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PANORAMIC ANALYSIS ON GROUND WATER AND LANDUSE IN ACHARAPAKKAM MINI WATER SHED USING ARC GIS

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ABSTRACT

The watershed is a logical unit for the efficient management of water resources in any regions. Along with water, other natural resources, such as soil, vegetation, project planning and biota, can also be managed efficiently by adopting an integrated watershed management approach. Decreasing water availability per capita in more and more countries is the result of inefficient management over the past centuries. The 'world water crisis', however, is not inevitable. The study area is demarcated as mini watershed, namely 'Acharapakkam mini watershed' for detailed investigation by geochemical approach and the Groundwater assessment estimation. The Acharapakkam mini watershed falls in Varahanadhi major basin of Ongur river sub basin. Administratively this watershed falls in Kancheepuram district in major portion and one village falls in nearby Villupuram district. The details are furnished in the following statement. The study area includes fourteen villages. Eight villages are in Chithamur block, Cheyyur taluk and Kancheepuram district. Five villages are in Acharappakkam block, Madhurantagam taluk and Kancheepuram district. Remaining one village is in Olakkur block, Tindivanam taluk and Villupuram district. All villages are come under Varahanadhi basin and Ongur sub basin. Reconnaissance survey of the study area during January 2008 provided an opportunity for fixing tentative locations for and water samples.

The study area is comprised of barren lands, villages and agricultural fields apart from the fast developing urbanizing area, where both bore wells and open wells are being used for extracting water. Accordingly, field techniques were determined by the purpose, for which the sample was taken. Based on the above criteria, 14 sites have to be identified to fix the monitoring wells throughout the study area in grid pattern. The analytical results of major ions of 14 water samples are listed in order to know the distribution patterns of concentration for different elements and to demarcate the high concentration zones, shaded contour maps were prepared by using Arc View 3.2a, Spatial Analyst and Arc GIS 9.0 software's for Total Hardness, Alkalinity, Total Dissolved Solids and Nitrate. The results obtained are discussed one by one. Water quality study shows that majority of the area is of moderate quality and some places good quality water is available based on BIS standard. As per Piper trilinear diagram most of the samples are of mixed type and remaining

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samples are of calcium bicarbonate type. As such there is no poor quality is observed in the study area with regard to drinking water standard. Further the study shows that all the waters are suitable for agricultural purposes. As per USSL diagram the water quality falls is C2S1 and C3S1 category and suitable for agricultural purposes. In general the water available in the mini watershed can be used for both drinking and agricultural purposes.

1. INTRODUCTION

Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of lithologic formations. A unit of rock or an unconsolidated deposit is called an aquifer when it can yield a usable quantity of water. The depth at which soil pore spaces or fractures and voids in rock become fully saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs and seeps, streams and can form oases or wetlands. Groundwater is also often withdrawn for agricultural, municipal and industrial use by constructing and operating extraction wells. The porous media in which groundwater occurs are the complex geologic materials near the earth surface; hence local details of porosity and permeability are as complex as those materials. Generally, the more productive and useful aquifers are in sedimentary geologic formations, though weathered and fractured crystalline rocks yield smaller volumes of groundwater in many environments. Among the most productive groundwater environments are unconsolidated to poorly cemented alluvial materials that have accumulated as valley-filling sediments in major river valleys and geologically subsiding structural basins. Groundwater can be a long-term 'reservoir' of the natural water cycle (with residence times from days to millennia). Decreasing water availability per capita in more and more countries is the result of inability to meet the requirement. The ‘world water crisis’, the study area is demarcated as mini watershed, namely ‘Acharapakkam mini watershed’ for detailed investigation by geochemical approach and the Groundwater assessment estimation. The watershed is a logical unit for the efficient management of water resources in any regions.

1.1 Objectives of the Present Study

To collect the ground water samples in Varahanadhi basin and Ongur sub basin and to assess the ground water quality to meet the requirement of drinking and irrigation purposes.

2. STUDY AREA

2.1 Location

The Acharapakkam mini watershed falls in Varahanadhi major basin of Ongur river sub basin. Administratively this watershed falls in Kancheepuram district in major portion and one village falls in nearby Villupuram district. The details are furnished in the following statement. The study area includes fourteen villages. Eight villages are in Chithamur block, Cheyyur taluk and Kancheepuram district. Five villages are in Acharappakkam block, Madhurantagam taluk and Kancheepuram district. Remaining one village is in Olakkur block, Tindivanam taluk and Villupuram district and the locations were given in the table 1. All villages are come under Varahanadhi basin and Ongur sub basin shown in Figure 1.

2.2 Physiography

In the study area lot of tanks are seen and are connected by the local streams. In the south the Ongur river is flowing from west to east. Generally the area is sloping towards east and south east direction. General elevation of the study area ranges from 20 metre to 200 metre from mean sea level. The study area is connected with good transport network. Each village has a good settlement and seems to be a lot of lineament in the structural has been notice

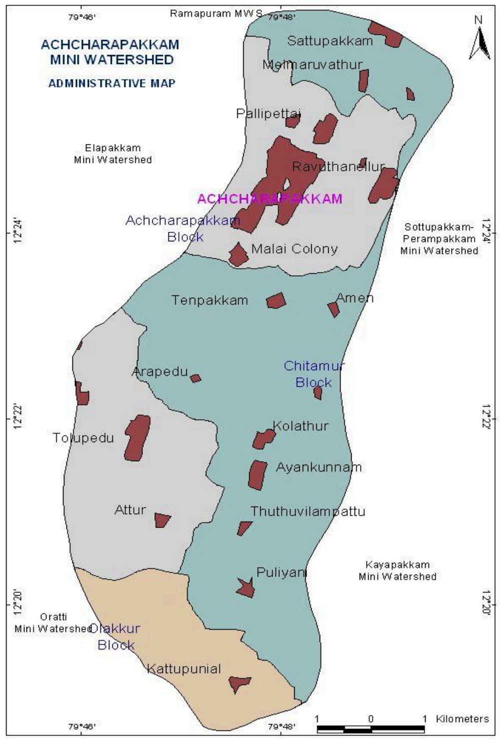

Figure 1 Administrative and hydrological setup of Acharapakkam mini watershed.

