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Groundwater Quality Assessment in hard rock terrain of Rasipuram Taluk, Namakkal District

K.Ramesh, P.Pavithra
Centre for Water Resources, Department of Civil Engineering, Anna University, Chennai-600 025, India)

ABSTRACT
Groundwater is of most important to rural development in many countries of the world. Over exploitation of groundwater has become a major challenge not only to the present civilization and also for the future generations. The main focus of this study is to assess the suitability of groundwater quality for drinking and irrigation purposes in vicinity of Rasipuram block in Tamil Nadu. Groundwater samples from 15 locations were collected from different wells during January 2015 and analyzed for different physico-chemical parameters. The usefulness of these parameters in predicting groundwater quality characteristics were discussed. The quality of groundwater in the study area is fresh to brackish water, moderately hard to very hard in nature. The piper plot shows that the most of the groundwater samples fall in the field of Na^{+}-Cl^{-} and mixed Ca^{++}-Na^{+}-Cl^{-} type. Water quality index rating was carried out to quantify overall groundwater quality status of the area. The WQI for these samples ranges from 37.34 to 650. Hence majority of the water samples are poor to very poor in water quality. The area in general is characterized by hard water, hence is not suitable for drinking purpose. The samples plotted in the piper and USSL diagram were used to understand the chemical characteristic of groundwater for irrigation purposes. However, the values of SAR, Na% and RSC indicate that groundwater is suitable for irrigation purposes. Overall water quality of the study area was found satisfactory for drinking purpose except in few locations and suitable for irrigation purpose. Hence the local government needs to initiate remedial measures.
Keywords **-** Physiochemical characteristics, WQI, suitability drinking and irrigation, Rasipuram taluk.

I. INTRODUCTION

Water means life and life means water. We can hardly live for a few days without water. In man's body 70-80% is water, Cell, blood and bones contain 90%, 75% and 22% water respectively. Groundwater plays a fundamental role in human life and development. Groundwater is the most essential prerequisite for increasing crop production as well as sustainable agricultural development. Availability of groundwater for irrigation has contributed to manifold increase in crop productivity in India. Increasing population, food insecurity, growing economy and poor water management are exerting unprecedented pressure on the world's freshwater resources [1]. It is estimated that approximately 1/3rd of the world's population use groundwater for drinking purposes. Water shortages have become an increasingly serious problem in India. Groundwater is ultimate and most suitable fresh water resources for human consumption in both urban as well as rural areas. The importance of groundwater for existence of human society cannot be overemphasized [2]. In India, groundwater constitutes about 53% of the total irrigation potential and about 50% of the total irrigated area is dependent on groundwater irrigation [3]. The quality of groundwater is the resultant of all the processes and reaction that acts on the water from the moment it condenses in the atmosphere to the time it is discharged by a well. Therefore, determination of groundwater quality is important to observe the suitability of water for a particular use. The problems of groundwater quality are more acute in areas that are densely populated and thickly industrialized and have shallow groundwater tube wells. The safe portable water is absolutely essential for healthy living. About 80% of the diseases of the world population and more than 1/3rd of the deaths in the developing countries are due to contamination of water [4]. Geochemical studies of groundwater provide a better understanding of possible changes in quality as development progress. Anthropogenic activities have exerted small to large scale changes on the hydrologic cycle. Over-exploitation may cause the imbalance in the hydrological system. In such areas, groundwater is commonly the only water resources and the most prevalent issue relevant is the quality of the groundwater. Groundwater is highly valued because it constitutes the major drinking water source in most of the parts in India. Still more than one billion people all over the world do not have ready access to an adequate and safe water supply and more than 800 million of those unsaved live in rural areas. More than 95% of rural population depends on groundwater for all needs. Groundwater accounts for about 85% of the safe drinking water in rural areas where water treatment and transport do not exist. According to the Centre Groundwater Board, the dynamic fresh groundwater resources of India have been estimated at 432 km^2/year of which 396 km^2 is estimated to be utilizable [5]. The chemical composition of groundwater is controlled by many factors that include composition of precipitation, geologic structure and mineralogy of the watersheds and aquifers, geological processes within the aquifer [6]. Groundwater quality data gives important clues to the geologic history of rocks and indications of groundwater recharge, movement and storage [7]. Depletion of groundwater levels and deterioration of water quality requires immediate attention. Therefore, water quality monitoring of various sources is essential to know the status so as to suggest safety measures. Groundwater is mostly chemically non-polluted when drawn from greater depth. Human beings have made aquifer as their prime requisite due to unavailability of reliable source of water as that of the groundwater. So during past decades, groundwater quality has emerged as one important and confronting environmental issued [8]. Water quality analysis is one of the most important aspects in groundwater studies. Chemical classification also throws light on the concentration of various predominant cations, anions and their interrelationship. According to National Water Policy [9] both surface and groundwater should be regularly monitored and progress should be undertaken for the improvement of water quality. Water quality plays an important role in promoting agricultural production and standard of human health. Suitability of groundwater for domestic and irrigation purposes is determined by its groundwater geochemistry. The objective of the present work is to discuss the major ion chemistry of groundwater of Rasipuram block.

