwater. If the disposal of waste is not properly managed, it will aid in polluting both surface water and groundwater, since water stored is taken to the fields through canals and also it infiltrates into the ground and reaches the groundwater reservoir. Groundwater is an important natural resource required for drinking, irrigation and industrialization and this resource can be optimally used only when the quality of groundwater is assessed. It has been observed that lack of tools for handling the data, leads to lot of problems. Overexploitation and unabated pollution of this vital resource is threatening our ecosystems and even the life of future generations, therefore it is essential to maintain a database, which help to overcome the cause, which poses a serious problem for sustainable agricultural production. The database, which can be used must have facilities for better interpretation of data which often requires that their spatial location be incorporated and spatial relationship has been established. This can be effectively done by using Geographic Information Systems (GIS) software; it also provides the facility to analyses the spatial data objectively using various logical conditions. As a result, nowadays, GIS is widely used for spatial modeling of hydrogeological prospect of a large area with more reliability. GIS allows users to transfer a database into the map based on coordinates in the database. By adopting a GIS platform the result obtained will be faster and more accurate.

I.2 Objectives

The main objective of the study is to characterize the water quality and study its spatial distribution in the command area of Singanallur tank.

The specific objectives are the following.

1. To study the variation of quality of water in the Singanallur tank with time.
2. To determine the effect of groundwater in the command area of the tank.
3. To determine the effect of crop yield in the command area of the tank.
4. To determine the zone of concentration in the command area of the tank using GIS.

II. LITERATURE REVIEW

Literature on the following topics were reviewed and discussed below.

- Groundwater quality assessment using GIS
- Physico-chemical characteristic analysis

II.1 Groundwater Quality Assessment Using GIS

GIS continues to expand at an ever-increasing rate in almost all the spheres of science, technology, planning, administration, now GIS has wide application in physical and human endeavors like crime and disease analysis, routing of vehicles in case of traffic jams, business and industrial location analysis, urban and regional planning, military simulations etc.

A well-designed GIS should be able to provide the following facilities:

- Quick and easy access to large volumes of data.
- Select the details by area or theme.
- Link or merge one data set with another.
- Analyze spatial characteristics of data.
- Search for particular characteristics or features in an area.
- Updating of data quickly and economically.
- Data modeling and assessment alternatively from time to time.
- Output capabilities of maps, graphs, address list, summary statistics, etc., to meet the required needs.

Mohammed Ismail and Pattabi (2000) used GIS techniques for mapping the spatial variability of groundwater in Erode district. In this study, the groundwater quality of 40 wells randomly distributed in erode district was selected. MapInfo was used for zoning the ranges of pH, bicarbonate, chloride, calcium and magnesium. The frequency distribution of the parameters was randomly classified into four ranges. Based on these ranges, the thematic maps for pH, bicarbonate, chloride, calcium and magnesium for open and bore wells are prepared and presented.

Raja Mohan (2000) applied GIS techniques for groundwater quality assessment in Madurai Corporation. In order to assess the groundwater quality, 105 wells were identified throughout the Madurai Metropolitan region and water samples have been collected during summer as well as winter seasons in the year 1997-98. The estimated data of 105 locations for each parameter have been converted into contour maps by using GIS (ARC-INFO).Total dissolved solids, total hardness, chlorides and fluorides have been integrated through GIS and three priority classes(high ,medium, low) have been derived.

Saraf et al (2000) study involves remote sensing and GIS based methodology for selection of suitable recharge sites in a hard rock area. Data products used were IRS LISS –II data, survey of India (toposheets) at 50000 scales. GIS analysis brings out the relationship among different factors controlling the artificial recharge phenomena. The suitable areas were delineated by a combination of Boolean logic analysis and weighted index overlay. Based on the land use class, different methods of artificial recharge suggested.

Sinha et al (1997) the study involves visual interpretation of IRS LISS II and SPOT data to derive information on geology, geomorphology, lineament and hydro geomorphology. Based on the integration of the above themes along the drainage density, lineament density, and their intersections, feasible artificial recharge sites have been proposed for the rainwater harvesting structures.

Arora et al (2003) highlighted the use of GIS in development of conceptual ground water model .various layers of information such as canal network, recharge zones, subsurface geology and DTM of Hanumangarh and Srinagar districts were developed in GIS and transferred to finite difference grid for developing groundwater flow model of the area.

Arun et al (2003) developed an integrated remote sensing and GIS based methodology and tested for the evaluation of groundwater resources of Silai watershed, Bankura district, west Bengal.

Kharad et al (1999) developed a GIS based ground water assessment model .this model allows assessing the ground water more efficiently, accurately and at a fast pace.

Krishnamurthy et.al, (1996) developed a GIS based model for delineating ground water potential zones of Marvdaiyar basin Tamilnadu, India by integrating different thematic layers derived from remote sensing data. The field verification of this model established the efficacy of GIS in demarcating the potential groundwater reserves.

Shasidhar (2000) has developed GIS based ground water assessment model to estimate the ground water potential in sub water shed in Ambur minor basin in Upper Palar Basin.

Srinivas Rao.k, (2002), has created the database (i.e. spatial and Non-Spatial database) and imported into ARC/INFO as coverage. The required non-spatial database is attached to respective coverage. The module selects the relevant coverage's and calculates the recharge or seepage of individual component / coverage.

Application of GIS for groundwater resource assessment has also been reported by Sander (1997), Teeuw (1999) and others.

Gustafson (1993) used GIS for the analysis of lineament data derived from SPOT imagery for groundwater potential mapping.

Vasanthakumar et al (1999) applied GIS and remote sensing in identifying artificial recharge zones of upper Kondavanar River Basin, Tamil Nadu.

II.2 Physico-Chemical Characteristic Analysis of water

In order to ensure that the water suits the quality standards it is necessary to carryout the physico-chemical characteristic analysis.

Katie McDonald and John LaFave (2000–2003) have carried out the study for Assessing Ground-Water Quality and for developing a Monitoring Plan for the North Flathead Valley and Flathead Lake Perimeter. They sampled the groundwater in the targeted areas for a period of 1 year which was used to establish a monitoring network. The results helped to characterize the occurrence and distribution of nutrients in the selected shallow aquifers in relation to potential nutrient sources, and to assess seasonal changes in nutrient concentrations. Additionally, the monitoring well network and the project results provided a foundation for assessing long-term trends in water quality.

V. G. Johnson and J. Chou (2002) have carried out the study to determine the rate of movement and extent of contamination in the uppermost aquifer beneath Waste Management Area S-SX in the 200 West Area of the Hanford Site. In addition to routine quarterly groundwater sampling from the new and existing network wells, additional hydrologic testing was also conducted, adding to the understanding of site-specific hydrologic conditions.

Needhidasan et al., (2006) assessed the quality of surface water in both the upstream and downstream side of the Sathyamoorthy reservoir in Tiruvallur Taluk by collecting samples at 10 different locations.

Magudeswaran et al., (2006) have carried out a similar study to find out water quality index for Orathupalayam dam water. They assessed the quality by finding the water quality index.

Drusilla et al., (2006) has carried out the study aimed at estimating the minerals in and around Tenkasi, Tirunelveli District.

Similarly, assessment of groundwater flow and pollutant transportation in the Sulur Watershed of Coimbatore district was carried out (Victoria Ljungberg, Saran Qvist, 2004).

Likewise, recently, research has been conducted to determine suitable recharge areas in Tiruppur Taluk (Gopinath, 2004).

Mahender et al (2000) developed an integrated remote sensing and geographical information system approach for the selection of water harvesting structures. His study is aimed at the selection of suitable sites for water harvesting structures in Dehradun and its environs using an integrated approach of remote sensing and GIS technology. Using SOI topomaps and remotely sensed data different thematic maps such as drainage, contour, geology, geomorphology, soil, and land use were prepared. The DEM was utilized for the generation of slope, aspect and soil maps .Integrating soil texture, thickness, land use, slope of the area, suitable sites were identified for Bundies, Farm ponds, check dams and percolation tanks.

Ramalingam et al (1999) applied gis and remote sensing to delineate areas favorable for recharge both in hard rock and sedimentary environs, to recommend suitable recharge structures. Different thematic maps, such as geology, geomorphology, soil, land use, etc., were prepared from IRC-IC LISS III satellite data and overlaid with suitable ranks and weights. By integrating the various thematic maps, the favorable zones for recharge is identified and the suitable recharging structures are recommended based on field conditions.

Choubey (1996) stated that a rapid and accurate assessment of the extent of waterlogged areas can be made using remotely sensed data. The waterlogged area was determined with the available water depth and electrical conductivity data to assess the area sensitive to waterlogging.

Goyal et al (1999) the study involves generation of thematic maps and their integration through GIS. Remote sensing data were used to generate the maps like drainage, slope, soil, land use, etc. Based on the values of the weighted map, they were classified as more, moderate, less and poor groundwater potential zones. The rocks were supporting the storage and drainage will allow more percolation. Some of the water divide zones are delineated by drainage zones.

Joseph Atsu Tsagli studied the Spatial distribution of water quality and eutrophication Levels of wetlands of Lake Cuitzeo, México. Point source pollution from the capital state of Michoacán and non-point sources from agricultural Lands has brought serious environmental concerns of eutrophication and sustainability of this resource .And this study was undertaken to characterize the eutrophication levels of wetlands and the spatial Distribution of water quality of Lake Cuitzeo using GIS.

A team of six Systems Engineering students under the direction of professor Garrick E. Louis developed a model for ground water assessment (GWA) that could be used for planning development in rural areas that depend primarily on ground water for their water supply. The project was carried out on private wells in the Ivy subdivision of Albemarle County, Virginia.

In Iran, GIS was used to map the groundwater quality in Gorganroud-Gharehsou watershed and it was found that the salt content increased from the South to the North part of the study area (Shamanian, 2006).

Dixon carried out the study to develop a model using Neuro-fuzzy techniques in a GIS to predict ground water vulnerability .The model was validated using nitrate-N concentration data. The majority of the highly vulnerable areas predicted by the model coincided with agricultural land use, moderately deep to deep soils, soil hydrologic group C (moderately low Ksat) and high pedaled points (high water transmitting properties of the soil structure).

Though a study carried out at Germany did not involve groundwater quality, it followed a similar methodology in preparing a map showing the groundwater levels in Northrhine-Westfalia state (Leppig, 2006).

Minor et.al, (1994) developed an integrated interpretation strategy to characterize ground water resources for identification of well locations in Ghana using GIS as the unifying element.

For the assessment of groundwater resources of Northwest Florida water management district, Richards et.al, (1996) took the advantage of GIS for spatial analysis and data visualization.

III. STUDY AREA

III.1 Introduction

Coimbatore district is in the North West part of the state of Tamil Nadu. It is between latitudes of 10°12' N and 11°57' N and between longitudes of 76°39' E and 77°56' E and has an area of 7469 Km^2. The total population of Coimbatore city is 9,70,000.The extent of city cooperation is 105.6 Km^2 .Of this 52.4% of the total is urbanized and the remaining 47.6 % constitutes rural areas comprising of agriculture, unused vacant lands and wastelands. And in the total area industries constitutes about 7.37%. And a conservative estimate said that Coimbatore city generates about 440 lakh liters of sewage everyday and 750 tonnes of solid waste, 50-100 tones of biomedical wastes are also generated .Due to improper drainage system effluents are discharged into water bodies, Singanallur is one such tank.

The Singanallur tank is situated in the South East part of Coimbatore in the village Singanallur in the plain and downstream of Vellalur tank.

III.2 Specifics of Singanallur Tank

Latitude	10°59'46"
Longitude	77°01'11"
Total ayacut area	845 acres
Catchment area	11.776 Km^2
Tank full water level	4.25 m
Water spread area	1153 Km^2
Capacity of the tank	52.27 mcft

The study area is covered with very deep, medium to fine textured, brown and grayish brown alluvial soil and the crops that are generally grown are maize, sugarcane, plantains, etc. and water surface here is covered with Eichornia Crassipus, which floats on the surface of the water. The tank was chosen by the city's civic body for providing entertainment like boating to Coimbatore people. But due to the entry of wastewater, it was reduced to a water body filled with sewage water.

The study area is shown in fig3.1 and a view of the Singanallur tank is shown in fig 3.2

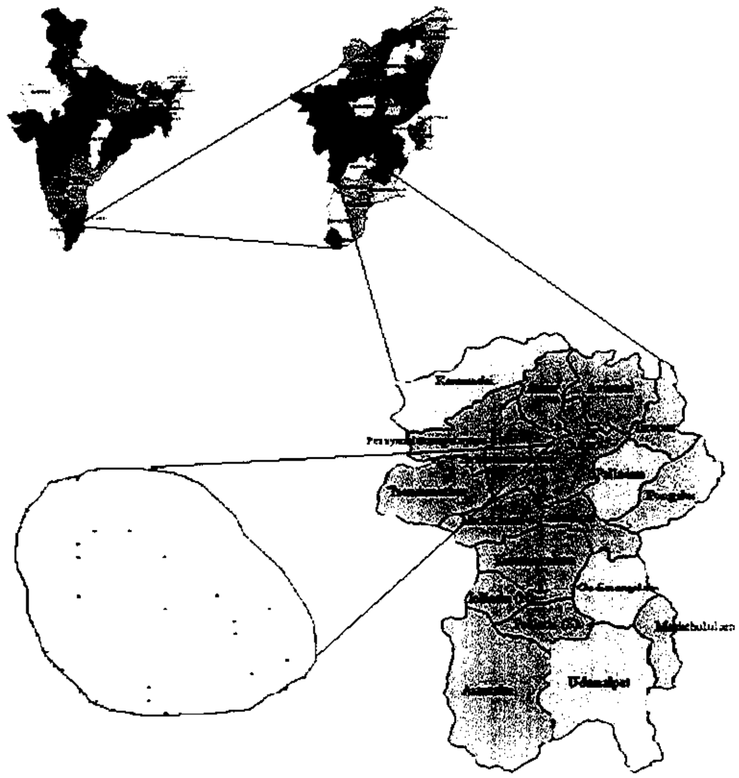

Fig. 3.1 Study area

Fig. 3.2 Singanallur tank

IV. PRELIMINARY SURVEY

IV.1 General

The focus of the research was to study the variation of quality of water in the Singanallur tank with time and to determine the groundwater quality in the command area of the tank.

