



Research Paper

HYDROGEOCHEMICAL STUDIES IN AND AROUND KAVERIPAKKAM BLOCK, VELLORE DISTRICT, TAMIL NADU

Rakesh Roshan Gantayat^{1*}, Khyati Joshi¹, C Karthikeyan¹, S Chidambaram¹,
M V Prasanna¹, Smruti Ranjan Beuria¹, Nepolian M¹ and T Illamathi¹

*Corresponding Author: **Rakesh Roshan Gantayat** ✉ rrgantayat@gmail.com

The region like Vellore has a higher density of population to be supported with water. Nearly greater than 50% of the day to day need of people in this Arakonam Taluk including domestic, industrial, agricultural and partly drinking purpose is made by the groundwater resources only. A study on hydrogeochemistry is done to understand the utilization of groundwater for various purposes. A total of 12 groundwater samples were from various parts of Kaveripakkam Block were collected and Physico-chemical parameters [pH, Electrical Conductivity (EC) and Total Dissolved Solid (TDS)], ions (Na, K, Cl, HCO₃, Ca, Mg, SO₄, PO₄, H₄SiO₄) were analyzed to understand the suitability of groundwater for consumption, cultivation and household purpose and also to identify the hydrogeochemical processes. The Piper trilinear diagram and USSL diagram were also plotted which indicates CaHCO₃ facies and shows high salinity hazard. Quality of groundwater has been measured to ensure its suitability for consumption and irrigation, based on WHO standards, US Salinity Laboratory (USSL), Sodium Absorption Ratio (SAR), Residual Sodium Carbonate (RSC), and Na%. The study implies that most of the groundwater samples are suitable for irrigation and drinking purposes. The study also identified that hydrogeochemistry of the region is mainly influenced by weathering processes.

Keywords: Hydrogeochemical Studies, Kaveripakkam, Water Quality, Groundwater Chemistry, Weathering

INTRODUCTION

It has become essential to understand that earth deserves to live with clean environment along with its unique element 'water', which is the main cause of life evolution on this planet. Due to the development of groundwater resource and utilisation of its fullest potential for human activities as being an age old history all over the world left

us with no exception to our study area (Victor M Ponce, 2006). During the past few decades several impacts of groundwater pollution in India has been reported due to urban effluent inputs, fertilizer input due to agricultural activities, besides sea water with intrusion (Hariprasad, 2013). The industrial waste water, sewage sludge and solid waste materials are currently being discharged

¹ Department of Earth Sciences, Annamalai University, Annamalai Nagar.

into the environment indiscriminately. These materials enter into subsurface aquifers resulting in the pollution of irrigation and drinking water (Chidambaram, 2008; Prasanna, 2010).

These have resulted in the fact to understand the need for better protection necessitates along with understanding the groundwater potential and geo-chemical nature as well (Howarth, 2000). In the past decades, these methods played valuable role in analyzing the pollution rate and successfully came out with some resolutions as well (Razmkhah, 2015).

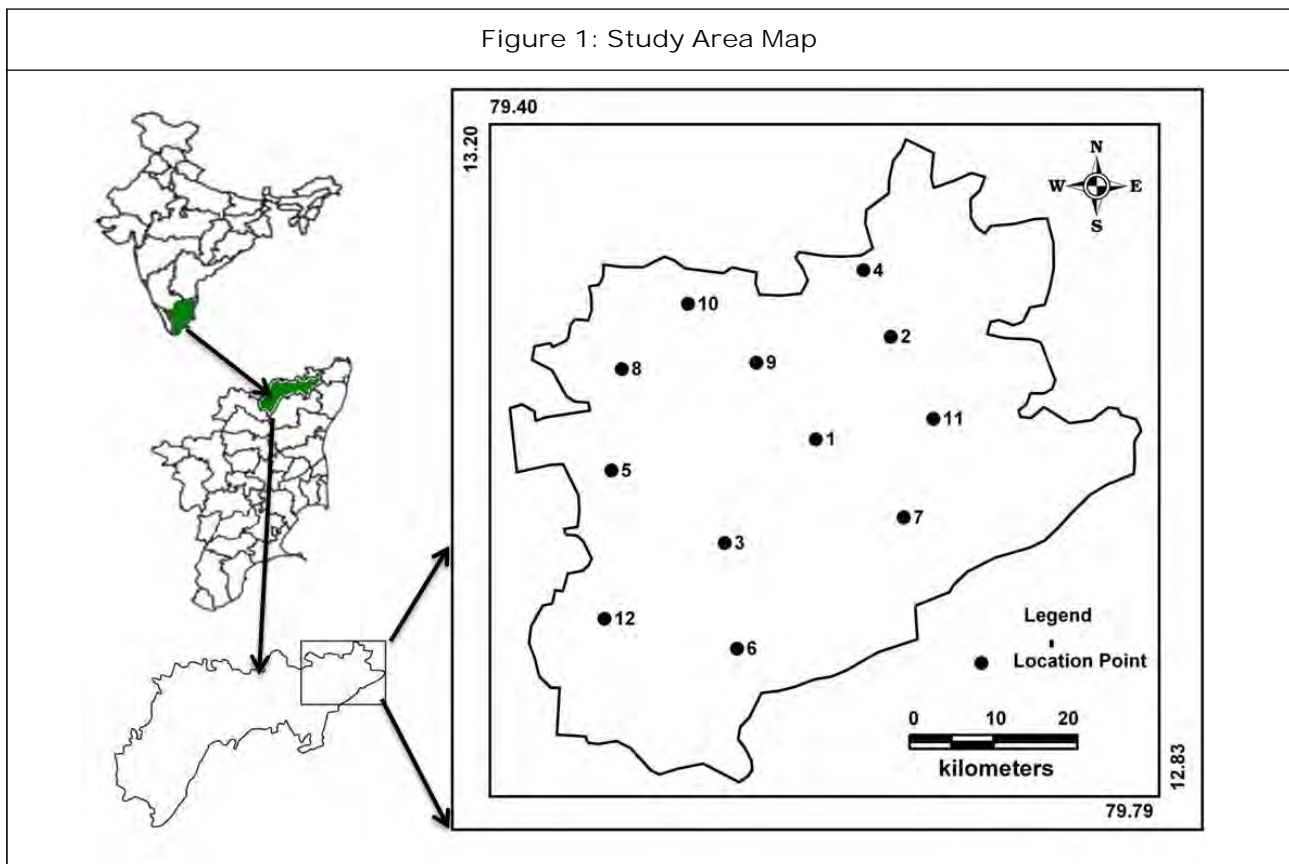
So, the increasing concerns over groundwater quality created the necessity to investigate further (Chapman, 1992) and this is an attempt for the spatial evaluation of water quality in parts of Kaveripakkam block, Vellore District, Tamilnadu and its utilization for various purposes.