Table 1 Administrative and Hydrological Setup of the Study Area

S.No	VILLAGE	BLOCK	TALUK	DISTRICT	BASIN	SUB BASIN
1	Sothupakkam	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
2	Melmaruvathur	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
3	Thenpakkam	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
4	Arapedu	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
5	Kolathur	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
6	Ayankunnam	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
7	Thuthuvilambattu	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
8	Puliyani	Chithamur	Cheyyur	Kancheepuram	Varahanadhi	Ongur
9	Tholupedu	Acharapakkam	Madurantagam	Kancheepuram	Varahanadhi	Ongur
10	Athur	Acharapakkam	Madurantagam	Kancheepuram	Varahanadhi	Ongur
11	Acharapakkam	Acharapakkam	Madurantagam	Kancheepuram	Varahanadhi	Ongur
12	Ravuthanallur	Acharapakkam	Madurantagam	Kancheepuram	Varahanadhi	Ongur
13	Pallipettai	Acharapakkam	Madurantagam	Kancheepuram	Varahanadhi	Ongur
14	Kattupunial	Olakkur	tindivanam	Villupuram	Varahanadhi	Ongur

2.3 Environmental Sampling Design of Groundwater Level, Sample and Data

To know the hydrogeology and hydrogeochemistry of the watershed, it is important to select the location for the monitoring wells for water quality sampling, its frequency, collection methods and water quality parameters. Wells used for monitoring were selected based on several criteria, including depth, surface elevation, location, even spacing between monitoring wells was key to obtaining uniform aerial, coverage of the watershed, availability of a well log, road approach, and the owner's willingness to let their well be monitored. A stratified, random sampling design was chosen and as many sites as possible were sampled to provide sufficient coverage of the study area. The topography, geology and geomorphic maps were taken into consideration for planning and performing the field work and sampling.

2.4 Field Techniques

Reconnaissance survey of the study area during January 2008 provided an opportunity for fixing tentative locations for and water samples. The study area is comprised of barren lands, villages and agricultural fields apart from the fast developing urbanising area, where both bore wells and open wells are being used for extracting water. Accordingly, field techniques were determined by the purpose for which the sample was taken.

2.5 Sampling Design

Based on the above criteria, fourteen sites have to be identified to fix the monitoring wells throughout the study area in grid pattern. Once sampling locations have been located to ensure samples collected are representative in space, sampling frequency also be specified so that the samples are representative in time. Samples have collected March 2008 and presented in Table 2. Water levels in wells were measured while water sampling by using 30 meter long plastic measurement tapes. In order to accommodate the variability of sample matrices, suitable methods were adopted for sample collection, preservation and analysis. To collect the water samples, specialized one liter polyethylene bottles were utilised. All bottles are pre-cleaned with 1:1 nitric acid, detergent and were rinsed with double distilled water to be sampled before collecting the sample for analysis. At the time of sampling, the bottles were thoroughly rinsed 2–3 times using the groundwater to be sampled. In the case of bore wells, the water samples were collected after pumping the water for 10 minutes. In the case of open wells, water samples were collected 30 cm below the water level using a depth sampler. The collected water samples were then labeled according to the sample point identification name, date of collection, and then transported to the laboratory in the same day and they were filtered using 0.45µm Millipore filter paper. The samples were analysed for major cations (Na^{+}, Ca^{2+}, Mg^{2+}, K+) and anions (Cl^{-}, SO4 $^{2-}$), HCO3 $^{-}$, CO3 $^{2-}$). The chemical analysis was carried out as per the procedure given in APHA (1996). Samples were analysed with in a short span of time to get reliable analytical results.

Table 2 Water Level in Study Area

S.No	Village	Water level in M
1	Sothupakkam	5.18
2	Melmaruvathur	5.79
3	Thenpakkam	8.22
4	Arapedu	6.10
5	Kolathur	6.40
6	Ayankunnam	6.40
7	Thuthuvilambattu	6.40
8	Puliyani	4.26
9	Tholupedu	7.31
10	Athur	3.04
11	Acharapakkam	9.00
12	Ravuthanallur	6.09
13	Pallipettai	4.80
14	Kattupunial	6.40

3. METHODLOGY

An aquifer is a geologic unit (or layer) of permeable material (like sand, gravel or fractured bedrock) that is capable of providing usable quantities of water to a well and may be confined or unconfined. The porous media in which groundwater occurs are the complex geologic materials near the earth surface; hence the details of porosity and permeability are as complex as those materials. In this present study attempt has been made to quantify the quality and water represent the complexity of the movement of groundwater and its quality represented by Arc GIS. Hence the methodology broadly divided into two broad classes. First part determines concentration of the electrical conductivity, pH, anion and cation, gases were analysed by the standard chemical analysis and the ground water quality model was constructed by using Arc GIS 9.1 software in the second part of the present study.

3.1 Analytical Techniques

The groundwater samples were analyzed for the determination of major ions and the standard procedures were followed and presented in table 3. The water samples were filtered before analysis (APHA, 1996). Reagents were prepared using double distilled water for water quality analysis.