The field study involved

Preliminary survey of the study area,

GPS survey and

Collection of samples for laboratory analyses.

IV.2 PRELIMINARY SURVEY

Preliminary Survey was carried out in several occasions to find out the existing situation of the tank and to collect some information regarding the command area by means of interaction and finally to identify and locate the sampling points. And from the preliminary survey it was found that the domestic waste, wastes from various industries, hospitals, etc. lying along various canals flowing toward Singanallur tank were also let into the tank .The further more information which we gathered is given in the previous chapter.

IV.3 GPS Survey

GPS survey was carried out to find the latitude and longitude of the sampling points and to track the boundary along the Singanallur tank.

GPS is provided with facilities for storing and locating the waypoints (the location of sampling points). Each sampling points were located and the position coordinates (latitude and longitude) was stored. GPS is provided with a facility called navigation with the help of which it is possible to keep track of waypoints travelling on the way and stored in a track log. The boundary of the Singanallur tank was tracked by means of travelling all along the boundary and inaccessible points of track are recorded and way points are noted in that location.

The waypoints and track log details were transferred to the computer for using in the GIS software.

IV.4 Sampling Plan

Different number of samples was taken from the lake for the purpose of analysis and to study the variation of quality of water in the command area. Samples were collected from tanks, wells and bore wells. Samples were collected from twenty-one locations in the study area as given in the following table.

Eastern side	5
Northern side	2
Western side	4
Southern side	3
Within the tank	7

Test results are dependent upon the samples, which have been taken from a whole population. The main aim is to obtain samples, which are representative and valid for whole population. Therefore, very special attention had been paid to the organization of the collection and sampling techniques.

Each sample provides data on water quality. Water is a dynamic system. During sampling, the water is removed from its natural environment. Due to this change, the chemical composition of water may not remain same. As only a few parameters can be measured during collection, primary treatment or stabilization was essential. In case of the samples, which have no organic and microorganisms, stabilization is not necessary. But the physico-chemical changes are possible, when large amounts of organic materials are present in the samples and conditions are suitable for growth of microorganisms, the water contents can change in a very short time. Hence preservation was highly recommended in such cases so that the change in contents between original and preserved sample should not exceed 10%.

As pointed out by M. Ramakrishnan, the Project Co-coordinator of Siruthuli (Source: The Hindu), about 10 million litres of sewage enters the Singanallur tank every day. In addition to the domestic waste, wastes from various industries, hospitals, etc. lying along various canals flowing toward Singanallur tank are also let into the tank. In order to find out the present condition of the tank, preliminary survey was carried out on several occasions and the following information was gathered.

- Water, which was potable, has become unsuitable for drinking
- Crop yield has declined
- The entry of sewage into the tank can further be substantiated by the presence of water hyacinths that cover a considerable surface area of the tank as shown in figures 4.1 & 4.2.
- Color of water has changed in nearby irrigation wells as shown in fig. 4.5.
- Sewage is being let into the tank or carried around the tank as depicted in figures 4.9 & 4.10.
- As per the local farmers, the effect of pollutants in the tank is severe only after some distance away from the tank for which no concrete corroboration was found out in this study.
- It was also gathered from PWD officials that in a particular season of the year, the menace due to flies, which are similar to mosquitoes, is terrible in the area nearby the tank. During the period of this study, no such problem was encountered.

Following are some of the pictures that were taken during the preliminary survey.