II. STUDY AREA

The study area is Rasipuram block in Namakkal district, Tamil Nadu state, approximately 250 km^2 in extent (Figure 1) is located on the foot hill slopes of the Kolli hills to the east and Bodamalai hills to the north. General slope is towards south and southwest direction, the area charcteristerizd by almost elevated topography with some undulation and hills. It is located on the highway NH7 which connects Salem and Namakkal. The town is located on new broad gauge line which connects Salem and Karur. Rasipuram got its name from Rajapuram which literally means king’s town. It is located 364 km south of Chennai city and 27 km from Salem city. Rasipuram is important taluk in Namakkal district. The chief industry of the town is weaving. Puttunoolkarar who belongs in Sourashtra Community lives in large numbers in this town together with kaikolar. They are weaving cotton cloth and silk saris. Another important aspect in the taluk is the Sago production. Nearly 176 Sago factories are located in and around the Rasipuram taluk. Sago and Starch production in this area are exported other countries. Ghee and handloom silk saree production and education are also famous in Rasipuram taluk. The area receives the rain under the influence of both southwest and northeast monsoons. The northeast monsoon chiefly contributes to the rainfall in the area. Most of the precipitation occurs in the form of cyclonic storms caused due to the depressions in Bay of Bengal. The southwest monsoon rainfall is highly erratic and summer rains are negligible. Rasipuram and surrounding areas have an average rainfall of 700 mm. The area enjoys tropical climate. The weather is pleasant during the period from November to January. Mornings in general are more humid than afternoons, with the humidity exceeding 78% on an average. In the period June to November the afternoon exceeds 66% on an average. In the rest of the year the afternoons are drier, the summer afternoons being the driest. The hot weather begins early in March, the highest temperature being felt in April and May. Weather cools down progressively from about the middle of June and by December; the mean daily maximum temperature drops to 40 C, while the mean daily minimum drops to 20 C in January. A large number of small sized tanks are found in the area. The cultivation generally depends on monsoon rains, wells and tanks. Dug wells and tube wells are the major source of water for drinking and irrigation in the region. The whole area depends on groundwater for all its uses. Nearly 90% of the cultivated area is under food crops. A large number of small-sized reservoirs (tanks) are found in the area. However, almost all the tanks remain dry for most of the year, with no area under agriculture depending on them. In fact, all these tanks are silted up and covered with plants belonging to the species Prosapsis Juliflora. The study area is underlain predominantly by charnockites with occasional pockets of granitic gneisses, as well as few bands of ferruginous quartzites (BIF) and dolerite dykes. The area is structurally distributed, the rocks having undergone fracturing, jointing and shearing. Results of bore well drilling show that water-bearing joints occur up to a depth of 300m below ground level. The major soil types of this area are red soil, black soil and mixed soil. Agriculture is principle occupation of the people and is backbone of the rural economy. Both wet and dry crops are raised in this area. Sugarcane, paddy and plantain are some of the wet crops and groundnut, cotton, ragi and tapiaco are some of dry crops raised in this area. Lowering of groundwater levels and consequent drying up of bore wells has had a profound impact on cropping pattern and land use in the area. Much of the irrigated cropped area has now been converted to rain-fed area. People living in rural areas, small villages and towns are dependent upon groundwater as their main source of