STUDY AREA

Vellore district has a total area of 6077 km² lying between 12° 49' to 13°11' North latitudes and 79°24' to 79°47' East longitudes in Tamilnadu state (Figure 1). The district is bound on the north-east by Tiruvallur district, on the south-west by Tiruvannamalai district, on the south west by Krishnagiri district and on the north-west and north by Andhra Pradesh state. Major towns in the district include Ambur, Arakonam, Ranipet, Sholinghur, Arcot, Jolarpet, Titupattur, Vaniyambadi, Vellore and Kaveripakkam.

Kaveripakkam is the second largest lake in Tamil Nadu. The average maximum temperature experienced in the plains is 39.5°C and average minimum temperature experienced is 15.6°C. The region experiences an average annual rainfall of 795 mm, out of which north-east monsoon

Figure 1: Study Area Map



contributes to 535 mm and the south-west monsoon contributes to 442 mm.

Major rivers of the district are Palar and Ponnai (Figure 2), these rivers will almost be dry and sandy and may not be of much use for sustained irrigation as these are seasonal. Palar river is the major river draining the district, flowing towards east for a distance of about 295 km. It runs parallel to the hill ranges of the Eastern Ghats for a major part of its course. It has a vast flood plain in the lower reaches, but is dry for major part of the year. Ponnaiyar, Cheyyar, Pambar and Malattar are some of the major tributaries of Palar draining the district. Almost all the streams are ephemeral in nature and are mostly structurally controlled. Kaveripakkam city has a tropical climate in winter, there is much less rainfall than in summer. The temperature here averages 28.3°C with an average rainfall of 968 mm.