Table 3 Methodology

SL.NO	NAME OF THE TEST	METHODOLOGY
1	**Specific Conductance (Electrical conductivity)**	conductivity meter
2	**Determination of pH**	The pH of the water sample is determined by electrometric method by means of a pH meter with glass electrode.
3	**Determination of Alkalinity, Carbonate, Bicarbonate**	The sample is titrated against standard sulfuric acid in two steps, first to the phenolphthalein end point at pH 8.3 and then to the methyl orange end point at pH 4.5.
4	**Determination of Calcium**	To determine the calcium content, a complexometric method is employed, in which the water sample is titrated with standard EDTA solution using murexide (commercially as calcium hardness indicator) as indicator.
5	**Determination of Chloride**	The water sample is titrated with a standard silver nitrate solution, using potassium chromate as an indicator.
6	**Determination of Magnesium**	Calculated from the total hardness and the calcium concentrations determined separately by the complexometric method.
7	**Determination of Sodium**	The Sodium concentration of the water sample is determined by flame photometric method.
8	**Determination Of Nitrate**	Spectrophotometer, for use at 220nm with 275nm matched silica cells of 1 cm or longer light path.

3.2 ARC View

Arc GIS 9.0 is powerful software for GIS. It was created exclusively for GIS by environmental systems research institute (ESRI) and it supports analysis of raster images like satellite imageries and aerial photographs a part from vector data it also supports spatial data and spatial analysis.

4. RESULT AND DISCUSSION

The geochemical characteristics of groundwater give important information regarding the geologic history of the enclosing rocks, sources of groundwater recharge, and the velocity and direction of flow. The chemical composition of groundwater may significantly change due to the mixing with other water, natural biological processes in aquatic plants and animals, and as a result of direct or indirect human activities. Presentation of geochemical data in the form of contour maps, graphical charts such as Piper-Hill diagram and Wilcox diagram help us in recognizing various hydrochemical types in a mini watershed. Analysis of the chemical constituents of groundwater also shed light on the geochemical evaluation of groundwater as well as identification of recharge areas the following discussion describes the hydro geochemistry of the groundwater in the study area with specific emphasis on the control exercised by lithology and the disturbance caused due to anthropogenic activities. The analytical results of major ions of 14 water samples are listed in order to know the distribution patterns of concentration for different elements and to demarcate the high concentration zones, shaded contour maps were prepared by using Arc View 3.2a, Spatial Analyst and Arc GIS softwares for Total Hardness, Alkalinity, Total Dissolved Solids and Nitrate. The results obtained were presented in table 4.

4.1 Physico Chemical Properties of Acherapakkam Mini Watershed: Hydrogen Ion Concentration (pH)

The p^H of a natural groundwater is a measure of its net alkalinity or acidity. More accurately stated that the pH value is measure of the Hydrogen ion concentration of water. Where the concentration of Hydrogen ion in moles per liter and the desirable limit for drinking water was specified by the BIS and is 6.5 to 8.5 (BIS, 1995). The pH value of drinking water should be as close to 7.0 as economically feasible. Waters with pH between 7.4 and 8.4 were practically inactive. Waters below 7.0 (acid waters) is corrosive and causes tuberculation. In the study area the pH value varies from 6.5 to 8.1 and within the limit prescribed by the BIS.

4.2 Electrical Conductivity (EC)

The presence of charged ionic species in solution makes the water conductive. As ion concentration increases, conductance of the solution increases. The U.S Salinity Laboratory (USSL) classified the salinity hazard of irrigation water in terms of E.C values as fallows; Less than 250 micromhos/cm: low salinity i.e. excellent quality, 250 to 750 micromhos/cm: medium salinity i.e. good quality, 750 to 2250 micromhos/cm: high salinity i.e. doubtful quality, greater than 2250 micromhos/cm: very high salinity i.e. unsuitable quality. In the study area the electrical conductivity varies from 270 to 1580 micromhos/cm at 25^oC. In this study three samples were of medium salinity and classified as good quality having the electrical conductivity in range of 250 to 750, the remaining eleven samples were of high salinity and classified as doubtful quality having the electrical conductivity varies in the range of 750 to 2250 as U.S. Salinity Laboratory (USSL) classification.

4.3 Total Dissolved Solids (TDS)

The Total Dissolved Solids means the total concentration of dissolved solids minerals (or salts) in water. Other terms used are dissolved solids and total solids. It may be determined from the weight of the dry residue remaining after a sample of water has evaporated. Based on the BIS standard, the TDS range has classified into three categories, namely good, moderate and poor for range of 0 to 500 mg/L, 500 to 2000 mg/L and more than 2000 mg/L respectively. In this present study the total dissolved solids varies from 155 to 968 mg/L. Five samples having the TDS value below 500 mg/L and classified as good quality water for domestic purposes and the remaining nine samples having the TDS value between 500 to 2000 mg/L, which is classified as moderate quality as per BIS standard. Contours were constructed for less than 500 mg/L and the contour interval of 500 to 2000 mg /L using Arc GIS 9.1 and presented the Figure 2, it is observed that entire study area having TDS in the range of 500 to 2000 mg/L the geographical formation of the study area was Charnockite series based on the weathering of the basement rock and the movement of the ground water TDS values varies and indicating high degree of weathering of the base rock.