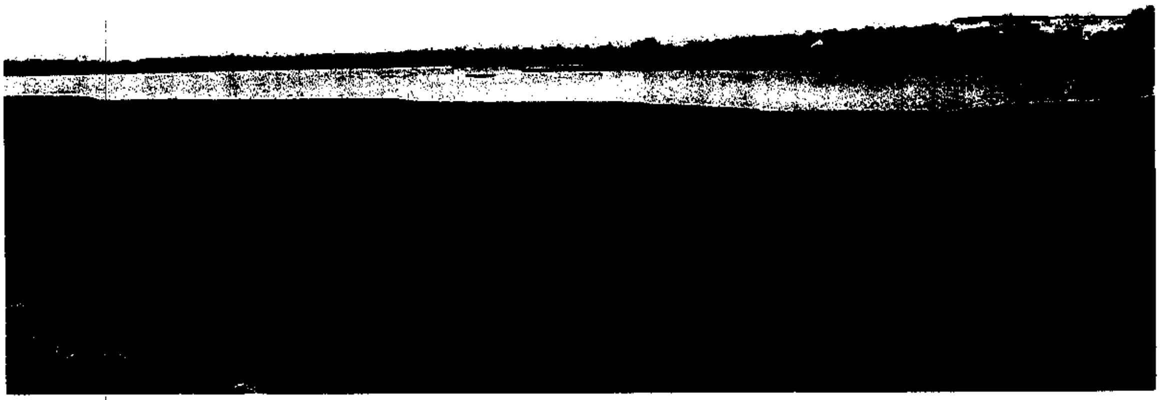

Fig.4.1 Water Hyacinth in the tank

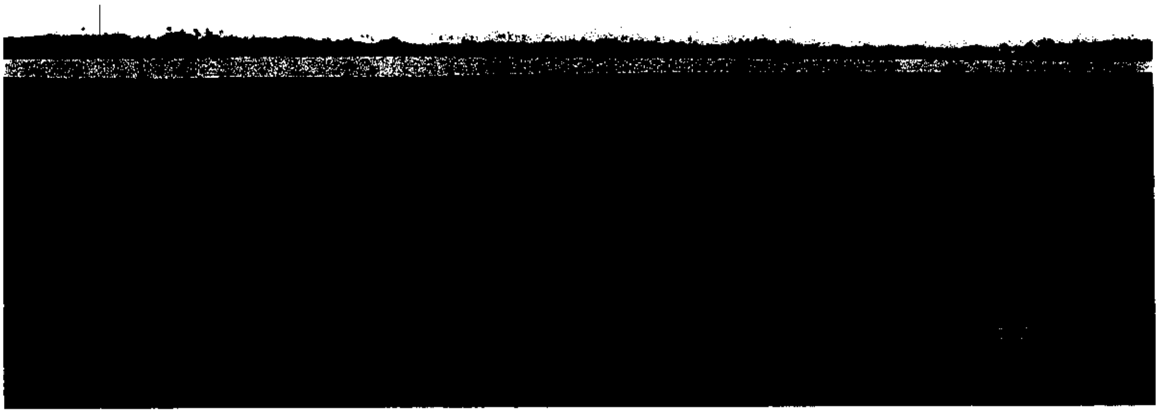

Fig.4.2 Water Hyacinth in the tank

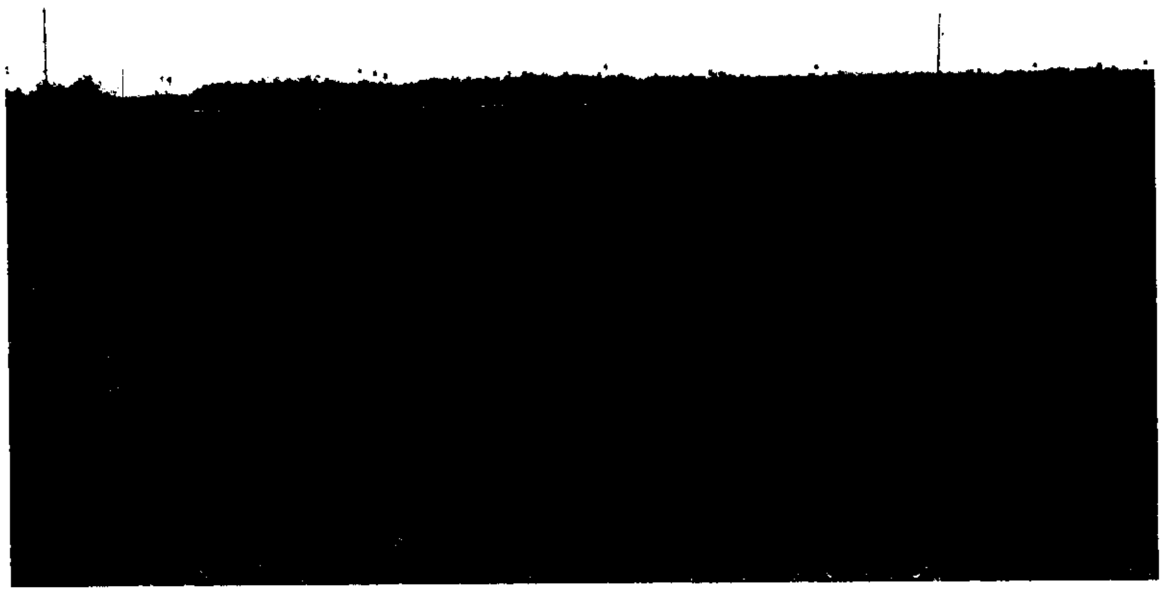

Fig.4.3 View of tank during Non-monsoon period

Fig.4.4 Interaction with farmer

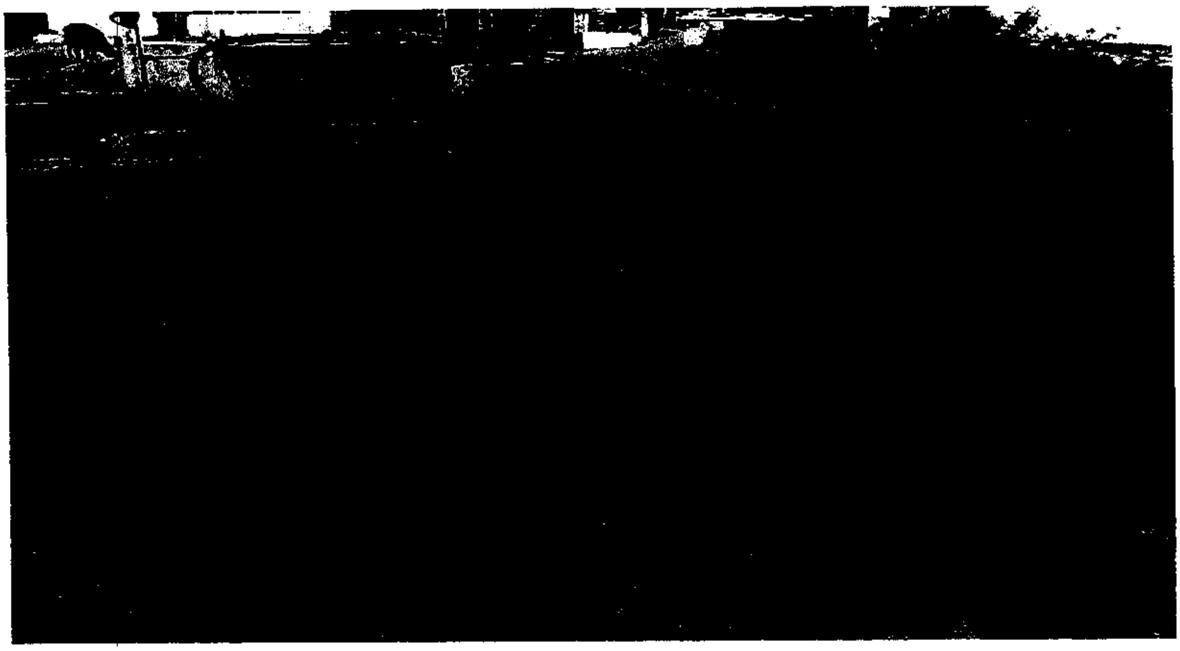

Fig.4.5 **Irrigation Well in the Tank Command Area**

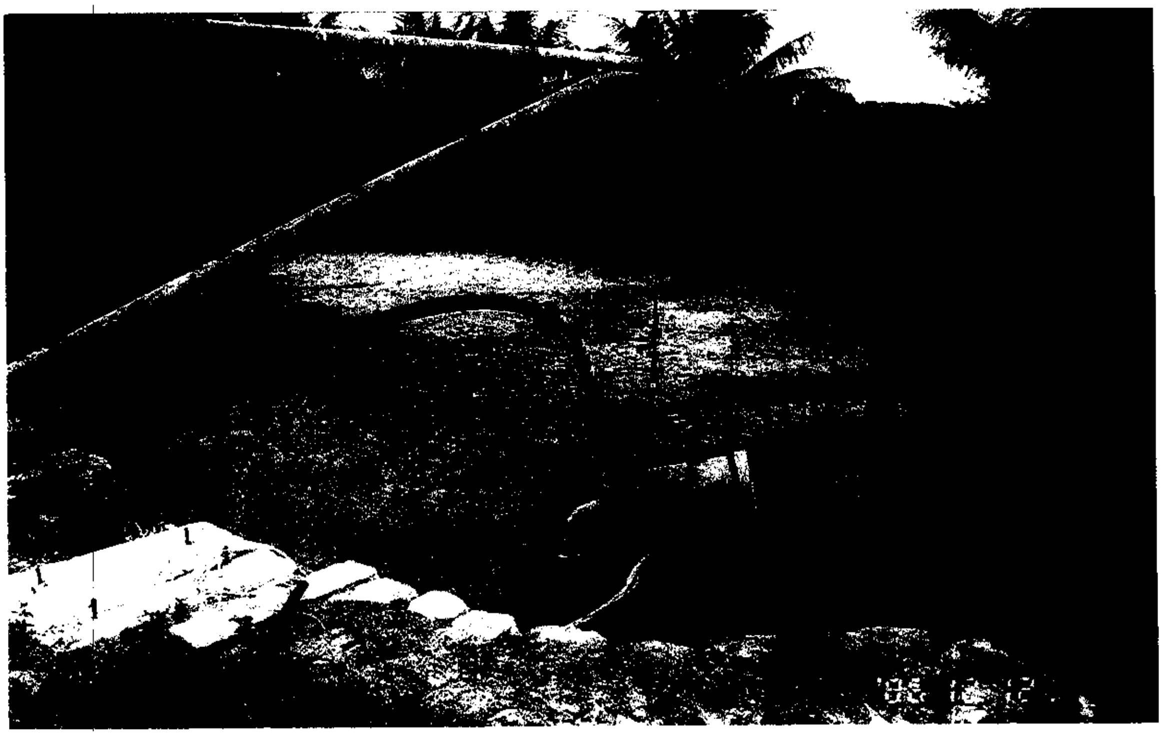

Fig.4.6 View of well

Fig.4.7 Well water used for irrigation

Fig.4.8 Sample collection in the well

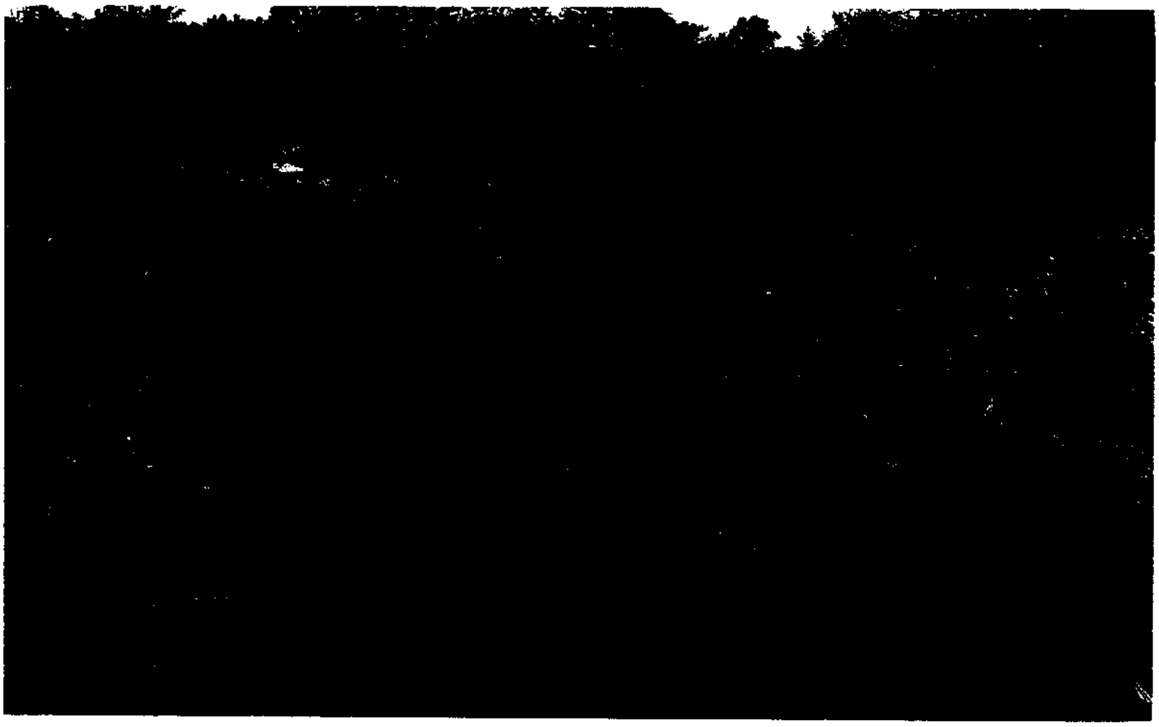

Fig.4.9 Flow of municipal sewage near by the tank

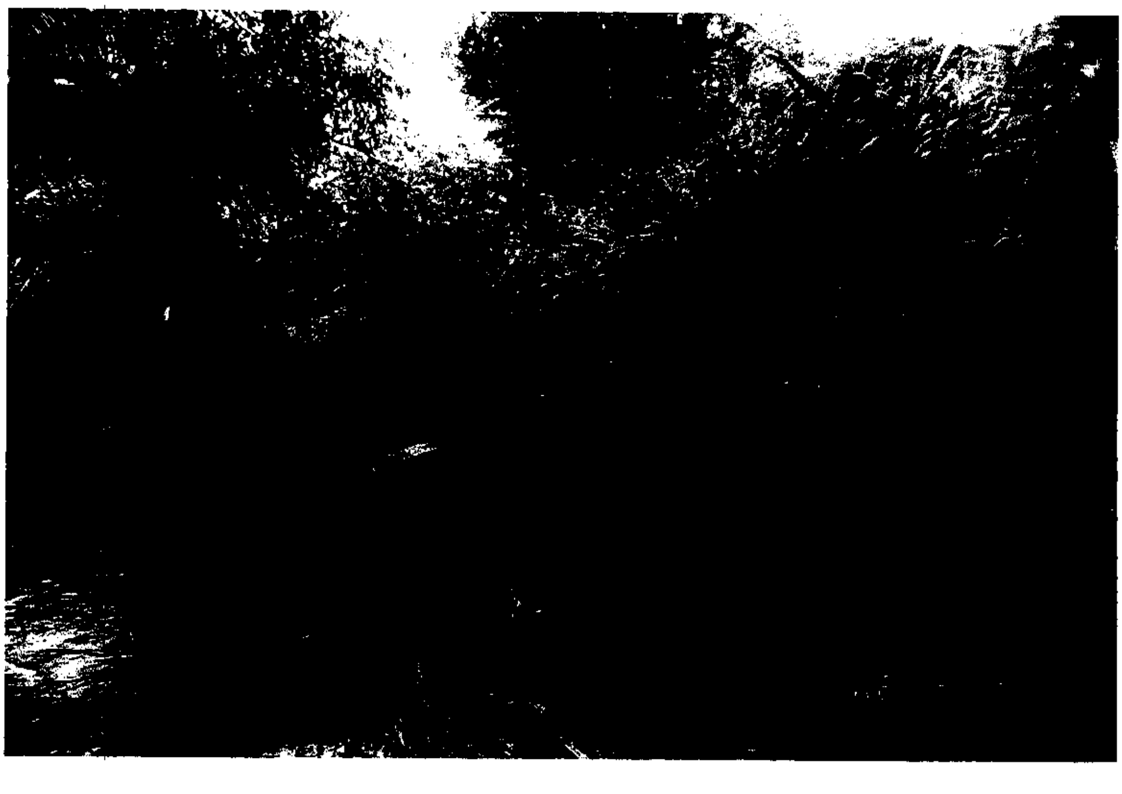

Fig.4.10 Partial inflow of Municipal sewage in to the tank

Fig.4.11 Entry of Municipal sewage flow into Noyyal river

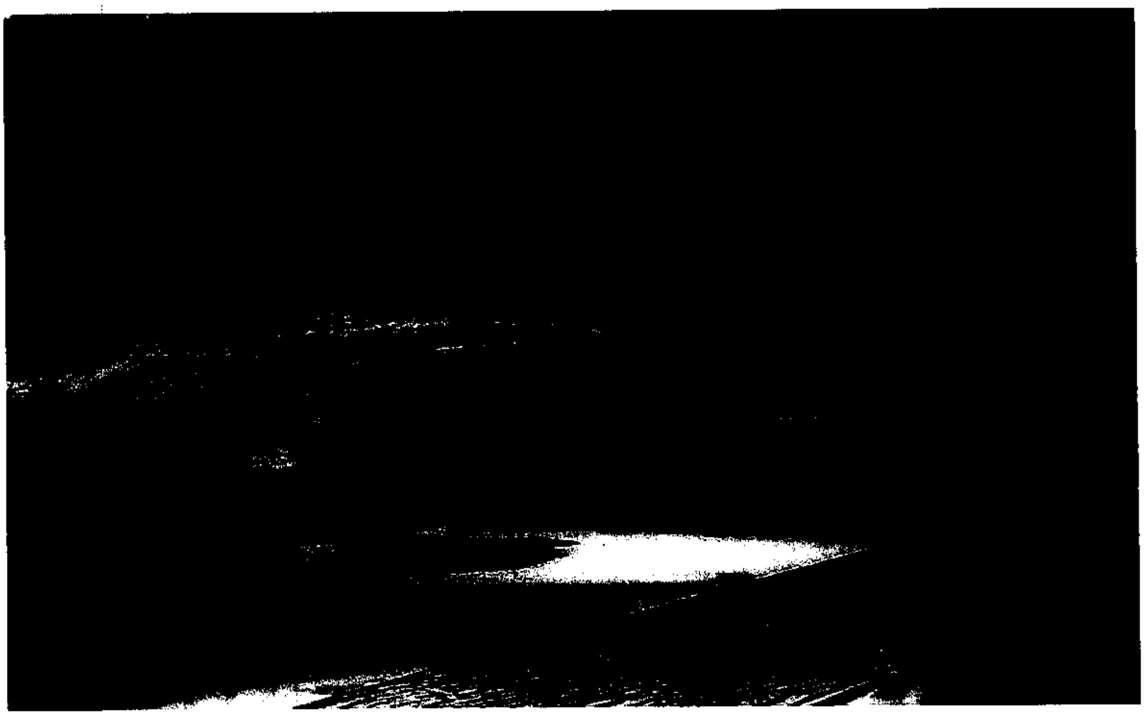

Fig.4.12 Municipal sewage flow in Noyyal River

Fig.4.13 Municipal sewage entering into the Noyyal River

Fig.4.14 Municipal sewage flow in Noyyal River

V. METHODOLOGY

V.1 General

Groundwater samples collected from the command area were analyzed for chemical constituents. Since the level of ground water contamination depends on the physical characteristics of the area, the chemical nature of the pollutant. Attribute value files of chemical constituents of groundwater and the spatial data layers were constructed and pollution properties were investigated to establish out spatial relationships between the groundwater constituents and pollution sources using geographic information systems (GIS). ArcGIS was used to create the GWA map using the well sampling and survey database. The ability to quickly spot anomalous points is the number one strength of the GIS software.

V.2 Materials and Methods

The main objective of the study is to characterize the ground water quality and study its spatial distribution in the command area of Singanallur tank. This was done in two phases.

1. The sampling and analysis phase.
2. Water quality assessment in the study area using GIS

V.3 Laboratory Sample Analysis

The laboratory sample analyses was carried out to find out the physical chemical characteristic of the sample water collected and to check whether the quality characteristics match the quality standard.

V.3.1 Physical characteristics

Physical analysis of water is carried out in order to determine the physical characteristics of water. This includes test for determining turbidity, electrical conductivity etc.

Turbidity: If large amounts of suspended matter such as clay, silt or some other finely divided organic materials are present in water, it will appear to be turbid in appearance. The turbidity depends upon the fineness and concentration of particles present in water. Although, the suspended particles may not be harmful to health, yet they are to be removed for aesthetic and psychological reasons. The turbidity of water can be measured using turbidimeters. The turbidimeters works on the principle of measuring the interference caused by the water sample to passage the light rays.

Electrical conductivity: The Electrical conductivity's the measure of a substance of solution to carry an electric current. The electrical conductivity indicates the concentration of dissolved electrolytes present in water sample. And it is very useful to measure dissolved salts in water sample. The electrical conductivity value depends on the concentrations and degree of dissociation of the ions as well as the temperature and migration velocity of the ion in the electric field. Electrical conductivity is measured using TDS meter.

V.3.2 Chemical Characteristics

Chemical analysis of water is carried out in order to determine the Chemical characteristics of water. This involves test for determining pH value, hardness, chloride content, sodium, potassium, total dissolved solids, BOD and COD etc.

pH value of water: The pH value of water indicates the logarithm of hydrogen ion concentration present in water. It is thus indicator of the acidity or alkalinity of water. A $_P$H meter using a glass electrode was used for measuring $_P$H value. The basic principle in $_P$H meter is that the potential difference developed between two electrodes is directly proportional to the concentration of hydrogen ion present in the sample. Testing the pH value will directly tell us whether the water is acidic or is alkaline.

Hardness of water: Hardness in water is that characteristic which prevents the formation of sufficient leather or foam. It is usually caused by the presence of calcium and magnesium salts present in water. Hardness is defined as the calcium carbonate equivalent of calcium and magnesium ions present in the water and is expressed in mg/lit. This was determined by means of titration with versanate solution (i.e. EDTA method).

Chloride content: Chlorides are generally present in water in the form of sodium chloride and may due to entry of sewage and waste water from industries. The chloride content of the water can be measured by titrating the water with standard silver nitrate solution using potassium chromate as indicator.

Sodium and Potassium: Sodium and potassium is an important factor as for as water is used for irrigation. When this water is used for irrigation it affects the soil chemistry and even the fertility of land. Sodium and potassium are determined in the laboratory using flame photometer.

Total Suspended Solids: Total Suspended Solids is an important factor to be determined since it is aesthetically displeasing and provides adsorption sites for chemical and biological agents. It is used to measure the quality of the wastewater influent and effluent and extremely valuable in the analysis of polluted waters. The TSS was determined using spectrophotometer instrument.

BOD: BOD is Biochemical Oxygen Demand and is the measure of amount of oxygen required for the biological decomposition of waste organic matter. The values of BOD indicate the organic matter present and indicate the extent of treatment required for purifying.BOD is measured by means of measuring difference between initial DO and final DO level after incubating it for 5 days at 20 degree Celsius.

COD: COD is chemical oxygen demand and is the amount of oxygen required for chemical oxidation of organic matter in a water sample using strong chemical oxidizing agents such as potassium dichromate, potassium permagnate,etc.the cod is more useful in estimating strength of industrial wastes which are contained toxic chemicals. Cod was determined in the laboratory by means of using spectro photometer.