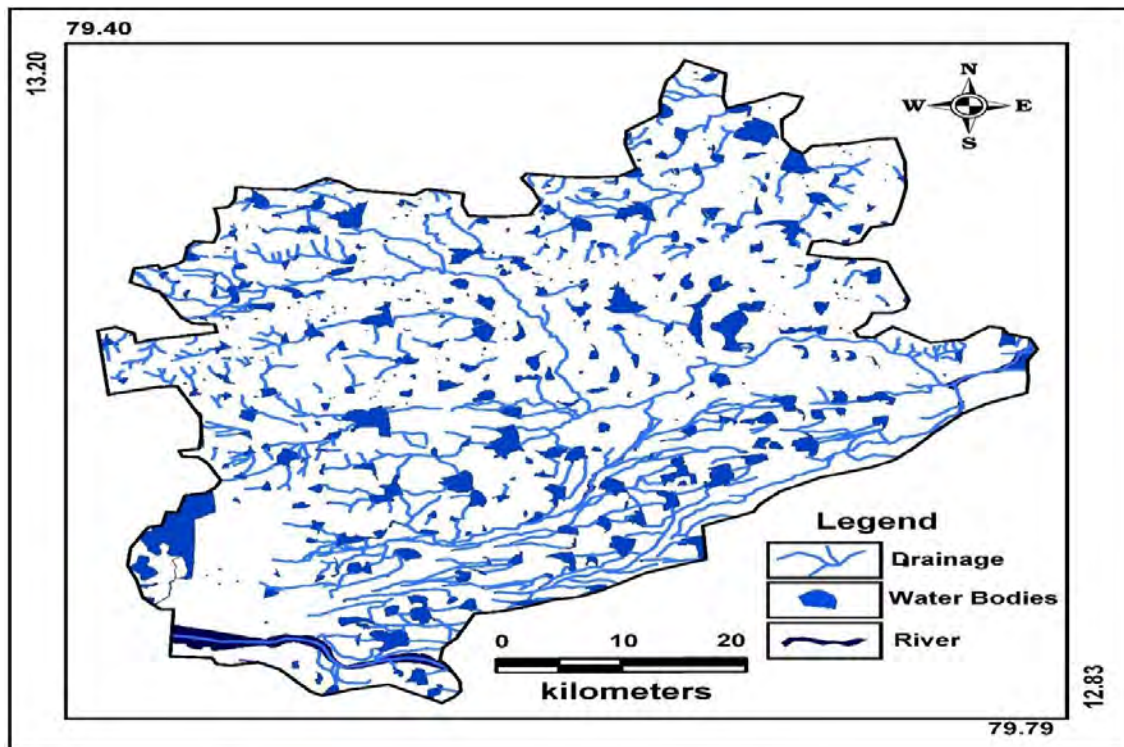
GEOLOGY OF THE STUDY AREA

The basin consists mainly of red, black, sandy and mixed soil. The important rock formations are hard or crystalline rocks of Archean age Dharwar super group (Chadwick, 1991), Cuddapah series of rock belonging to Proterozoic rock age, soil comprising of Guvalacheruvu-quartzite, Vempally dolomites, limestones and shales of Papaghani series and Cheyyeru series. Nallamalai series comprise of Cumbumshales, which are metamorphosed to slates and phyllites.

METHODOLOGY

Hydrogeochemical research requires proper site for collection of water samples and appropriate methods of analysis. Sampling sites were located taking several factors into considerations like lithology, structure, geomorphology, river influence industry, urban agricultural activity and

Figure 2: Drainage Map of Study Area



availability of wells. Sampling of groundwater has been carried out in Kaveripakkam block of Arakonamtaluk in Tamil Nadu. The sampling was carried out in such a way that sample reflects the variation in water chemistry.

A total of 12 samples of 1 L capacity were collected from bore wells in polyethylene bottles (Map Figure 1). The samples were then brought to the laboratory for analysis and stored properly (4°C). Temperature and conductivity were analyzed in field itself by using water analysis kit. Sampling and analysis for Na, K, Cl, HCO₃, Ca, Mg, SO₄, PO₄, H₄SiO₄, p^H, EC, TDS are carried out by Titrimetric method, Flame Photometer, Turbidity method, Ascorbic acid method, Molybdo-silicate method and p^H meter respectively. The analytical results have been processed by using WATCLAST programme (Chidambaram, 2003). This programme is capable of providing most of the needed output using the major ion chemistry data.

RESULTS AND DISCUSSION

The major cation found in groundwater samples is Sodium and major anion is chloride. The pH of the study area varies from 6.71 to 7.29 (Table 1). The pH average concentration in the region is 6.93. About 1/4th of the total area shows high pH value. The electric conductivity of the study area varies from 348 µs/cm to 2535 µs/cm. On an average 1126.17 µs/cm is observed in the region. About 1/3rd of the total area has higher electric conductivity due to hardness of water. Calcium concentration in all groundwater samples is within permissible limits. The main sources for Calcium are Amphiboles, Feldspars, Gypsum, Pyroxenes, Aragonite, Calcite, Dolomite and Clay minerals. It ranges from 10-80 mg/L and the average

concentration in the region is 41.75 mg/L. The main sources of Magnesium are Amphiboles, Olivine, Pyroxenes, Dolomite, Magnesite and Clay minerals. It ranges from 13.8 to 74.4 mg/L and the average concentration in the region is 40.37 mg/L. The Magnesium concentration is higher at some places because of the residence time over the clay or because of the domestic waste like soap waters. The main sources of Sodium are Feldspars, Clay minerals evaporate and industrial wastes. It ranges from 10.4 to 43.4 mg/L and the average concentration in the region is 27.19 mg/L. Here the concentration Na is higher in the surface water due to four reasons: as it stays in the clay bed, cation exchange, due to the evaporation effect and due to domestic waste water. Potassium concentration in groundwater samples is also within permissible limits. The main sources of Potassium are Feldspar and Mica. It ranges from 0.2 to 72.6 mg/L and the average concentration in the region is 8.16 mg/L. Main reason for increasing Potassium in groundwater is due to agricultural activities. Bicarbonate is generally derived from the silicate and carbonate weathering process. It ranges from 109.8 to 311.1 mg/L and the average concentration in the region is 202.09 mg/L (Table 2). Gypsum, Anhydrides and Fertilizers may contribute to the Sulphate concentration. It ranges from 16.84 to 31.76 mg/L and the average concentration in the region is 22.40 mg/L. The chief source of Chloride are sedimentary rocks (evaporates) and the minor sources are igneous rocks (Pedro Fierro, 2007). It ranges from 2.4 to 123.7 mg/L and the average concentration in the region is 44.29 mg/L. The TDS ranges from 193 to 1170 mg/L and the average concentration in the region is 553.67 mg/L. It shows that the area is free from pollution and major anthropogenic signatures.