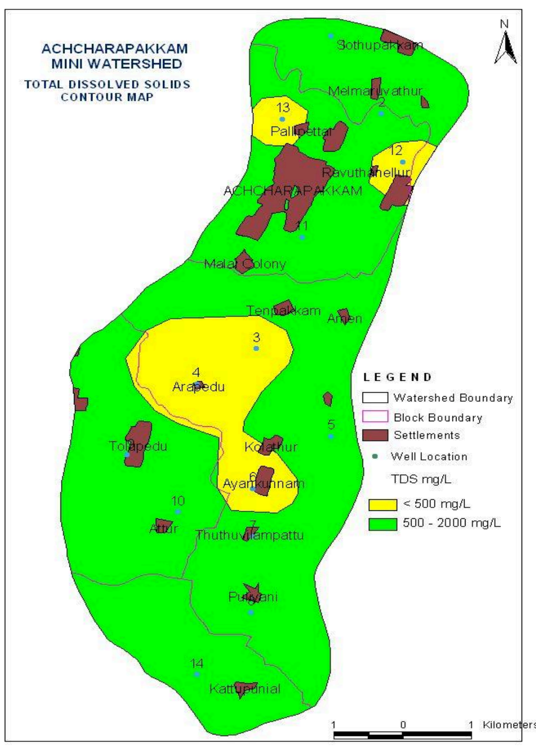

Figure 2 Distribution of Good, Moderate and Poor Quality of Groundwater based on Total Dissolved Solids.

Table 4 Acharapakkam Mini Watershed - Water Quality – Data

S.No	pH	EC	TDS	NO3	Alk_T	TH	Ca	Mg	Na	K	Cl	SO4	CO3	HCO3
1	8.1	1570	968	40	335	575	100	79	138	3	262	142	0	409
2	7.3	1490	936	18	435	460	116	41	161	33	216	86	0	531
3	6.7	760	441	31	175	290	66	30	48	5	110	44	0	214
4	6.8	570	327	13	185	240	48	29	30	1	50	43	0	226
5	6.5	1510	844	75	170	545	62	95	104	2	308	94	0	207
6	7.3	270	155	4	135	140	38	11	5	1	7	6	0	165
7	7.1	1210	783	9	375	450	94	52	115	1	53	230	0	458
8	7.3	1270	765	35	575	430	38	81	138	10	71	41	0	702
9	7.1	970	605	22	350	330	92	24	104	1	82	66	0	427
10	6.9	1580	922	9	435	530	122	55	150	2	209	110	0	531
11	6.9	1420	889	66	315	470	126	38	138	2	202	125	0	384
12	6.6	500	311	18	160	270	56	32	12	1	57	38	0	195
13	7.4	760	418	27	165	300	68	32	35	5	110	41	0	201
14	pH	EC	TDS	NO3	340	430	52	73	115	1	124	118	0	415

4.4 Cation Distribution in Acharapakkam Mini Watershed: Calcium

Calcium and fifth most abundant natural element, Calcium may have beneficial effects when ingested. It may block the absorption of heavy metals in the body and is thought to increase bone mass and prevent certain types of cancer. Very high concentrations of calcium may adversely affect the absorption of other essential minerals in the body. Calcium is naturally present in water and it may dissolve from rocks such as limestone, marble, calcite, dolomite, gypsum, fluorite and apatite. Calcium is a determinant of water hardness, because it can be found in water as Ca^{2+} ions. The desirable limit of calcium in water as per BIS was 75 mg/L and it should not exceed 200 mg/L. Eight samples have the calcium value less than 75 mg/L and six samples have recorded more than 200 mg/L.

4.5 Magnesium

Magnesium is very common elements and fifth most eighth abundant element. Both elements are present in all natural waters. The most common source of magnesium in groundwater is through the erosion of rocks, such as limestone and dolomite, and minerals, such as calcite and magnesite. Magnesium may contribute undesirable tastes to drinking water. Sensitive people may find the taste unpleasant at 100 mg/L. The average person finds the taste unpleasant at about 500 mg/L. These levels are well above the magnesium concentrations found in most water. Magnesium in drinking water may have a laxative effect, particularly with magnesium sulphate concentrations above 700 mg/L. However, the human body tends to adapt to this laxative effect with time. The desirable limit of calium in water as per BIS was 30 mg/L and it should not exceed 100 mg/L. Four samples have the calium value less than 30 mg/L and ten samples have recorded more than 200 mg/L.

4.6 Sodium

Sodium and potassium are chemicals commonly found in soils and rocks. They belong to a group of chemicals called the “alkali earth metals.” (Lithium, cesium and rubidium are also alkali earth metals. Sodium and potassium are often associated with chloride and bromide. In these forms, they readily dissolve in water. In soils containing appreciable amounts of clay, these metals are not mobile. Sodium and potassium are released slowly upon dissolution of rocks. Consequently, concentrations increase as residence time in ground water increases. There is no spiced limit for the sodium and the range of value observed in the present study varying between 5 and 150 mg/L.

4.7 Potassium

Potassium, an important fertilizer, is strongly held by clay particles in soil. Therefore, leaching of potassium through the soil profile and into ground water is important only on coarse-textured soils. Potassium is common in many rocks. Many of these rocks are relatively soluble and potassium concentrations in ground water increase with time. Important anthropogenic sources of sodium include road salt and animal wastes. Sodium is more mobile in soil than potassium and so it is used often as an indicator of human impacts to shallow ground water. Because there are anthropogenic sources of potassium and sodium, and because concentrations increase with residence time in ground water, concentrations may be elevated in shallow ground water as well as deep aquifers. There is no specified limit for the potassium and the range of value observed in the present study varying between 1 and 33 mg/L.

4.8 Hardness: Alkalinity

The properties of alkalinity in water are ability to neutralize acid and its determination by titration with standard acid to an end point of pH 4.5. Alkalinity is produced almost exclusively by bicarbonate and carbonate ion. In this study the total alkalinity value varies from 160 to 575 mg/L as $CaCO_3$, out fourteen samples six samples have the total alkalinity value less than 200 mg/L which is classified as good quality. Whereas the remaining eight samples have the total alkalinity value more than 200 mg/L but less than 600 mg/L which is classified as moderate quality as per BIS.