Table A1 of the appendix shows the environmental significance of each of the parameter measured during physicochemical Parameter analysis.

V.4 Developing a Database

After the field study was done, a GIS database was created using the data obtained. The use of GIS in creating a database is more reliable since it involves easy updating of information. The GIS helps in the creation of database of the existing situation, which can be used as a reference point in the future studies. The softwares used for the purpose of developing database in this study are

- Arc view GIS 3.2a
- MapInfo professional 8.0
- 3D Analyst 1.0
- Spatial Analyst 2.0

The input needed for the purpose of analysis are paper maps from PWD, GPS observations and various attribute data of spatial and non-spatial in nature.

V.4.1 Digitizing

After scanning the paper map, the file produced by the scanning equipment is not compatible with the GIS, so reformatting is done. Reformatting is the process of digitizing which help to convert the map into digital form before they can be input into Gis. The software module used for this purpose is MapInfo professional 8.0.using MapInfo Professional's Auto tracing feature the boundary of the tank was traced by using snap to node feature. The Snap feature is turned on; the mouse pointer is "pulled" to the nodes of other selectable objects. As the cursor gets close to a node, a cross hair appears, this indicates that the cursor has snapped to that node.

V.4.2 Buffering

Buffering is a powerful proximity analysis tool used to create a zone of interest in the study area. Using MapInfo Professional a buffer was created around the tank to find the zone of concentrations of the pollutants. The buffer zone is also used for querying in the later stage by means of using boundary select tool to select zone within the buffer range.

After the digitizing and buffering in MapInfo Professional, the file was saved as a shape file, GIS compatible form.

VI. RESULTS AND DISCUSSION

The main objective of this work has been to assess the effect of quality of water in the Singanallur tank on the quality of groundwater in the command area of the tank and to develop a database using GIS. The water quality has been analyzed in order to get a general idea of the situation in command area of Singanallur tank. The results obtained from the analyses were tabulated and specified in Appendix 1.

The results of the physical character analyses were obtained and using GIS, data layers were created for different constituents. Each of the data in data layers were separated into different quantity range based on the results and different colour scheme were given for easy identification. This ability to quickly spot anomalous points is the strength of the GIS software. And these data layers can be maintained for years and used as a reference for the future.

Using those data layers created with the GIS software, maps showing the existing situation in the tank and its command area were prepared which can be used as a reference point in the future. A graduated color scheme was used in which low values are displayed in light color, and as the range increases color of the points become darker.

From the results, it was found out that the concentration of different variables was more in some regions, which could be attributed to the entry of domestic and industrial effluents from the area around the tank. It is well known that the entry of domestic sewage into the tank aids in the growth of water hyacinth in the tank. Due to the growth of water hyacinth, the tank surface gets fully covered, which reduces the amount of light and oxygen that the water receives from the atmosphere. This leads to a change in water chemistry, in addition to affecting flora and fauna and causing significant increase in water loss due to evapotranspiration.

Apart from the results obtained from the laboratory tests, it was visually determined that the water in the open wells in the command area of the Singanallur tank had an abnormal color and odor. That definitely corroborated the statements given by the farmers that well water, which was earlier used for drinking, had become undrinkable lately and that the crop yields had declined appreciably.

It is to be emphasized that if the same trend of polluting the water in the Singanallur tank is continued in the coming days too, the whole command area of the tank will become uncultivable.

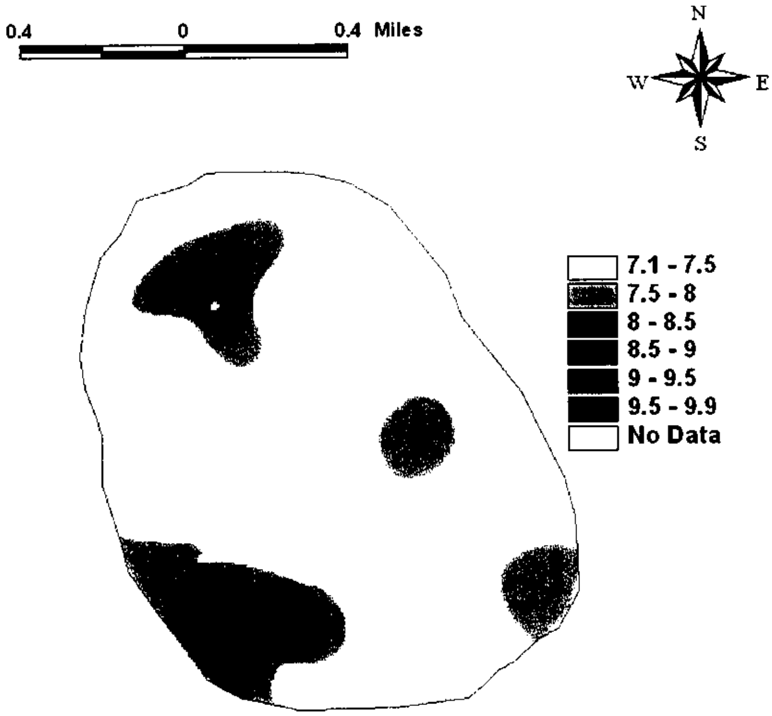

Fig.6.1 pH concentration in the study area (Sample.1)

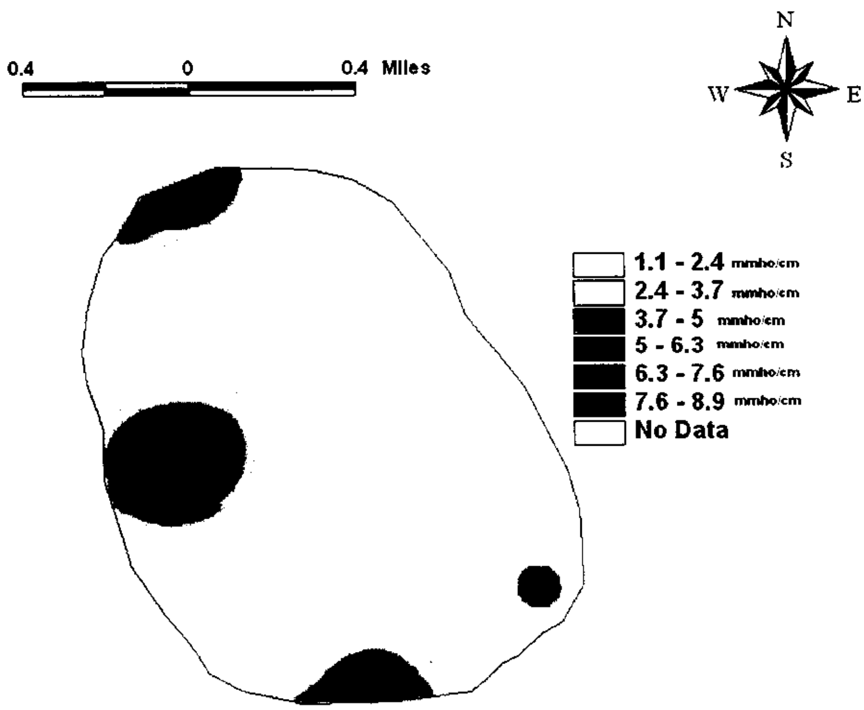

Fig.6.2 EC concentration in the study area (Sample.1)

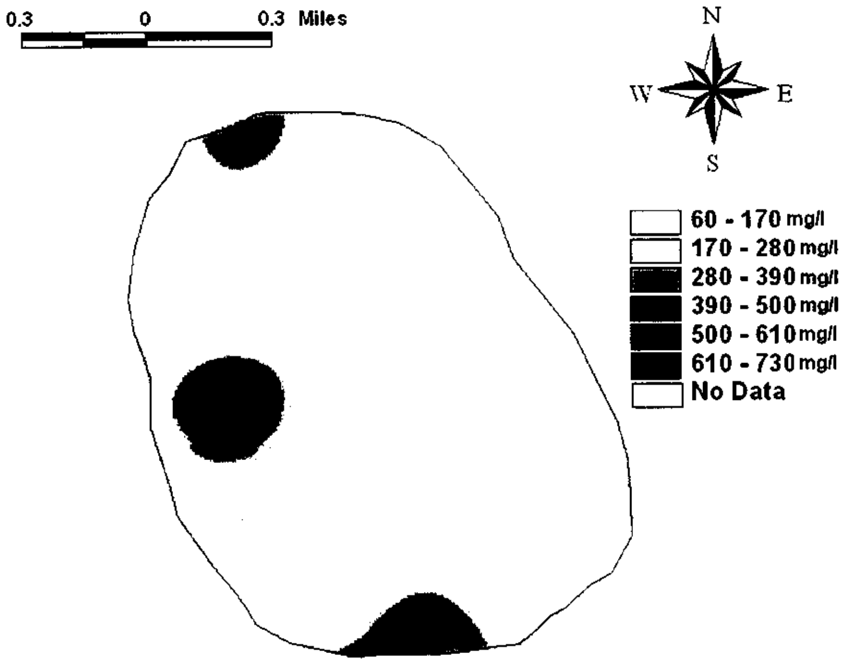

Fig.6.3 Chloride concentration in the study area (Sample.1)

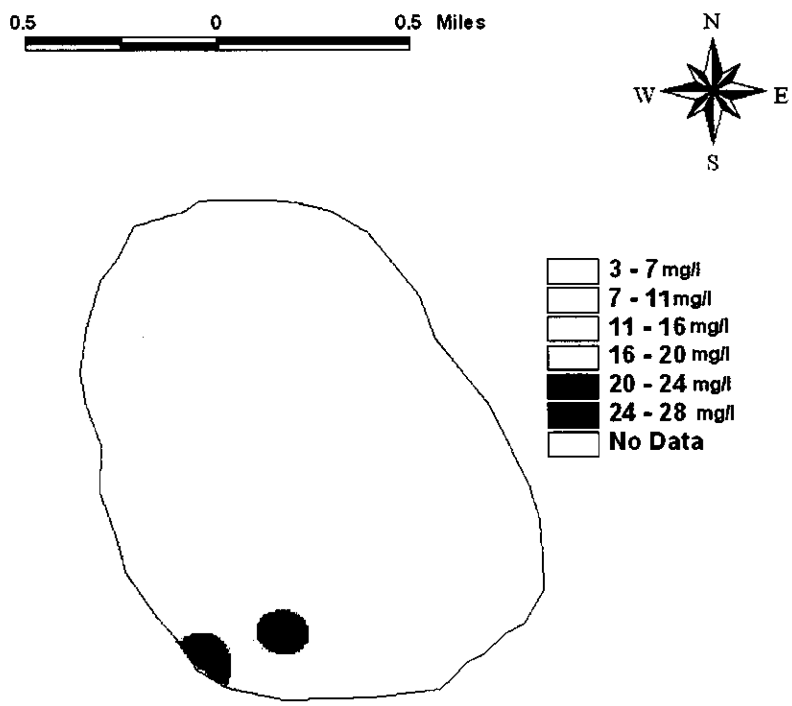

Fig.6.4 Total Hardness concentration in the study area (Sample.1)

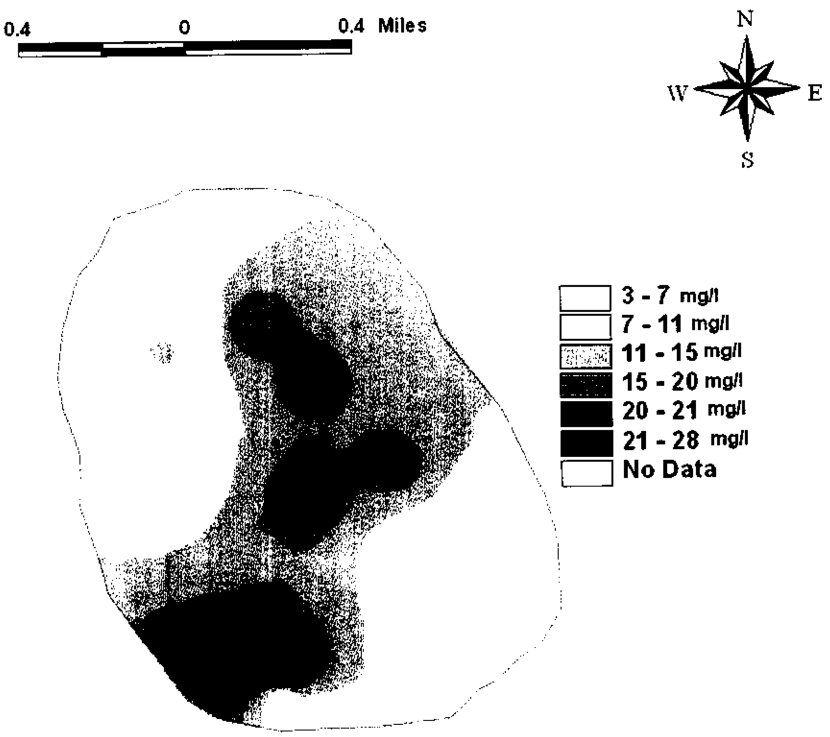

Fig.6.5 Suspended Solids concentration in the study (Sample.1)