Table 1: Table Showing Ionic Concentration in mg/l Except pH and EC

| Sample ID | Location | Ca | Mg | Na | K | Cl | HCO ₃ | SO ₄ | H ₄ SiO ₂ | pH | EC | TDS |
|-----------|-------------------|----|------|------|------|-------|------------------|-----------------|---------------------------------|------|------|------|
| 1 | MINNAL | 52 | 73.6 | 41.3 | 72.6 | 85.1 | 311.1 | 31.76 | 108.82 | 7.08 | 2363 | 1170 |
| 2 | THANDALAM | 36 | 13.8 | 10.4 | 1 | 2.4 | 135.9 | 18.31 | 2.2 | 6.89 | 377 | 207 |
| 3 | BANAVARAM | 70 | 61.6 | 43.4 | 14.2 | 123.7 | 244 | 25.06 | 2.2 | 7.29 | 2086 | 989 |
| 4 | PERUMALRAJAPETTAI | 60 | 36.4 | 20.2 | 1.1 | 31 | 199.6 | 21.67 | 8.25 | 6.86 | 831 | 429 |
| 5 | AAYAL | 35 | 27.4 | 18.7 | 0.9 | 3.1 | 198.6 | 19.58 | 13.03 | 6.97 | 603 | 315 |
| 6 | KARNAVUR | 33 | 32.2 | 29.1 | 2.2 | 31 | 195.2 | 20.85 | 4.85 | 6.87 | 930 | 477 |
| 7 | KOOTHANPAKKAM | 32 | 28.8 | 17.5 | 0.9 | 34.1 | 109.8 | 19.6 | 108.82 | 6.72 | 423 | 229 |
| 8 | THALIKAL | 80 | 32.6 | 42.5 | 1.4 | 99.2 | 237.9 | 30.21 | 2.21 | 6.75 | 2535 | 1150 |
| 9 | PANIYUR | 20 | 28.8 | 20.3 | 1.5 | 6.2 | 152.5 | 16.84 | 108.82 | 6.71 | 386 | 206 |
| 10 | PARANJI | 31 | 37.8 | 12 | 0.2 | 9.3 | 213.5 | 19.48 | 8.24 | 7.19 | 348 | 193 |
| 11 | CUDDALORE | 10 | 74.4 | 42.9 | 1.2 | 65.1 | 219.6 | 24.81 | 8.25 | 6.82 | 1542 | 737 |
| 12 | VEDAL | 42 | 37 | 28 | 0.7 | 41.3 | 207.4 | 20.63 | 21.21 | 7 | 1090 | 542 |

Table 2: Comparison of Groundwater Samples with (WHO 2004) Standards (BIS 2014) and (ISI 2012) (All values in (mg/L) except pH and EC)

| Samples | Maximum | Minimum | Average | WHO(2004) | BIS(2014) | ISI(2012) | Samples above the Permissible Level |
|--------------------------------|---------|---------|---------|-----------|-----------|-----------|-------------------------------------|
| pH | 7.29 | 6.71 | 6.93 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | |
| EC | 2535 | 348 | 1126.17 | 1400 | | | 1, 3, 8, 11 |
| TDS | 1170 | 193 | 553.67 | 1000 | 500 | 500 | 1, 8 |
| Ca | 80 | 10 | 41.75 | 100 | 75 | 75 | |
| Mg | 74.4 | 13.8 | 40.37 | 50 | 30 | 30 | 1, 3, 11 |
| Na | 43.4 | 10.4 | 27.19 | 200 | | | |
| K | 72.6 | 0.2 | 8.16 | 20 | | | 1 |
| Cl | 123.7 | 2.4 | 44.29 | 250 | 250 | 250 | |
| HCO ₃ | 311.1 | 109.8 | 202.09 | 300 | | | 1 |
| PO ₄ | 64.35 | 6.82 | 24.51 | | | | |
| SO ₄ | 31.76 | 16.84 | 22.4 | 250 | 200 | 200 | |
| H ₄ SO ₄ | 108.82 | 2.2 | 33.08 | | | | |

WATER QUALITY

The quality of water is determined by number of factors like geology, soil, weathering, presence

of industries, emission of pollutants, sewage disposal and other environmental conditions, with which it alters from the point of its entry to exit. All

the above said aspects alter chemical composition of the groundwater, which plays a significant role in determining the water quality for various utility purposes. Criteria used for classification of water for particular purpose is not suitable for other standards. Better results can be obtained by combining chemistry of all the ions than the individual or paired ionic character (Handa, 1964; Hem, 1985).

The groundwater of this area in general is colorless and odorless. Analytical data shows that most of the groundwater of the region is suitable for drinking and domestic purpose with few abnormal concentrations exceeding the maximum permissible limit. Chloride concentration exceeds the maximum limit in certain location indicating the anthropogenic influence or ion exchange.

IRRIGATION WATER QUALITY

In general high sodium waters are not suitable for irrigation activities because the sodium ion engages in cation exchange processes which tend to affect the ability of soils to sustain the crop productivity. The Na^+ ion adsorbs into cation exchange sites, causing soil aggregates to disperse, thus reducing soil permeability (Tijani, 1994). The irrigation waters enriched in Na^+ results in cation exchange reactions whereby Na^+ is taken up and Magnesium and Calcium are released into the water. On other hand, the use of Ca^{2+} enriched waters for irrigation leads to the release of Na^+ ion from cation exchange sites, and the preferential adsorption of the Ca^{2+} ions onto the cation exchange sites. In addition, high salinity waters have the tendency to reduce the osmotic potentials of irrigation crops over time. In the irrigation water quality two types of salt problems exist which are very different: Those

associated with the total salinity and those associated with sodium. Soils may be affected only by salinity or by a combination of both salinity and sodium.