4.9 Total Hardness (TH)

It is the main important properties of water considered in evaluating the solubility of water for domestic, irrigation and industrial uses. Hardness is due mainly to the presence of calcium and magnesium compounds and in the form of bicarbonates, Sulphate and chlorides.

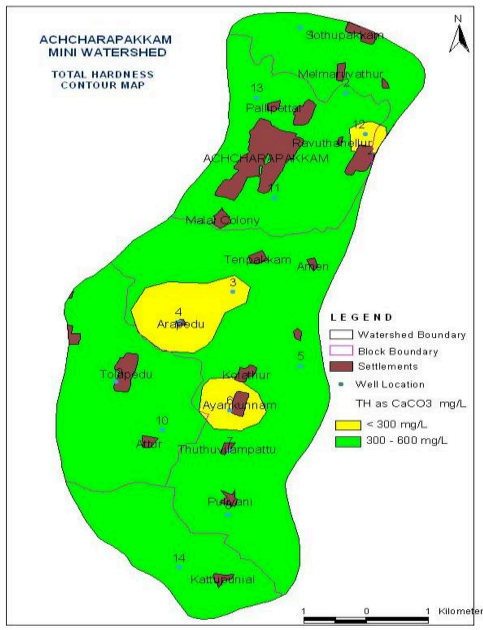

Figure 3 Total contour map Calcium Carbonate of Acharapakkam mini watershed

BIS classified the type of water based on total hardness into three categories namely good, moderate and poor with value of less than 300 mg/L, 300 – 600 mg/L and more than 600 mg/L respectively. In the study area the total hardness value varies from 140 to 575 mg/L as $CaCO_3$ out of fourteen samples five samples having the hardness value less than 300 mg/L which is classified as good quality and the remaining nine samples having the hardness value more than 300 mg/L but less than 600 mg/L which is classified as moderate quality. Contours were constructed for 300 mg/L and 300 to 600 mg /L using Arc GIS and presented the Figure 3, it is observed that entire study area was moderate hardness was due the weathering of the Charnockite basement rock in the study area. The variation was due the varying degree of weathering from various locations and the movement of the ground water.

4.10 Anion Distribution in Acharapakkam Mini Water Shed: Chloride

Chloride is a minor constituent of the earth's crust but a major dissolved constituent of most natural waters. By far the most common Chloride in natural water is Sodium Chloride which is the common table salt. It is commonly found in water, includes the chlorides of Calcium, Magnesium and Iron. The concentration of chloride in natural groundwater does not ordinarily exceed 100 mg/L. Water containing 250 mg/L of chloride was satisfactory for water supplying, agricultural or industrial use. BIS has classified the available natural water into three categories based on chloride content. It is found less than the permissible range of 250 mg/L treated as good, between 250 and 1000 mg/L treated as moderate, if it is beyond 1000 mg/L treated as poor quality. Usually if it is more than 500 mg/L, the water gets a disagreeably saltiest taste. In the study area chloride values ranges between 7 to 308 mg/L. As per BIS classification eleven samples having the chloride value less than 250 mg/L which can be classified as good quality and the remaining three samples were of moderate quality having the chloride value more than 250 mg/L but less than 1000 mg/L. Contours were constructed for 250 mg/L and 250 to 1000 mg /L using Arc GIS and presented the Figure 4, it is observed that entire study area was within the satisfactory level.

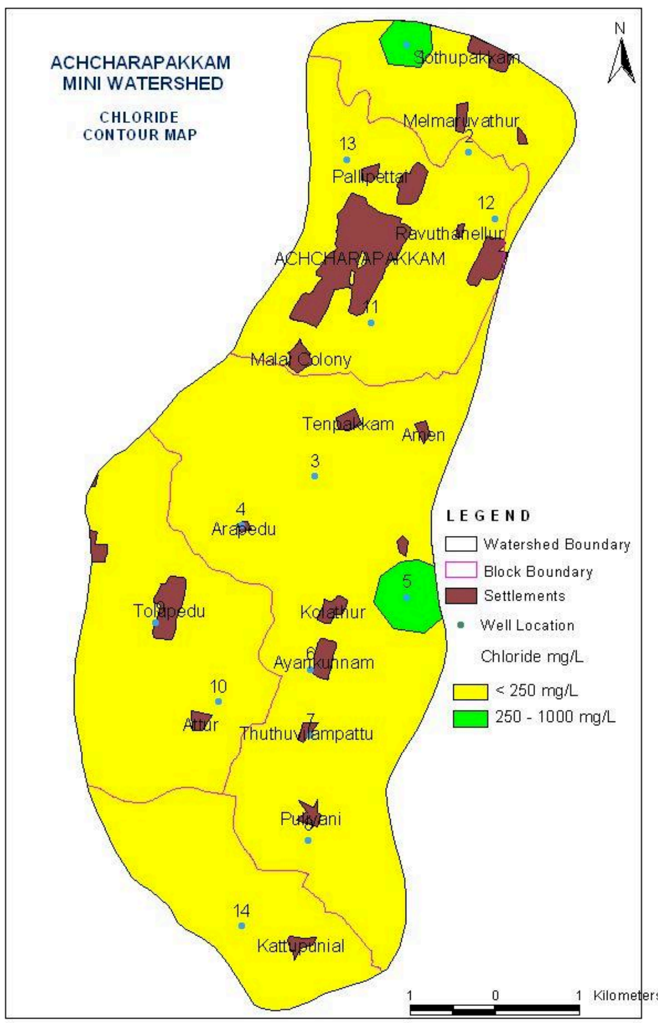

Figure 4 Chloride contour map Acharapakkam mini watersheds Sulphate

It is dissolved from most sedimentary rocks. Large quantities may be derived from beds of gypsum, sodium sulphates deposits and some types of shale. It occurs in water largely in oxidized form, it may also be present as Sulphides. In this study area the sulphate value varies between 6 – 230 mg/L, out of fourteen samples thirteen samples have the sulphate value less than 200 mg/L prescribed by BIS and classified as good quality and the remaining one sample was of moderate quality.