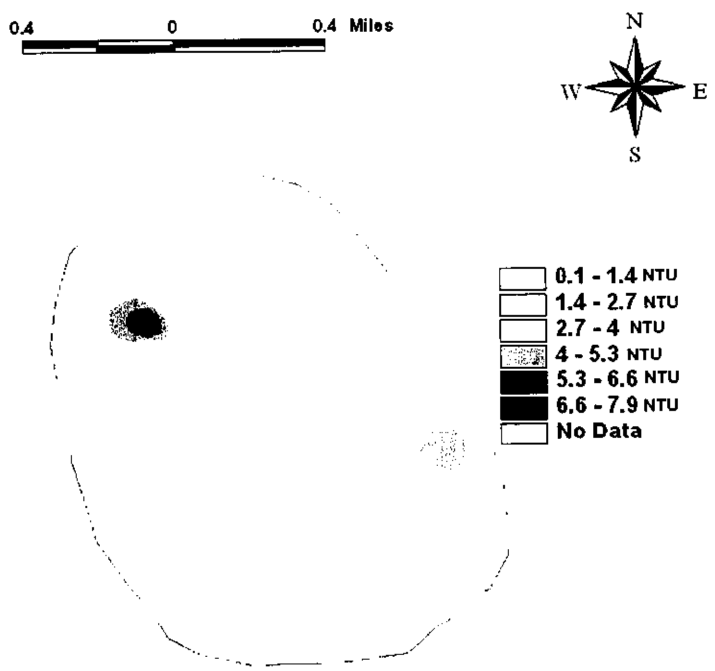

Fig.6.6 Turbidity concentration in the study area (Sample.1)

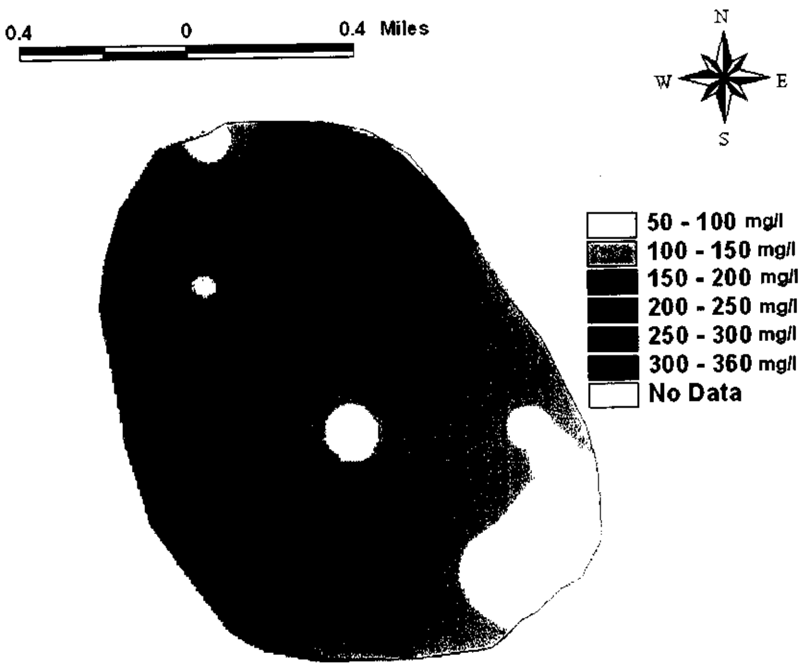

Fig.6.7 BOD concentration in the study area (Sample.1)

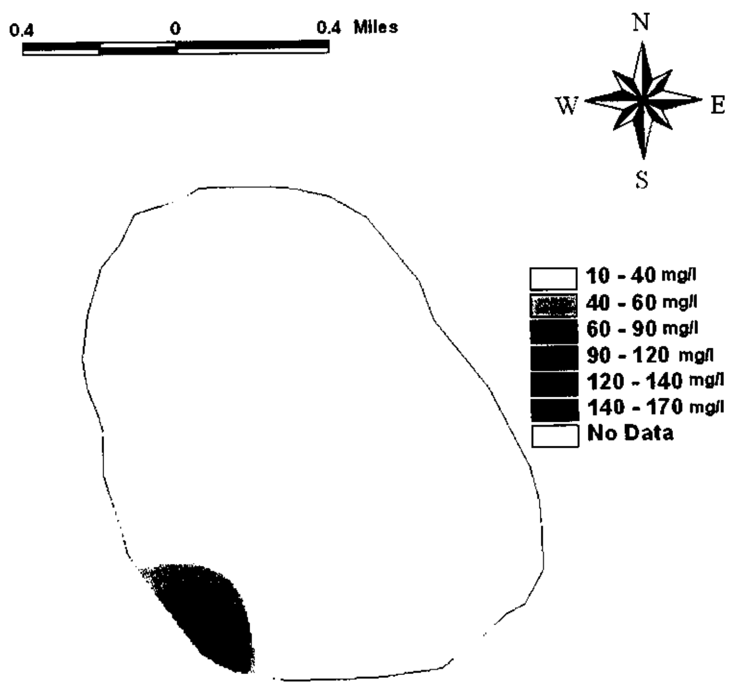

Fig.6.8 COD concentration in the study area (Sample.1)

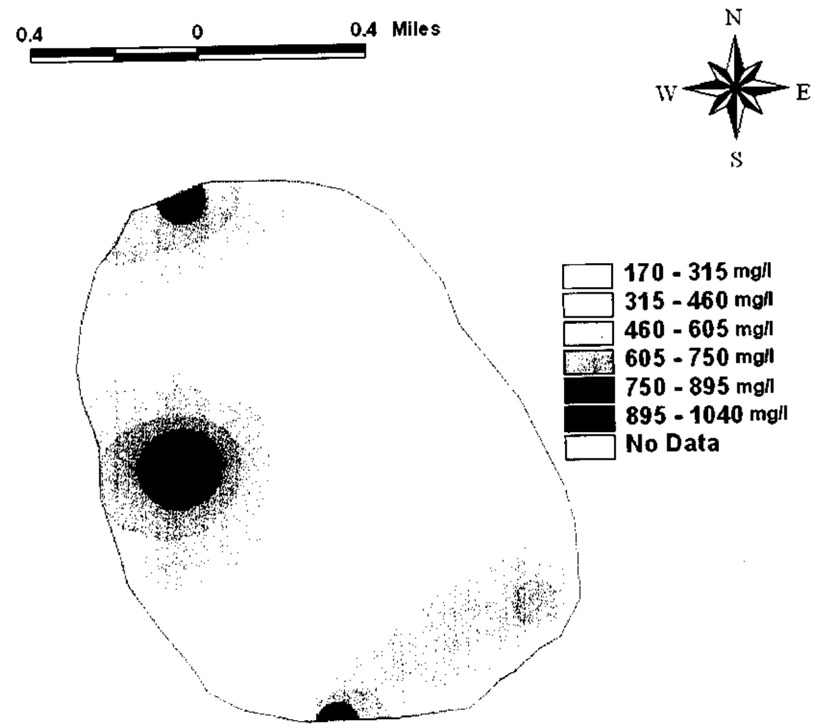

Fig.6.9 Sodium concentration in the study area (Sample.1)

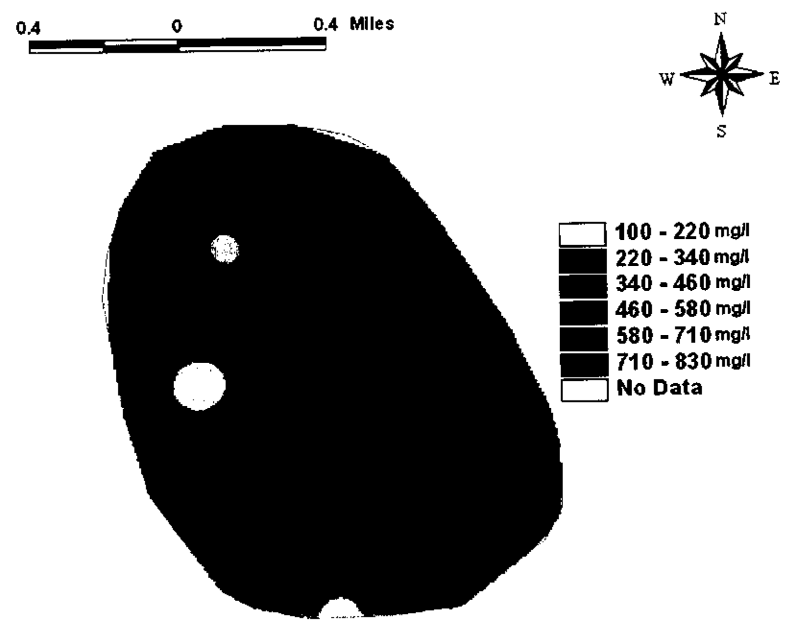

Fig.6.10 Potassium concentration in the study area (Sample.1)

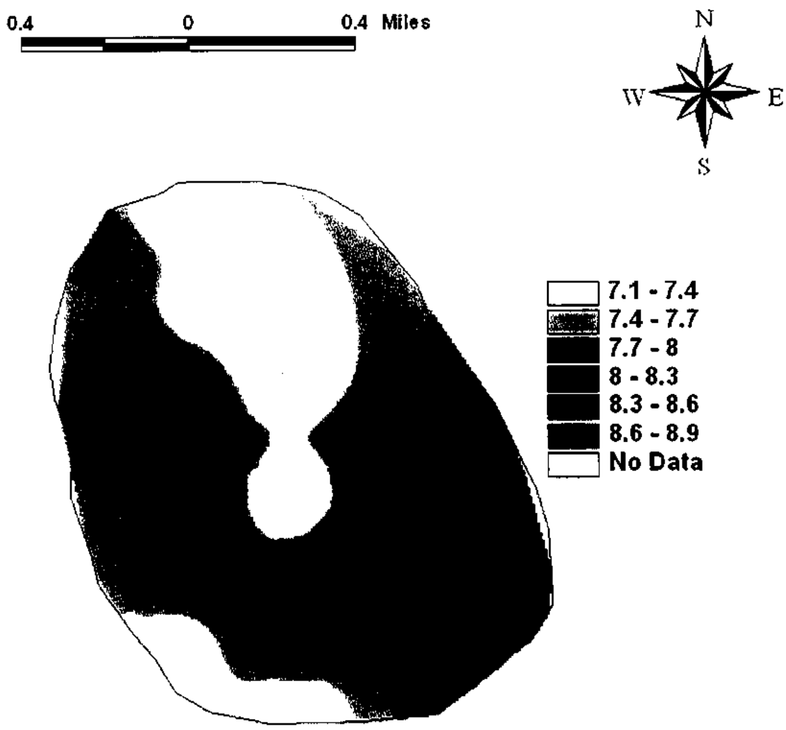

Fig.6.11 pH concentration in the study area (Sample.2)

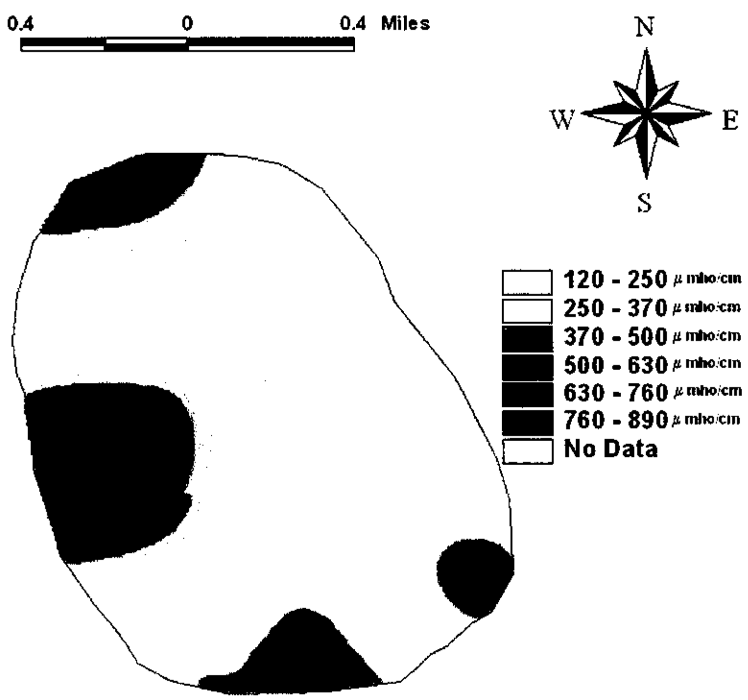

Fig.6.12 Ec concentration in the study area (Sample.2)

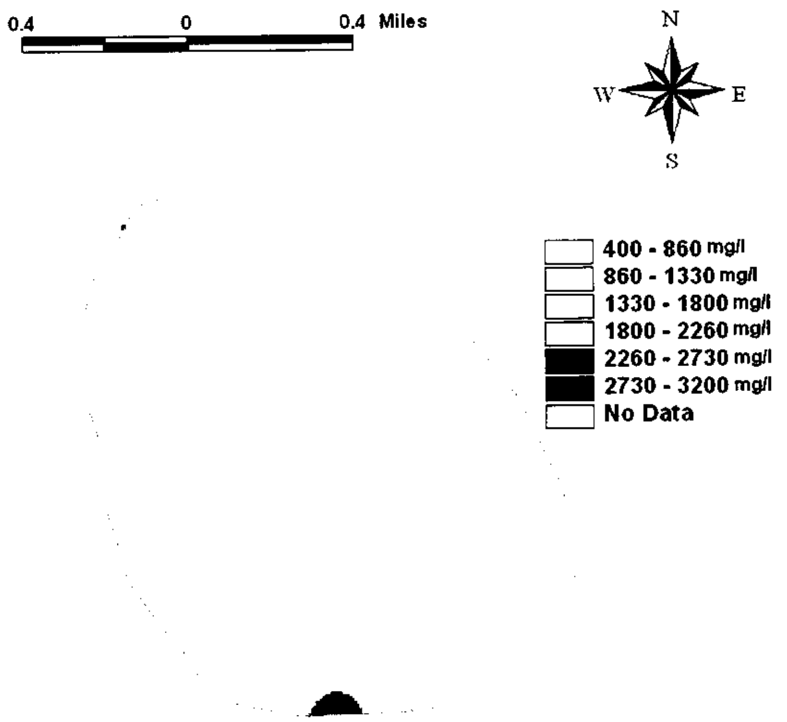

Fig.6.13 Chloride concentration in the study area (Sample.2)