SALINITY HAZARD

Water with high salinity is toxic to plants and poses a salinity hazard. Soils with high levels of total salinity are referred as saline soils. High concentrations of salt in the soil can result in a "physiological" drought condition. That is, even though the field appears to have plenty of moisture, the plants wilt because the roots are unable to absorb the water. Water salinity is usually measured by the TDS (Total Dissolved Solids) or the EC (Electric Conductivity). TDS is referred to as the total salinity and is measured or expressed in parts per million (ppm) or in the equivalent units of milligrams per liter (mg/L). The poor quality waters due to high electrical conductivity resulting salinization (Ghafoor *et al.*, 1990, 1993). Excess salt increases the osmotic pressure of the soil solution that can result in a physiological drought condition. Even though the field appears to have plenty of moisture, the plants wilt because insufficient water is absorbed by the roots to replace that lost from transpiration. Based on Electrical Conductivity, waters are classified into four major classes (Richards, 1954). The boundary values between the individual classes are 250, 750 and 2250 μscm^{-1} . These limit values were determined on the basis of the relationship between the electrical conductivity of waters and the electrical conductivity of saturated soil extracts.

- Low-Salinity Water ($\text{EC} < 250 \mu\text{s cm}^{-1}$) can be used for irrigation.

- Medium-Salinity Water ($250 < EC < 750 \mu\text{s cm}^{-1}$) can be used if the soil is washed with a moderate amount of water.
- High-Salinity Water ($750 < EC < 2250 \mu\text{s cm}^{-1}$) cannot be used on soils with restricted drainage.

Very High-Salinity Water ($EC > 2250 \mu\text{s cm}^{-1}$) is not suitable for irrigation under ordinary conditions, but it can be used under very special circumstances.

Irrigation water containing large amounts of sodium is of special concern due to sodium's effects on the soil and poses a sodium hazard. Sodium hazard is usually expressed in terms of SAR or the sodium adsorption ratio. SAR is calculated from the ratio of sodium to calcium and magnesium. The latter two ions are important since they tend to counter the effects of sodium. The Sodium Adsorption ratio is calculated by using the eqm values in the formula given below;

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

For waters containing significant amounts of bicarbonate, the adjusted Sodium Adsorption Ratio (SAR) is sometimes used. Continued use of water having a high SAR leads to a breakdown in the physical structure of the soil. Sodium is adsorbed and becomes attached to soil particles.

The soil then becomes hard and compact when dry and increasingly impervious to water penetration.

PERMEABILITY INDEX

An infiltration problem relate to water quality occurs when the normal infiltration rate for the applied water or rainfall is appreciably reduced

and water remains on the soil surface for long duration or infiltrates too slowly to supply the crop with sufficient water to maintain acceptable yields. Although the infiltration rate of water into soil varies widely, it can greatly be influenced by the quality of irrigation water, soil factors; such as structure, degree of compaction, organic matter content and ions, which can also greatly influence the intake rate. The two most common water quality factors which influence the normal infiltration rate are the salinity of water and its Sodium content relative/ relating to the Calcium and Magnesium content. High salinity water will increase infiltration. Low salinity water or water with high Sodium to Calcium and Magnesium ratio will decrease infiltration (Manivannan, 2011). Both factors may operate at the same time. The infiltration rate generally increases with increasing salinity and decreases with either decreasing salinity or increasing Sodium content relating to Calcium and Magnesium and SAR. Therefore, the two factors, salinity and SAR provide information on its ultimate effect on water infiltration rate. The Permeability Index (PI) of the water was derived by Doneen (1948) by using major cations and HCO_3 concentration using the following expression;

$$PI = \frac{\{Na + (HCO_3)\}}{\sqrt{Ca + Mg + Na}} \times 100$$

Permeability index is an important factor which influences quality of irrigation water, in relation to soil for development in agriculture. Another effect of high Na^+ concentrations in irrigation water is related to the Bicarbonate ion concentration. Toxicities related to the Bicarbonate ion arise when soils are deficient in Iron and other micronutrients. The PI of a water sample measures the collective concentrations of Na^+ and

HCO_3^- relative to the total cation content of the water.

The suitability of groundwater for irrigation purpose is also mainly based upon the estimation of their parameters like, Na% and RSC. Total Na concentration and EC are important in classifying the water for irrigation purposes (Wilcox, 1955). Sodium percentage is calculated against major cations and expressed in terms of SAR. Na is an important cation which in excess deteriorates the soil structure and reduces crop yield (Srinivasamoorthy, 2005). SAR values in all the seasons irrespective of depth ranges from excellent to good category irrespective of seasons. Majority of the plot falls in excellent range of Richards (1954).

Table 4 clearly reveals that the higher representations of the samples are noted in the fresh water type. Few samples also represents moderately fresh brackish and slightly brackish water as well during this season.

According to Wilcox classification (1955) the water is classified based on the Na% with respect to the other cations present in water. Percent Na+ is also widely utilized for evaluating the suitability of water quality for irrigation (Wilcox, 1955). Na+ (%) was computed with respect to relative proportions of cations present in groundwater, where the concentrations of ions are expressed in milli equivalents per liter as:

$$\text{Na}\% = \frac{\text{Na} + \text{K}}{\text{Ca} + \text{Mg} + \text{Na} + \text{K}} \times 100$$

The Na% for almost 50% of the samples, fall in excellent category (Table 3) and representation of 50% samples are noted in Good class. In this season samples shows good representations in excellent and good category.