4.11 Nitrate

Nitrate is usually the most prevalent form of nitrogen in water, because it is the end product of the aerobic decomposition of organic nitrogen. Nitrogen from natural sources is attributed to the oxidation of nitrogen of the air by bacteria and to the decomposition of organic material in the soil. Fertilizers may add nitrate directly to water resources. Nitrate concentration ranges from a few tenths to several hundred milligrams per litre, but in unpolluted water seldom exceed 10 mg/L.

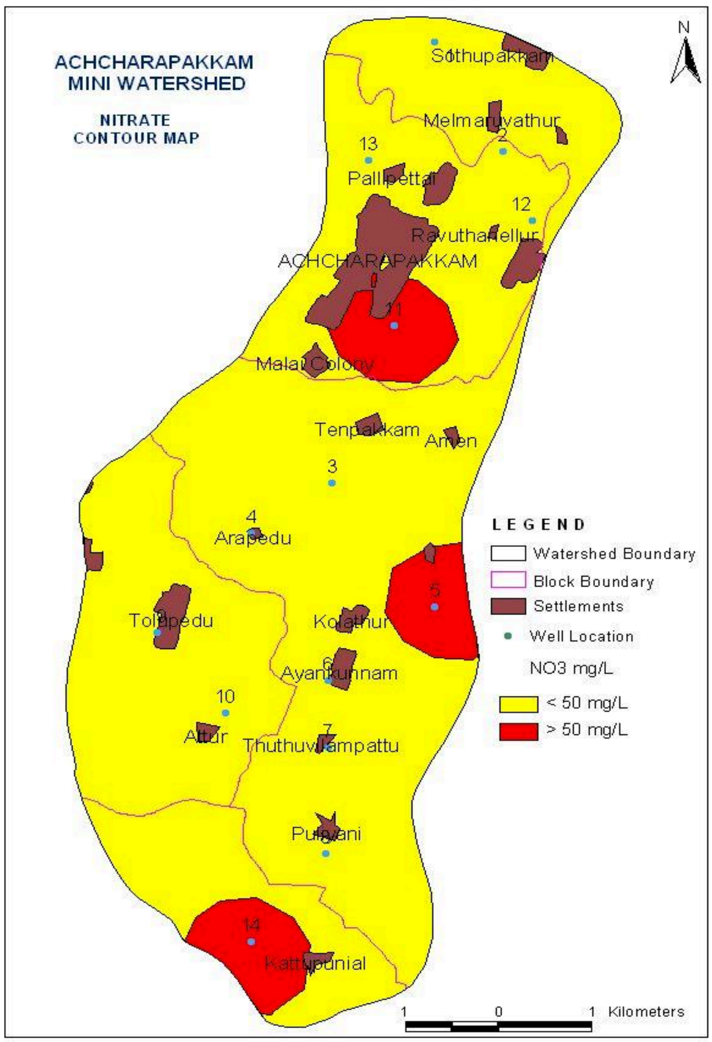

Figure 5 Nitrate contour map of Acharapakkam Mini Watershed

Nitrate and chloride were major components of human and animal wastes, and high concentrations of both suggest pollution. Cyanosis due to methemoglobinemia may occur in infants whose drinking or formula water contains a high concentration of nitrates. The nitrates, when ingested, are converted into nitrites in the digestive system of some infants. The nitrite ion oxidizes hemoglobin to methemoglobin, and there by causes cyanosis. It is widely recommended that water containing more than 10 – 20 mg/L of nitrate nitrogen should not be used in infant feeding concentration more than the local average may suggest pollution. BIS referred if water contains more than 50 mg/L of nitrate were classified as polluted. In this study the nitrate value varies between 4 to 75 mg/L. Eleven samples have less than 50 mg/L which has been classified as good quality and the remaining three samples were of poor quality having the nitrate value more than 50 mg/L. Contours were constructed for less than 50 mg/L and more than 50 mg /L using Arc GIS and presented the Figure 5, it is observed that entire study area having good quality of water as per the Nitrate is concerned and in three pockets more than 50mg/L was observed and the location were either tanks which have shrubs or nearby tank probably due to movement of ground water from the tank.

4.12 Graphical Representation of Water Quality Data: Chemical classification

The Physical and Chemical parameter of groundwater plays a significant role in classifying and assessing water quality. By considering the individual or paired ionic concentration Wlicox proposed certain indices for finding out the alkali hazards. Residual Sodium Carbonate (RSC) can be used as criteria for finding the suitability of irrigation waters. It was observed that the criteria used in the classification of water for a particular purpose may not find the suitability standards for other purposes, and better results can obtained only by considering the combined chemistry of all the ions rather than individual or paired ionic characters. Chemical classification also throws light on the concentration of various predominant cations, anions and their interrelationships. A number of techniques have been developed to interpret the chemical data. Presentation of chemical analysis in graphical form makes understanding of complex groundwater system simpler and quicker.

4.13 Hydro chemical Facies-Piper-Hill diagram

The Piper-Hill diagram (Piper, 1953) is used to infer hydro geochemical facies. These plots include two triangular, one for cations and the other for plotting anions.