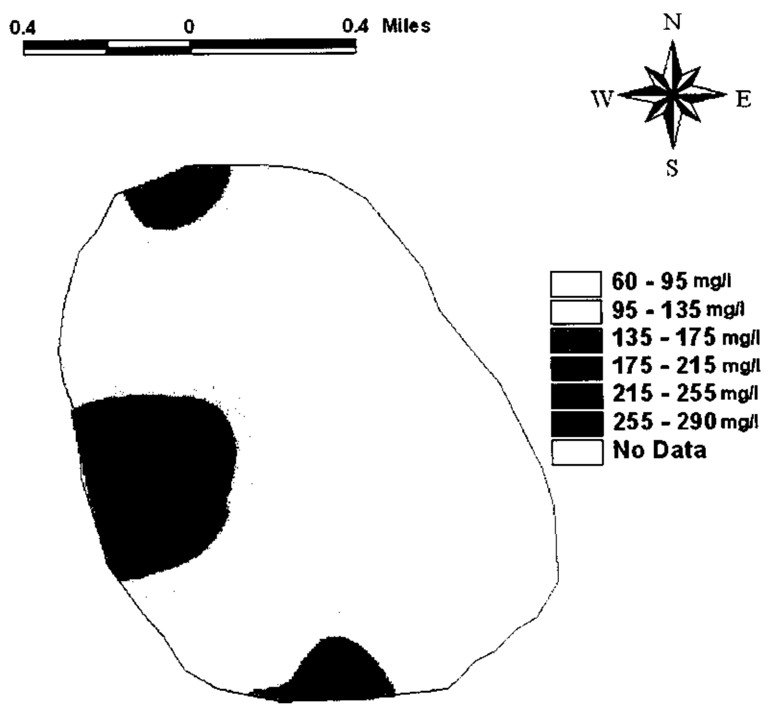

Fig.6.14 Total Hardness concentration in the study area (Sample.2)

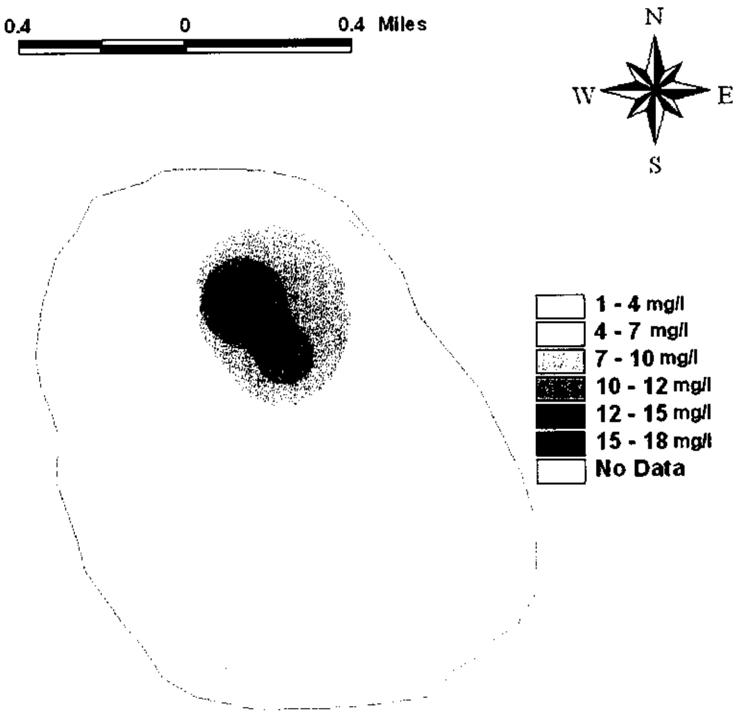

Fig.6.15 Suspended solids concentration in the study area (Sample.2)

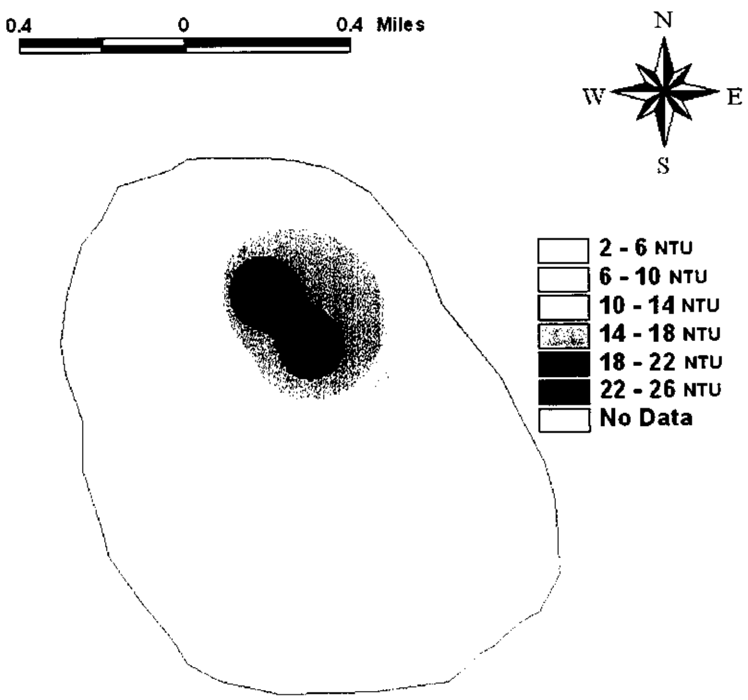

Fig.6.16 Turbidity concentration in the study area(Sample.2)

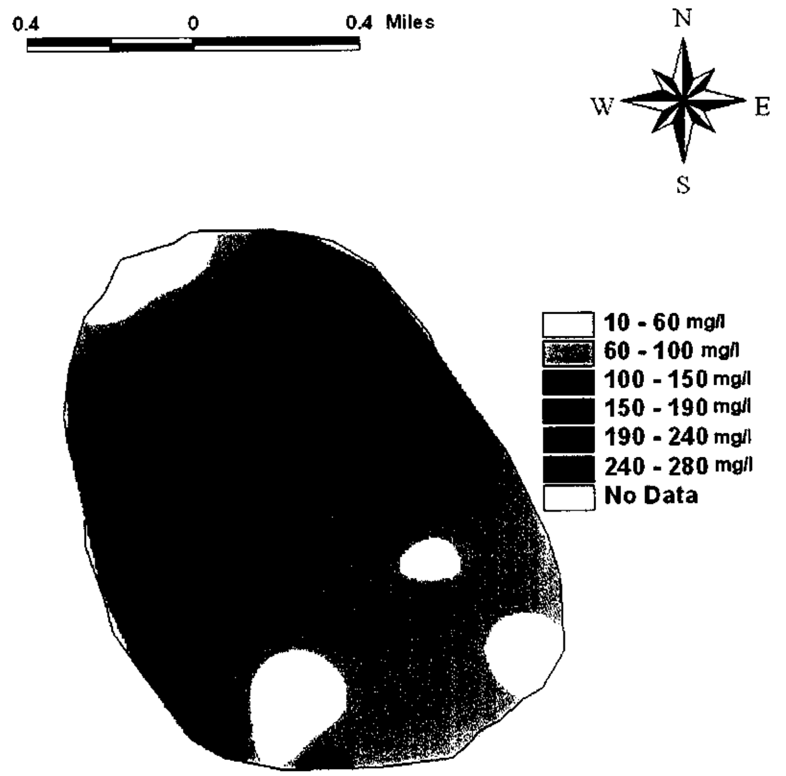

Fig.6.17 BOD concentration in the study area (Sample.2)

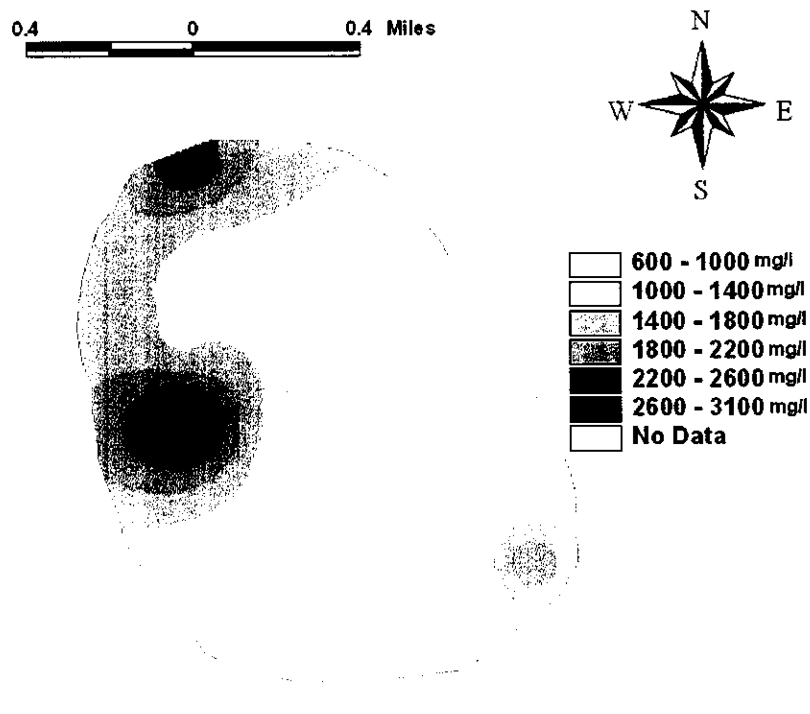

Fig.6.18 Sodium concentration in the study area (Sample.2)

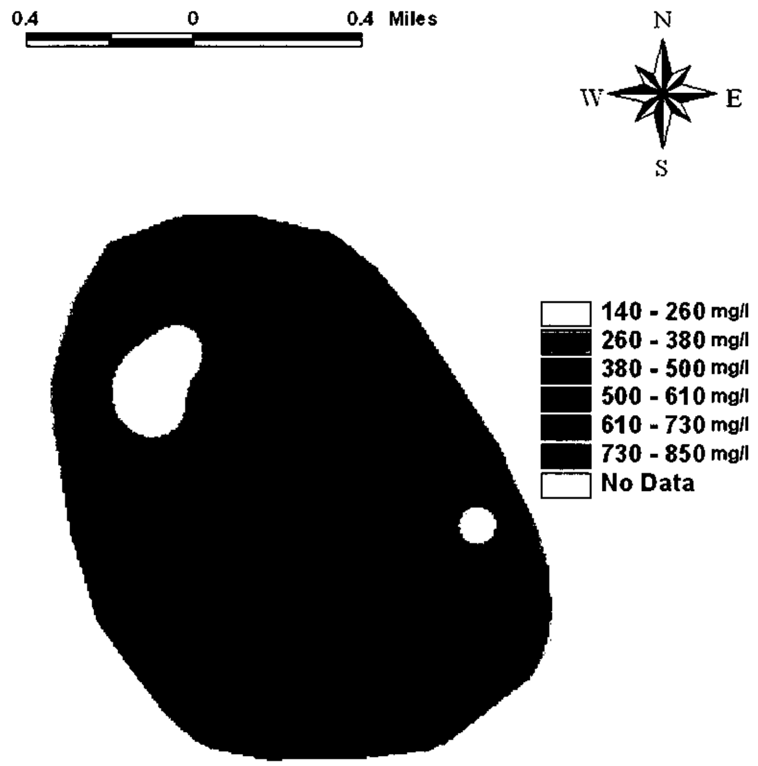

Fig.6.19 Potassium concentration in the study area (Sample.2)

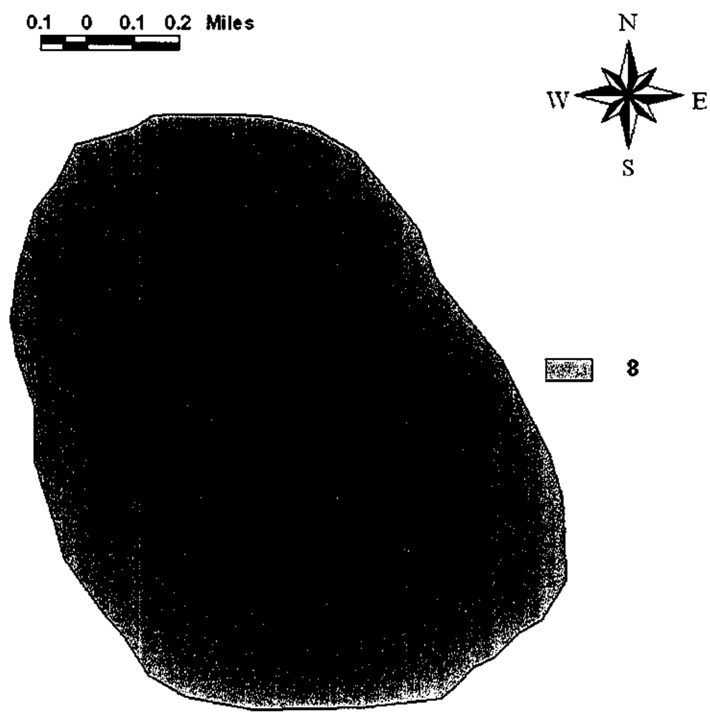

Fig.6.20 pH concentration in the study area (Sample.3)