In Na% Eaton (1950) classification of groundwater for irrigation purposes, 100% of the samples fall in Safe category for irrigation purposes.

When SAR (alkali hazard) and specific conductance (Salinity hazard) is plotted in USSSL diagram, classification of water for irrigation purpose can be determined. Majority of samples fall in C3S1 zone indicating high salinity and low sodium hazard, satisfactory for plants having moderate salt tolerance on soils (Figure 3). Minor representation of samples is also noted in C2SI and C3S2 zones indicates medium to high salinity waters.

$$\text{RSC} = (\text{CO}_3 + \text{HCO}_3) - (\text{Ca} + \text{Mg})$$

In RSC 100% of the samples fall in Good category (Table 3).

Hardness refers to the reaction with soap and formation of scale. It increases the boiling point and do not have adverse effect on human health. In the study area 60% of the samples fall in the Moderately Hard category, 30% of groundwater samples belong to very hard category, the remaining samples of this season fall in Slightly Hard category (Table 3).

$$\text{TH} = 2.497 \text{ Ca} + 4.115 \text{ Mg} \text{ (Todd, 1980).}$$

Chloro-Alkaline indices Scholler classification (1965), i.e., CAI1 and CAI2 are used to measure the extent of Base Exchange during rock water interaction. Where there is an exchange of Na+ and K+ in groundwater with Mg²⁺ or Ca²⁺ in rock matrix when both the indices are positive. All the ionic concentration is expressed in epm. 75% of the ground water samples of the study area exhibit exchange of Na+&K+ in the rock to Ca²⁺& Mg²⁺ in groundwater, remaining 25% samples (Table 3) fall in the other category. It is calculated by the following expression;

Table 3: Summary of Geochemical Classification of the Samples Collected in Study Area by WATCLAST Program (Chidambaram 2003)

| Category | Grade | POM n=12 | Category | Grade | POM n=12 | Category | POM n=12 |
|-------------------------------|-----------|----------|---|---------|----------|---|----------|
| Na% Wilcox (1955) | | | USGS Hardness | | | TDS Classification(USSL,1954) | |
| Excellent | 0-20 | 6 | Soft | <75 | 0 | <200 | 1 |
| Good | 20-40 | 6 | Slightly Hard | 75-150 | 1 | 200-500 | 6 |
| Permissible | 40-60 | 0 | Moderately Hard | 150-300 | 7 | 500-1500 | 5 |
| Doubtful | 60-80 | 0 | Very Hard | >300 | 4 | 1500-3000 | 0 |
| Unsuitable | >80 | 0 | IBE Schoeller (1965) | | | CationFacies | |
| Na% Eaton (1950) | | | (Na+k)rock->Ca/Mg g.w. | | 9 | Ca-Mg Facies | 5 |
| Safe | <60 | 12 | (Na+k)g.w.->Ca/Mg rock | | 3 | Ca-Na Facies | 7 |
| Unsafe | >60 | 0 | Schoeller Classification (1967) | | | Na-CaFacies | 0 |
| S.A.R. Richards (1954) | | | Type I | | 12 | Na Facies | 0 |
| Excellent | 0-10 | 12 | Type II | | 0 | Anion facies | |
| Good | 10-18 | 0 | Type III | | 0 | HCO3 Facies | 0 |
| Fair | 18-26 | 0 | Type IV | | 0 | HCO3-Cl-SO4 Facies | 0 |
| Poor | >26 | 0 | Corrosivity Ratio (1990) | | | Cl-SO4-HCO3 Facies | 12 |
| R.S.C. Richards(1954) | | | Safe | <1 | 0 | Cl- Facies | 0 |
| Good | <1.25 | 12 | Unsafe | >1 | 12 | Hardness Classification (Handa,1964) | |
| Medium | 1.25-2.5 | 0 | Chloride Classification (Stuyfzand,1989) | | | Permanent Hardness (NCH) | |
| Bad | >2.5 | 0 | Extremely fresh | 2 | | A1 | 11 |
| EC Wilcox (1955) | | | Very fresh | 2 | | A2 | 1 |
| Excellent | <250 | 0 | Fresh | 8 | | A3 | 0 |
| Good | 250-750 | 5 | Fresh Brackish | 0 | | Temporary Hardness (CH) | |
| Permissible | 750-2250 | 5 | Brackish | 0 | | B1 | 0 |
| Doubtful | 2250-5000 | 2 | Brackish-salt | 0 | | B2 | 0 |
| Unsuitable | >5000 | 0 | Salt | 0 | | B3 | 0 |
| | | | Hyperhaline | 0 | | | |

| Water type | Range (ppm) | POM |
|---------------------------------|-------------|-----|
| Fresh water | < 500 | 7 |
| Moderately fresh brackish water | 500-1000 | 3 |
| Slightly brackish water | 1000–5000 | 2 |
| Moderately brackish water | 5000–15000 | - |
| Very brackish water | 15000–35000 | - |
| Sea water | 35000-42000 | - |