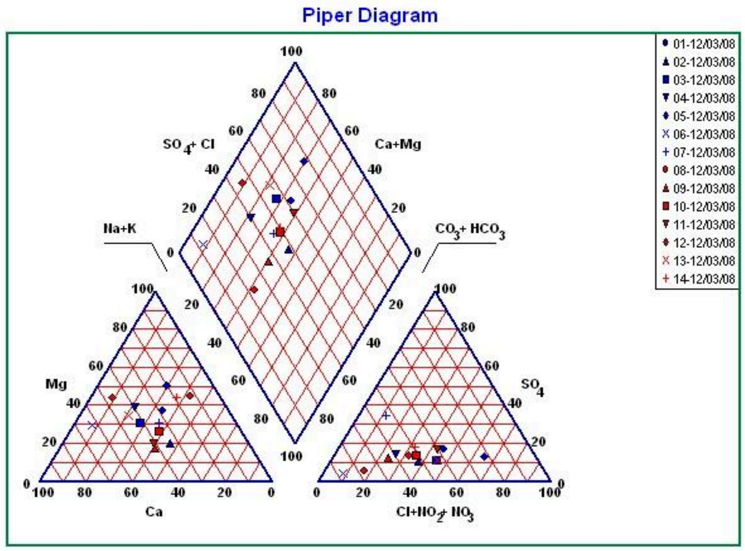

Figure 6 Piper Diagram

The cation and anion fields are combined to show a single point in a diamond-shaped field, from which inference is drawn on the basis of hydro geochemical facies concept (Back, 1965). These trilinear diagrams are very useful in bringing out chemical relationship among groundwater is more definite than with the other possible plotting methods (Walton, 1970). Chemical data of the study area were presented table 4 and plotted on a Piper trilinear diagram, which is shown in Figure 6.

4.14 Classification of groundwater for irrigation purposes

The suitability for groundwater for irrigation purposes depends upon its mineral constituents. The general criteria for judging the quality are:

1. The salt concentration as measured by electrical conductivity (EC).
2. Relative proportion of sodium to other principal cations was expressed by Sodium Adsorption Ratio. (SAR).

Wilcox (1955) classified groundwater for irrigation purposes based upon percent sodium and electrical conductivity. Eaton (1950) recommended the concentration of residual sodium carbonate for determining the suitability of water for irrigation purposes. The U.S Salinity Laboratory of the Department of Agriculture (1954) adopted certain techniques based on which the suitability of water agricultural purposes.

4.15 U.S Salinity Diagram

These have been termed as the salinity hazard, the sodium (alkali) hazard, the boron hazard and the bicarbonate hazard (U.S. Salinity Laboratory, 1954; Wilcox, 1955; Lyerly and Longnecker, 1957). For the purpose of diagnosis and classification, the total concentrations of soluble salts (salinity hazard) in irrigation water can be expressed in terms of specific conductance.

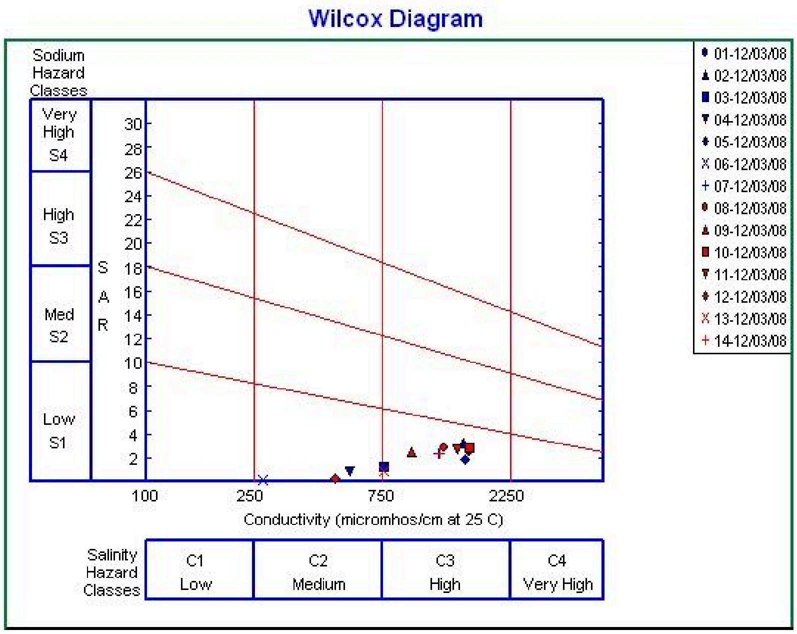

Figure 7 Wilcox Diagram

In the past, the sodium hazard has been expressed as the percent sodium of total cations. A better measure of the sodium hazard for irrigation is the Sodium Adsorption Ratio (SAR), which is used to express reactions with the soil. The SAR is computed as given in eq. 1

$$SAR \quad = (Na^{+})/\{(\sqrt{} (Ca^{++} + Mg^{++})/2\} \tag{1}$$

Where all the ionic concentrations were expressed in epm.

When the SAR and specific conductance of water are known, the classification of the water for irrigation can be determined by graphically plotting these values on the U.S .S.L.diagram and given in Figure 7. Water have been divided into C1,C2,C3 and C4 types on the basis of salinity hazard and S1, S2, S3 and S4 on the basis of sodium hazard. The salinity or total concentration of soluble salts is usually measured as Electrical Conductivity in irrigation work and the US Salinity laboratory has established guide groupings of water based on this parameter.

5. INTERACTIVE GROUNDWATER MODEL

5.1 Interaction between Rainfall, groundwater Table, Geology and groundwater Quality

An attempt has been made to find the relationship between rainfall, groundwater table, and geology and groundwater quality using GIS to understand the complex nature of the groundwater.