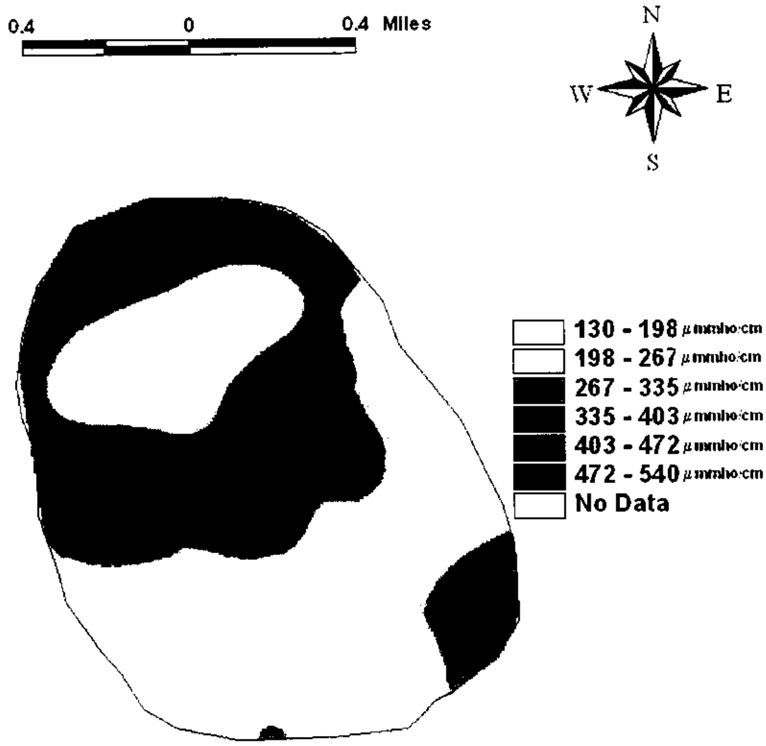

Fig.6.21 EC concentration in the study area (Sample.3)

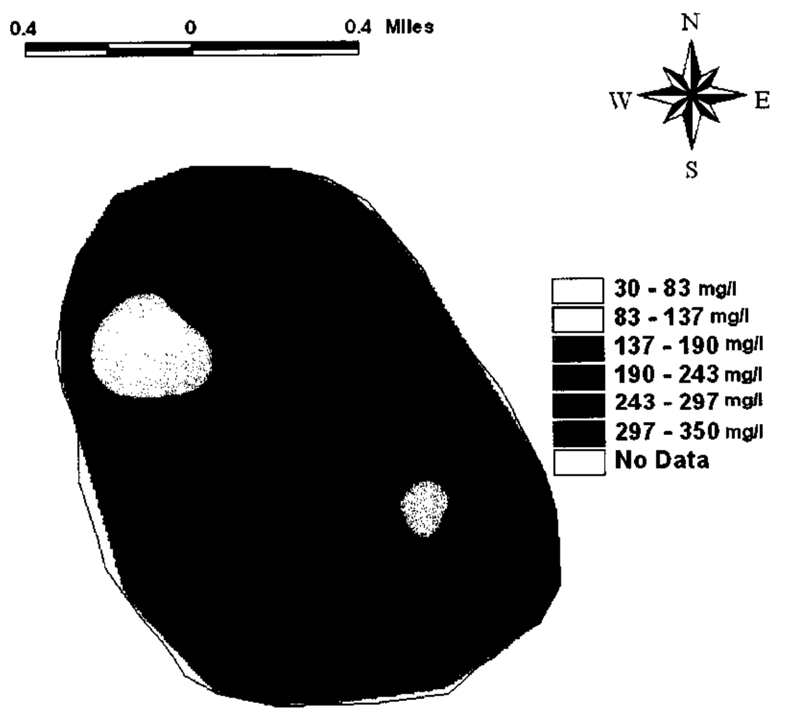

Fig.6.22 Chloride concentration in the study area (Sample.3)

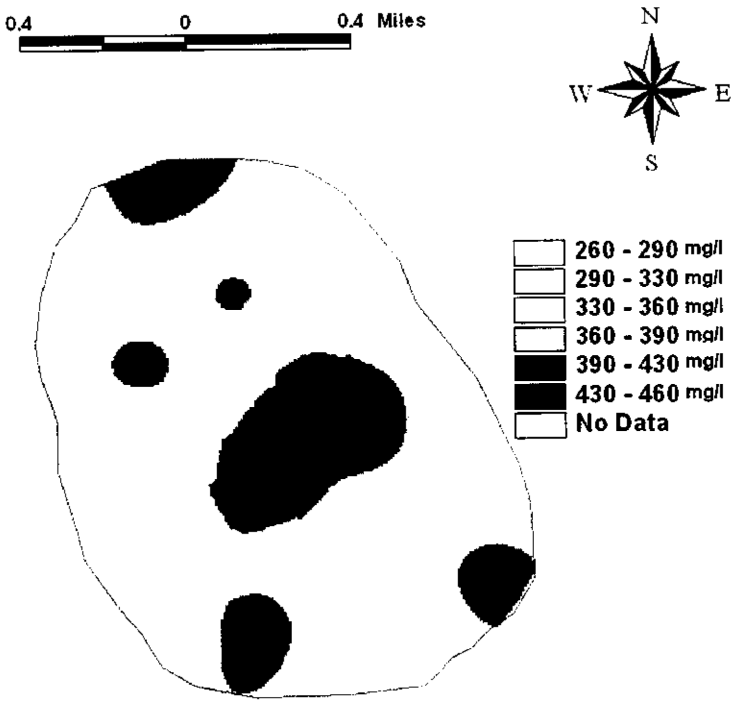

Fig.6.23 Total hardness concentration in the study area (Sample.3)

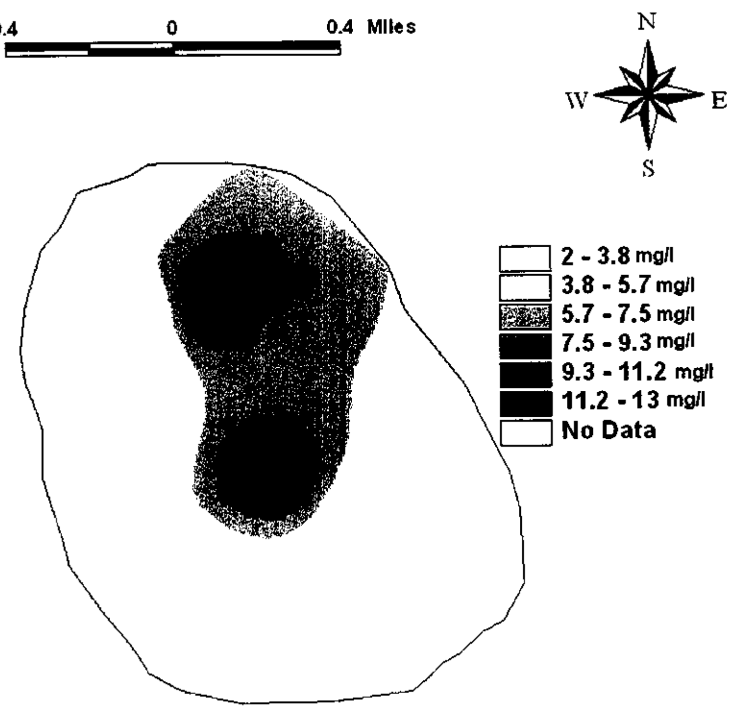

Fig.6.24 Suspended solids concentration in the study area (Sample.3)

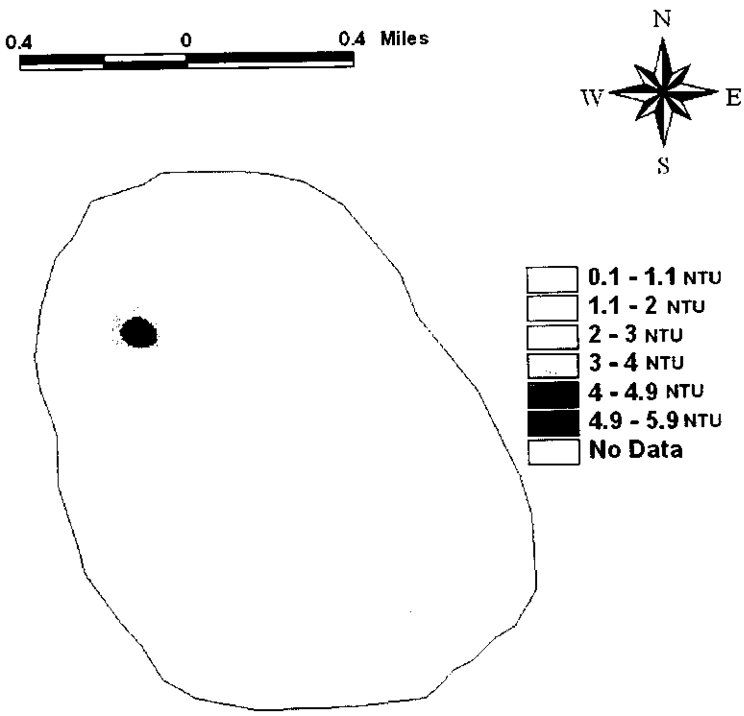

Fig.6.25 Turbidity concentration in the study area (Sample.3)

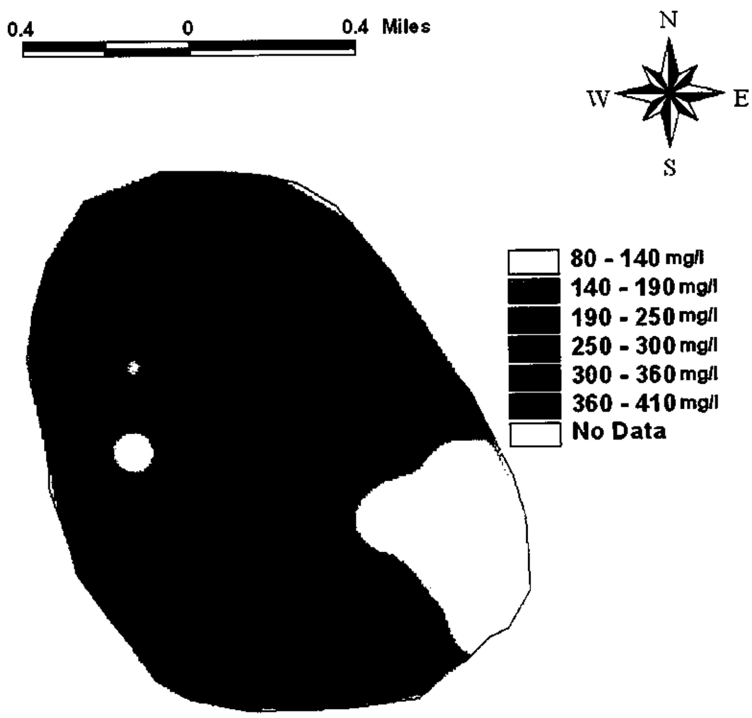

Fig.6.26 BOD concentration in the study area (Sample.3)

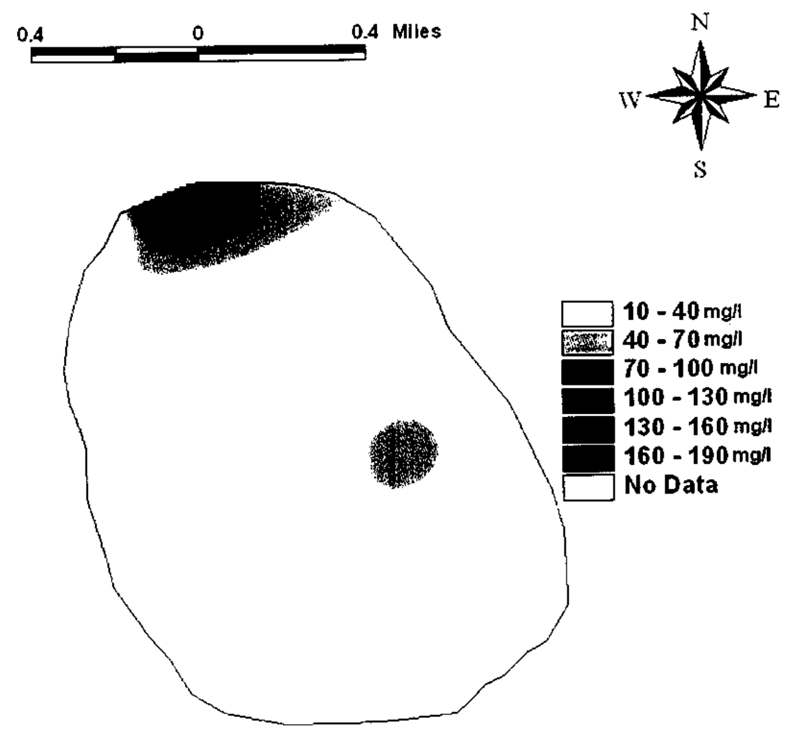

Fig.6.27 COD concentration in the study area (Sample.3)

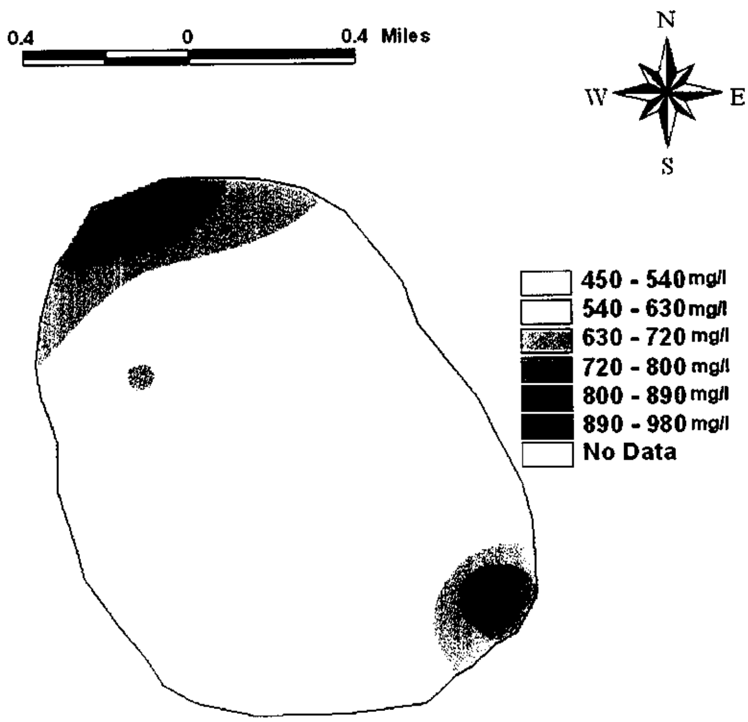

Fig.6.28 Sodium concentration in the study area (Sample.3)