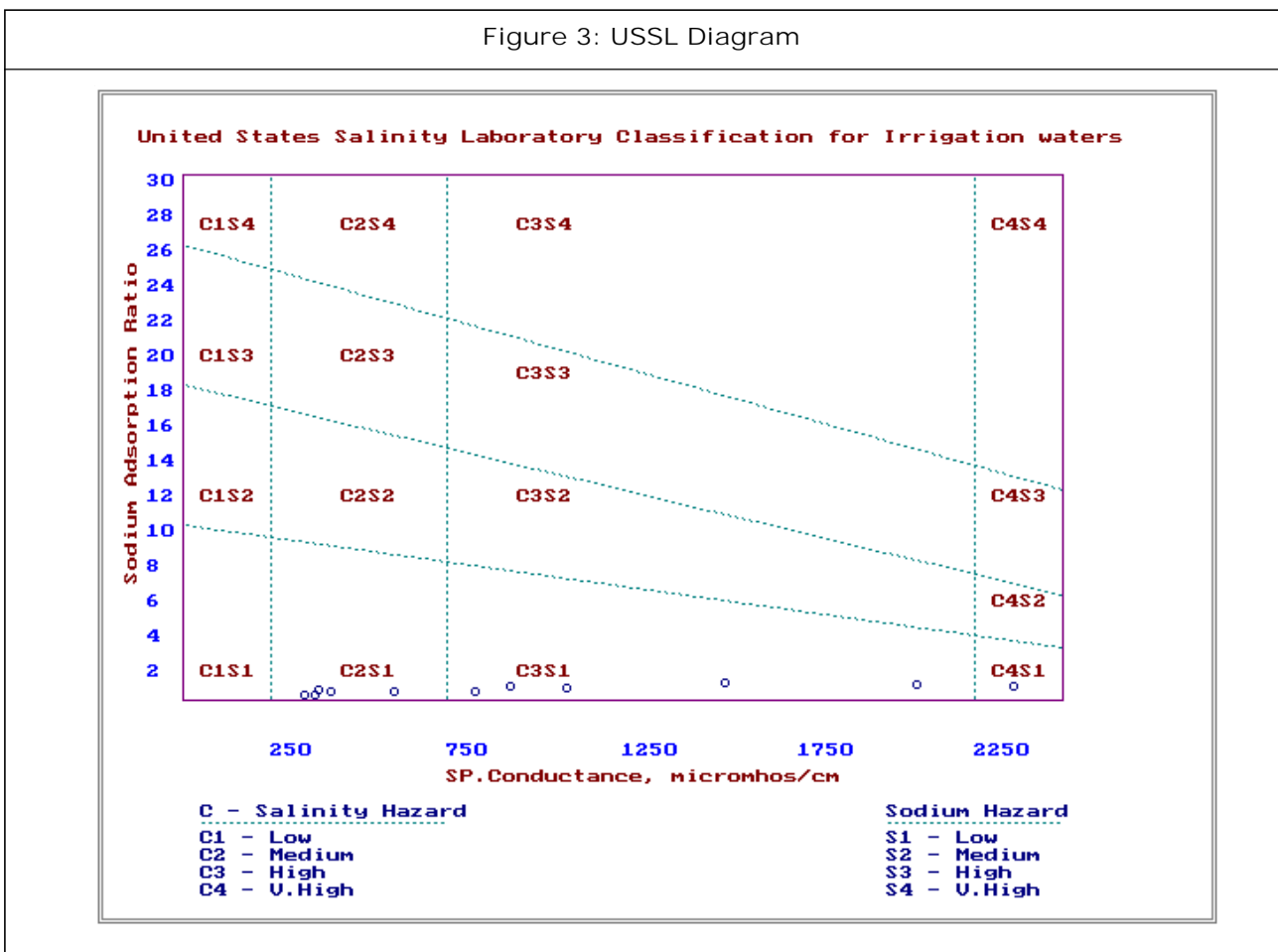
samples.

Groundwater extracted from the study area for various purposes is transported by metallic pipes that may or may not be suitable for the transport. This fact is highlighted using Corrosivity Ratio (CR) proposed by Ryzner (1984). The formula for calculating CR is;