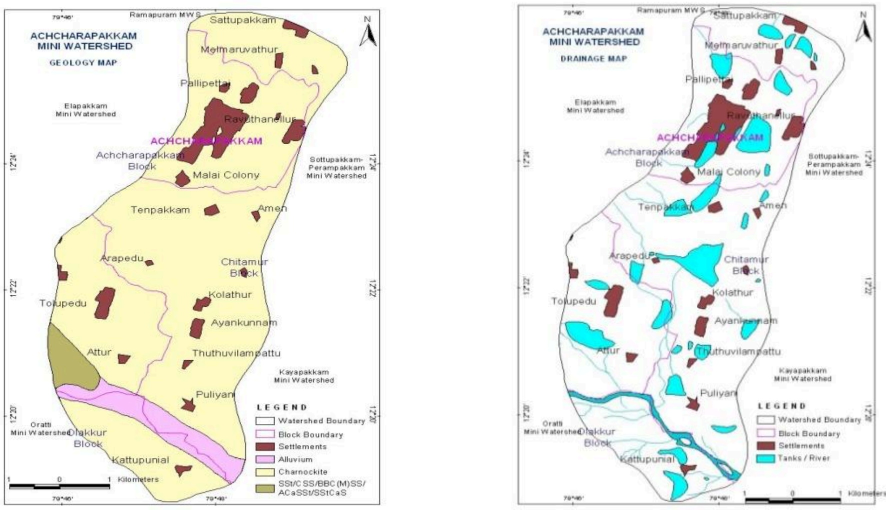

Figure 8 (a) Geological map of Acharapakkam mini water shed (b) Drainage map of Acharapakkam mini water shed.

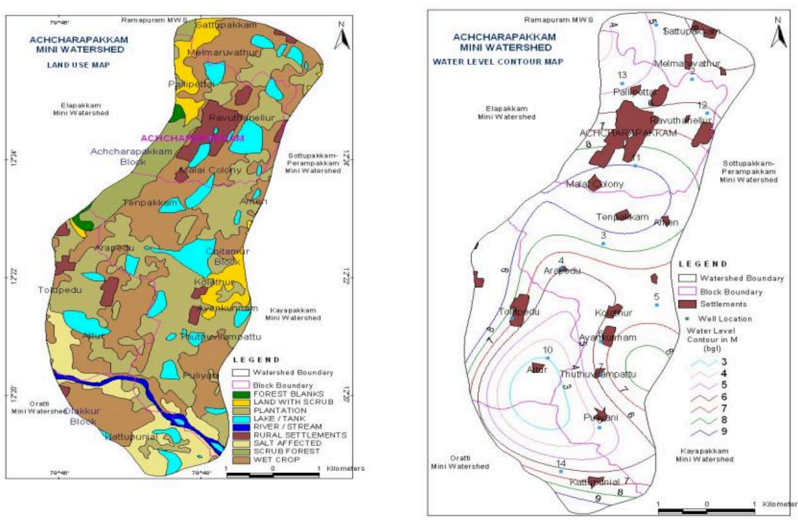

Figure 8 (a) Land use map of Acharapakkam mini water shed (b) Water level contour map of Acharapakkam mini water shed.

The average rainfall over the Acharapakkam mini watershed was 1290.4 mm for seventy years rainfall record and the rainfall during the year 2007 was 905.4 mm. The elevation of the watershed was in the range of +20 to +200 above MSL. However the watershed was flat except Acharapakkam and in few villages in the study area presented in Figure 9a and the study area having a water spread area of 405.7 hectares presented in Figure 8b.The geology of the entire study area was charnockite basement rock and flood plain was located south end of the study area and it is an alluvial soil and the groundwater table contour was presented in Figure 9b showing the equipotential line and the direction perpendicular to the equipotential is flow line. Constructing perpendicular line to equipotential line Arc GIS is difficult, however the trend of movement of groundwater can be observed from the Figure 9b Midway between Athur (location 10) and Kattupunial (location 14) of the river Varanadhi (flood plain) was identified as recharge area and movement of ground water towards in all direction was observed in southern half of the study area. Similarly the north end of study area Madurantam tank was located (highest storage capacity of tank this study area) and identified as groundwater recharge place. Movement of groundwater from north end of the study area towards south was observed from the equipotential line (flow line was assumed from the Figure 9b). Comparing the Figure 9a with the geology of the study area the presence of calcium carbonate was weathering of basement rock and the varying the concentration was due to the varying degree of weathering of basement rock and the movement of the groundwater in the vertical direction and horizontal direction.

6. CONCLUSION

The nearest rainfall station is Madurantagam the data collected shows that every alternate year normal as well as mild drought is observed as per the calculation based on the guidelines of Indian Meteorological Department. Since the formation is of crystalline in nature, the infiltration of rainwater is minimized. Since the elevation changes from 200 to 20 meter above mean sea level it seems that more run off is possible in this mini watershed. It can observed from the model that place of recharge sites were highly weathered and the electrical conductivity, total dissolved solids, major ion concentrations were generally high and decreasing towards the unweathered formation of the flow line of the aquifer. Water quality study shows that majority of the area is of moderate quality and some places good quality water is available based on BIS standard. As per Piper trilinear diagram most of the samples are of mixed type and remaining samples are of calcium bicarbonate type. As such there is no poor quality is observed in the study area with regard to drinking water standard. Further the study shows that all the waters are suitable for agricultural purposes. As per USSL diagram the water quality falls is C2S1 and C3S1 category and suitable for agricultural purposes. In general the water available in the mini watershed can be used for both drinking and agricultural purposes.

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