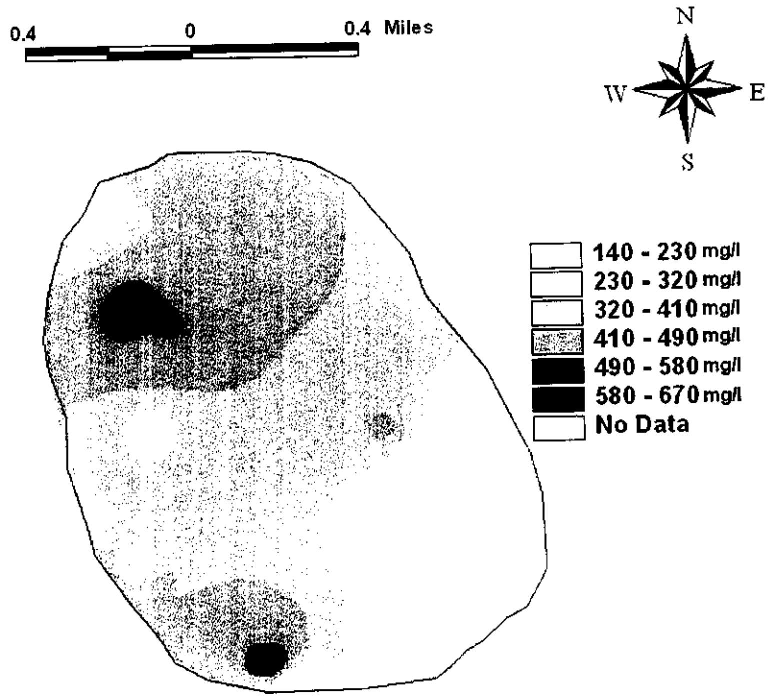

Fig.6.29 Potassium concentration in the study area (Sample.3)

VII. CONCLUSIONS AND RECOMMENDATIONS

The parameters generally used to determine groundwater quality, such as pH, Electrical Conductivity, BOD, COD, Total Suspended Solids, Sodium, Potassium and Hardness, were calculated for the samples collected from the study area. A GIS database was also developed using the above parameters. It could be concluded, from the results shown earlier, that the quality of groundwater in the command area of Singanallur tank was below the recommended standards, due to the ingress of sewage water into the tank. Due to want of earlier data, the rate at which the groundwater is getting contaminated could not be determined. However, the results from this study could be used as a reference for future studies in order to determine the growth.

In the given time, only a limited number of samples were collected and analyzed. It would be better if more number of samples, representing a larger area, were studied. Moreover, a larger-scale or at least a similar study should be carried over in the coming days so as to find out the impact of the quality of water in the Singanallur tank on the quality of groundwater in the surrounding areas. It is also recommended that a soil study be carried out to determine the effect of water quality on the soil in the command area. Similarly, the quality of the crop yields from the command area need to be analyzed to determine whether or not the quality of well water used for irrigation has any effect on the nutritional characteristics of the crop.

VIII. REFERENCES

1. APHA, standard methods for the examination of water and wastewater, 18th ed., Washington, DC (1992).
2. Drusilla, R, et al (1997) "Assessment of minerals in river Chittar in and around Tenkasi, Tirunelveli District (Tamil Nadu)" Pollution Reasearch 25 (2): 307-316(2006).
3. Gopinath B. (2004), "Application of GIS for groundwater studies in Tiruppur Taluk," M.E. thesis submitted at Department of Environmental Engineering, Government College of Technology, and Coimbatore.
4. http://mbmggwic.mtech.edu (Ground-Water Quality Assessment and Monitoring Plan for the North Flathead Valley and Flathead Lake Perimeter done by Katie McDonald, John LaFave (2000–2003))
5. http://thehindu@vsnl.com (dated Saturday, Oct 15, 2005)
6. http://www.fao.org/docrep/003/to234e/to234e006.htm
7. http://www.in.gov/ dem/water/index.html.
8. Leppig, B. (2006), "GIS based groundwater surface modeling in hard rock regions as basis of vulnerability mapping in Northrhine-Westfalia, Germany," to be presented in Integrated Water Resources Management and Challenges of the Sustainable Development, Morocco, May 23 – 25, 2006.
9. Mohammed Ismail S., Pattabi S. (2000), "Mapping of spatial variability of groundwater in Erode district using GIS," Proceedings of National Conference on Geoinformatics held on November 11 – 12, 2000 at P.S.G. College of Technology, Coimbatore.
10. Magudeswaran.P.N et al(2002) "Water Quality Index of Orathupalayam dam water (India)," Pollution Reasearch25(2):303-307(2006).
11. Needhidasan, Anji Reddy.M, And Thayumanavan.S (2005) "Physico-Chemical Characteristics of Surface Water in the Sathyamoorthy Reservoir Study Area, Tiruvallur Taluk," Tamil Nadu Water and Wastewater Management, August 2006, P 94-96.
12. Raja Mohan S. (2000), "GIS application in groundwater quality assessment in Madurai Corporation," Proceedings of National Conference

on Geoinformatics held on November 11 – 12, 2000 at P.S.G. College of Technology, Coimbatore.

13. Shamanian, Gh. H. (2006), "Assessment of groundwater pollution vulnerability in North of Iran: A GIS approach," Integrated Water Resources Management and Challenges of the Sustainable Development, Morocco, May 23 – 25, 2006.
14. Senthilnathan.Sa "Micro level environmental status report of river Noyyal basin", Environmental Cell Division, PWD, Coimbatore.
15. Tamil Nadu Pollution Control Board –a hand book of ready reference
16. Victoria Ljungberg, Saran Qvist (2004)," Assessment of Groundwater Flow and Pollutant Transportation Through Modeling - A Pilot Study in the Sulur Watershed, Coimbatore District," Master of Science Thesis, Stockholm, Sweden 2004.

APPENDIX -I

Table -1 Results of analysis of Sampl-1

Sample	Latitude Deg N	Longitude Deg E	pH	Chloride mg/l	TH mg/l	Turbidity NTU	EC mmho/cm	TSS mg/l	Sodium mg/l	Potassium mg/l	BOD mg/l	COD mg/l
N1	11.001	77.016	7.15	195.03	890	3	3.5	8	670	360	369.25	0.22
N2	11.002	77.018	6.85	401.88	1210	0	4.91	2	830	840	56.2	10.56
S1	10.985	77.022	6.98	156.02	665	3	2.25	7	397	310	109.4	3.15
S2	10.985	77.022	7.28	250.67	1060	1	3.43	0	530	100	154	9.44
S3	10.984	77.023	6.74	739.93	10	0	8.54	3	920	105	150.2	12.14
W4	10.993	77.018	7.09	483.44	1900	0	7.2	2	1050	90	127.8	2.25
W5	10.996	77.018	6.98	107.56	456.67	2	2.02	3	490	700	149	2.7
W6	10.997	77.018	6.84	53.19	406.67	8	1.073	13	160	360	71.4	6.97
W7	10.998	77.019	9.92	57.92	226.67	0	1.284	3	360	100	278.65	2.7
E1	10.991	77.027	7.36	271.86	400	3	2.01	11	330	360	107.68	3.82
E2	10.992	77.029	6.99	144.2	698.33	5	2.08	9	340	530	94.42	3.6
E3	10.990	77.027	6.9	208.03	606.67	0	2.06	2	397	310	124.6	0.9
E4	10.987	77.028	7.21	215.12	900	1	3.39	4	594	600	77.235	1.12
E5	10.988	77.030	7.52	251.77	966.67	4	3.76	3	652	410	47.005	17.76
T1	10.998	77.021	6.97	141.84	631.67	1	1.818	20	300	710	369.25	11.24
T2	10.996	77.023	6.97	102.83	713.33	3	2	17	360	810	112.5	11.91
T3	10.993	77.026	7.73	119.38	618.33	1	1.851	18	320	760	157.3	0.45
T4	10.992	77.023	6.85	98.11	625	2	2.16	19	340	740	80.27	10.56
T5	10.992	77.023	7.91	91.01	351.67	1	1.161	32	165	530	229.4	1.8
T6	10.986	77.022	7.63	107.56	361.67	4	1.399	29	223	700	272	7.19
T7	10.985	77.019	8.68	63.83	355	3	1.238	24	223	700	317.15	171.73

TH Total Hardness
EC Electrical Conductivity
TSS Total Suspended Solids
BOD Biochemical Oxygen Demand
COD Chemical Oxygen Demand

Table -2 Results of analysis of Sampl-2

Sample	Latitude Deg N	Longitude Deg E	pH	Chloride mg/l	TH mg/l	Turbidity NTU	EC μmho/cm	TSS mho	Sodium mg/l	Potassium mg/l	BOD mg/l
N1	11.001	77.016	7.72	117.018	825	4	389	1	1799.3	304.7	0
N2	11.002	77.018	7.15	195.03	1130	2	555	0	2597.6	705.9	0
S1	10.985	77.022	7.3	106.38	762.5	1	315	0	1001.1	342.3	0
S2	10.985	77.022	7.28	148.932	1017.5	4	346	2	1001.1	894	0
S3	10.984	77.023	7.34	288.99	3300	8	897	0	13401.61	790	146
W4	10.993	77.018	7.56	294.318	1610	3	765	0	3160.76	436.3	131.4
W5	10.996	77.018	8.12	83.331	500	4	257	0	1340.37	185.6	154.3
W6	10.997	77.018	7.69	53.19	365	9	114.7	2	1210.37	198.1	71.5
W7	10.998	77.019	7.28	51.417	392.5	4	204	0	1001.1	135.4	268.1
E1	10.991	77.027	7.87	76.239	662.5	5	230	0	659.1	323.48	0
E2	10.992	77.029	8.68	83.331	707.5	8	261	1	887.1	223.2	90.8
E3	10.990	77.027	7.96	62.055	557.5	5	307	0	773.09	304.7	126
E4	10.987	77.028	7.66	62.055	792.5	4	257	2	1221	599.3	76.5
E5	10.988	77.030	8.5	78.012	1002.5	5	442	2	2027.3	361.11	48.05
T1	10.998	77.021	7.49	101.061	812.5	27	296	19	1229.1	749.8	289.5
T2	10.996	77.023	7.18	102.834	835	22	302	12	1001.1	856.4	115.1
T3	10.993	77.026	8.45	51.417	600	13	200	2	545.5	630.6	172.5
T4	10.992	77.023	7.2	79.785	845	8	293	3	887.11	580.5	81.22
T5	10.992	77.023	7.62	76.239	582.5	10	214	3	659.1	637	0
T6	10.986	77.022	7.76	104.607	555	9	227	3	659.1	643.2	0
T7	10.985	77.019	7.45	101.061	550	2	210	0	545	586.8	289

TH Total Hardness
EC Electrical Conductivity
TSS Total Suspended Solids
BOD Biochemical Oxygen Demand
COD Chemical Oxygen Demand

Table -3 Results of analysis of Sampl-3

Sample	Latitude Deg N	Longitude Deg E	pH	chloride mg/l	TH mg/l	Turbidity NTU	EC m	TSS mg/l	Sodium mg/l	Potassium mg/l	BOD mg/l	COD mg/l
N1	11.001	77.016	7.8	237.58	340.00	1	340	5	771.2	196.5	294.3	8.46
N2	11.002	77.018	7.85	355.78	468.33	0	541	3	990.41	464.4	168.7	191.89
S1	10.985	77.022	7.85	237.58	456.67	0	182	1	565	603.7	232.2	10.72
S2	10.985	77.022	7.28	678.47	541.67	0	873	1	620.55	478.7	104	38.17
S3	10.984	77.023	7.75	163.12	282.50	1	280	1	510.95	164.3	167	8.25
W4	10.993	77.018	7.56	161.93	356.67	0	309	2	634.25	282.2	129.2	7.84
W5	10.996	77.018	7.66	133.57	456.67	0	265	1	647.94	442.9	137.4	0.2
W6	10.997	77.018	8.35	27.19	273.33	6	206	3	593.15	678.7	189.2	11.34
W7	10.998	77.019	7.8	187.94	311.67	2	244	5	469.86	410.8	410.9	9.07
E1	10.991	77.027	8.04	125.29	376.67	1	213	4	442.5	282.2	79.2	13.4
E2	10.992	77.029	7.92	143.02	253.33	0	247	1	456.16	196.5	121.2	34.87
E3	10.990	77.027	7.57	134.75	270.00	0	128	2	497.3	175	146	2.47
E4	10.987	77.028	7.65	135.93	355.00	0	199	1	634.25	132.1	153.2	5.57
E5	10.988	77.030	7.92	289.59	443.33	3	449	1	867.12	250	97.8	6.8
T1	10.998	77.021	8.22	159.57	403.33	0	157	14	593.15	475	392	21.45
T2	10.996	77.023	7.78	160.75	398.33	3	312	6	620.55	410.8	175.3	11.96
T3	10.993	77.026	8.08	159.57	463.33	3	294	6	552.05	432.2	281.2	63.55
T4	10.992	77.023	7.77	189.12	441.67	1	311	13	579.45	389.3	184.2	21.45
T5	10.992	77.023	8.01	135.93	365.00	1	252	7	497.3	442.9	310.2	4.53
T6	10.986	77.022	8.29	156.02	410.00	0	225	2	483.56	453.7	369	4.94
T7	10.985	77.019	7.63	150.02	333.33	1	249	3	524.65	442.9	312.4	8.8

TH Total Hardness
EC Electrical Conductivity
TSS Total Suspended Solids
BOD Biochemical Oxygen Demand
COD Chemical Oxygen Demand