$$CR = \{(Cl/35.5) + (SO_4/96)\} / 2(HCO_3) \times 100$$

100% of the samples fall under unsafe

Figure 3: USSL Diagram



$$CAI1 = [Cl-(Na+K) / Cl]$$

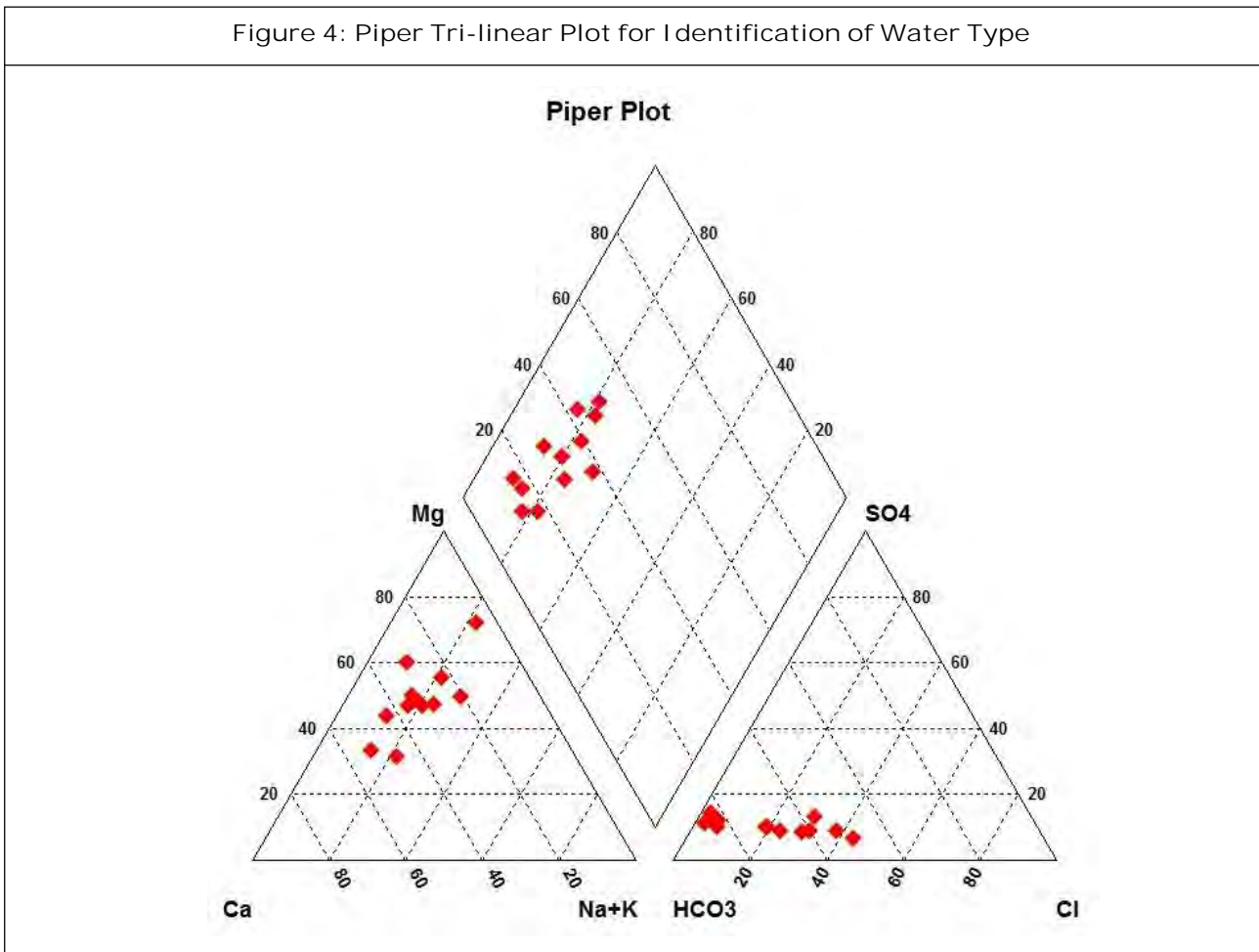
$$CAI1 = [Cl-(Na+K) / (SO_4+HCO_3+CO_3+NO_3)]$$

Scholler classification (1967) for the dominance of anion exhibits that Type I ($rCl > rHCO_3 > rSO_4$) is predominant in all the

category, which shows these are unsafe for transport.

The Styfzands classification (1989) based on the Chloride concentration in groundwater exhibits that Fresh Brackish and Brackish categories.

Figure 4: Piper Tri-linear Plot for Identification of Water Type



70% of samples fall in Fresh Category and 30% of the samples fall in very fresh and extremely fresh category (Table 3).

PIPER TRI-LINEAR PLOT

Hydrogeochemical nature of the groundwater was studied by Piper Tri-linear diagram (1944). It consists of two lower triangular fields for cations and anions and a central diamond shaped fields. The position of diagrams signifies the facies of groundwater. The geochemical evolution can be understood from the Piper plot. All the three fields have scale reading in 8 parts. The samples are plotted in the diagrams. The sample fall into major segments, representing types of water, i.e., Ca-HCO₃ (Figure 4).

i.e. CaHCO₃+CaNaHCO₃

The position of the samples in the plot shows that the dominant facies found in the area is CaHCO₃. As it is a hard rock terrain having rock types like Granite, Charnokite, Hornblende biotite gneiss, Sandstone, Shale and the dissolution of all minerals results increase of HCO₃ in groundwater (Drever, 1988). So it inferred that the dominance of HCO₃ in groundwater is mainly due to rapid infiltration of river water or rain water into it.

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CONCLUSION

The conclusions derived from samples of Kaveripakkam area indicate most of the groundwater samples have EC higher than 1000 $\mu\text{s}/\text{cm}$ but majority of water samples have concentrations of the ions are within permissible limits according to the water quality standards. Based on the hardness, the groundwater samples are moderately hard to very hard in nature. The quality of groundwater is suitable for drinking purposes and fit for irrigation. The groundwater nature is explained by the Piper Tri-linear diagram which indicates that most of the groundwater samples fall under Ca-HCO_3 type. The major process controlling the groundwater chemistry of the study area is rock water interaction or weathering. The conclusions derived indicate that the water is relatively free from pollution and anthropogenic influences except in few locations. The geochemical process dominantly controls the groundwater chemistry of the region is inferred to weathering.

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