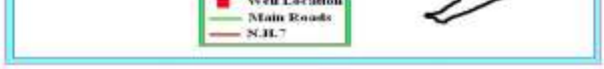

Fig.1: Location of the study area

water for domestic, industrial and agricultural needs. This large use and dependency on groundwater indicates that these resources are highly valuable and must be protected for the present and future use also. the introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

III. MATERIAL AND METHODS

Groundwater samples were collected randomly from 15 wells during winter period January 2015 from open wells and tube wells. The collected groundwater samples were transferred into precleaned polythene container for analysis of chemical characters. Electrical Conductivity (µS/cm) and hydrogen-ion activity (pH) of water samples were measured in the field by using portable kits. The collected groundwater samples were carried to the laboratory for the analysis of major ions such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-} and trace ions NO_3^{-}, F^{-}. The water quality variables analysis was done as per the standard procedure [10].

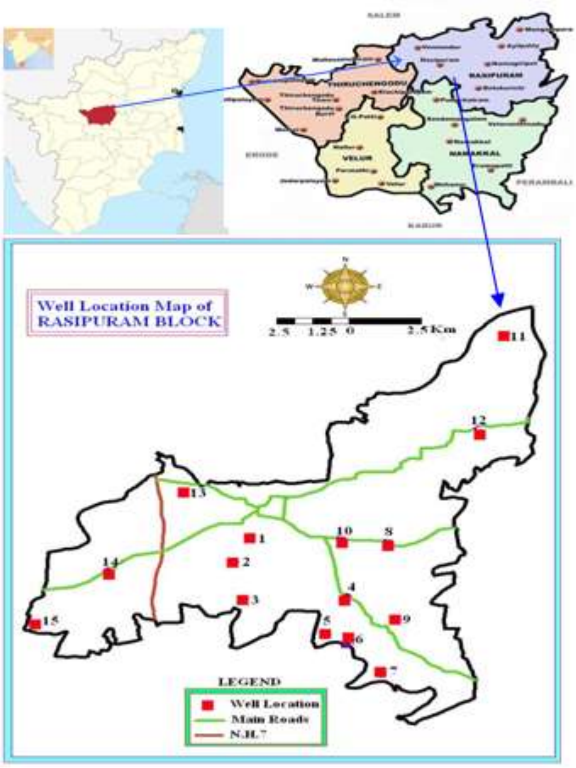

Fig.1: Location of the study area with sampling wells

IV. RESULTS AND DISCUSSION

Physico-Chemical Analysis of Groundwater: The groundwater quality analysis of different groundwater samples have been carried out for pH, EC, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-}, SO_4^{2-} ,NO_3^{-}, F^{-}. The data were used for understanding the spatial distribution of ions, suitability for domestic and irrigation purposes and it is described as below.

The pH of a solution is the negative logarithm of hydrogen ion concentration in moles per liter. pH is dependant on the carbon-dioxide-carbonate-bicarbonate equilibrium. pH is considered as an important ecological piece factor and piece of information on many types of geochemical equilibrium of solubility calculation [11]. Most natural groundwater has pH of 4 to 9. The pH is measured in the field at the time of collection of samples. Drinking water with a pH range of 6.5-8.5 is generally considered satisfactory (Figure 2). pH is one of the most important factors which serves as an index of the pollution. The purpose of finding the pH values is to determine whether the drinking water is acidic or alkaline in nature. About 86.67% of the samples are slightly alkaline in nature and the remaining 13.33% falls under the slightly acidic category. It is observed that almost all the water samples have pH value within the permissible limit prescribed by Indian standards. From the results it is clear that the pH of water is mainly due to the equilibrium between free CO_2^{2-} and HCO_3^{-} ions. TDS is the concentration of all dissolved minerals in water indicates the general nature of salinity of water. To ascertain the suitability of groundwater for any purposes, it is essential to classify the groundwater depending upon their hydrochemical properties based on their TDS values [12]. The groundwater of the area is fresh water except a few

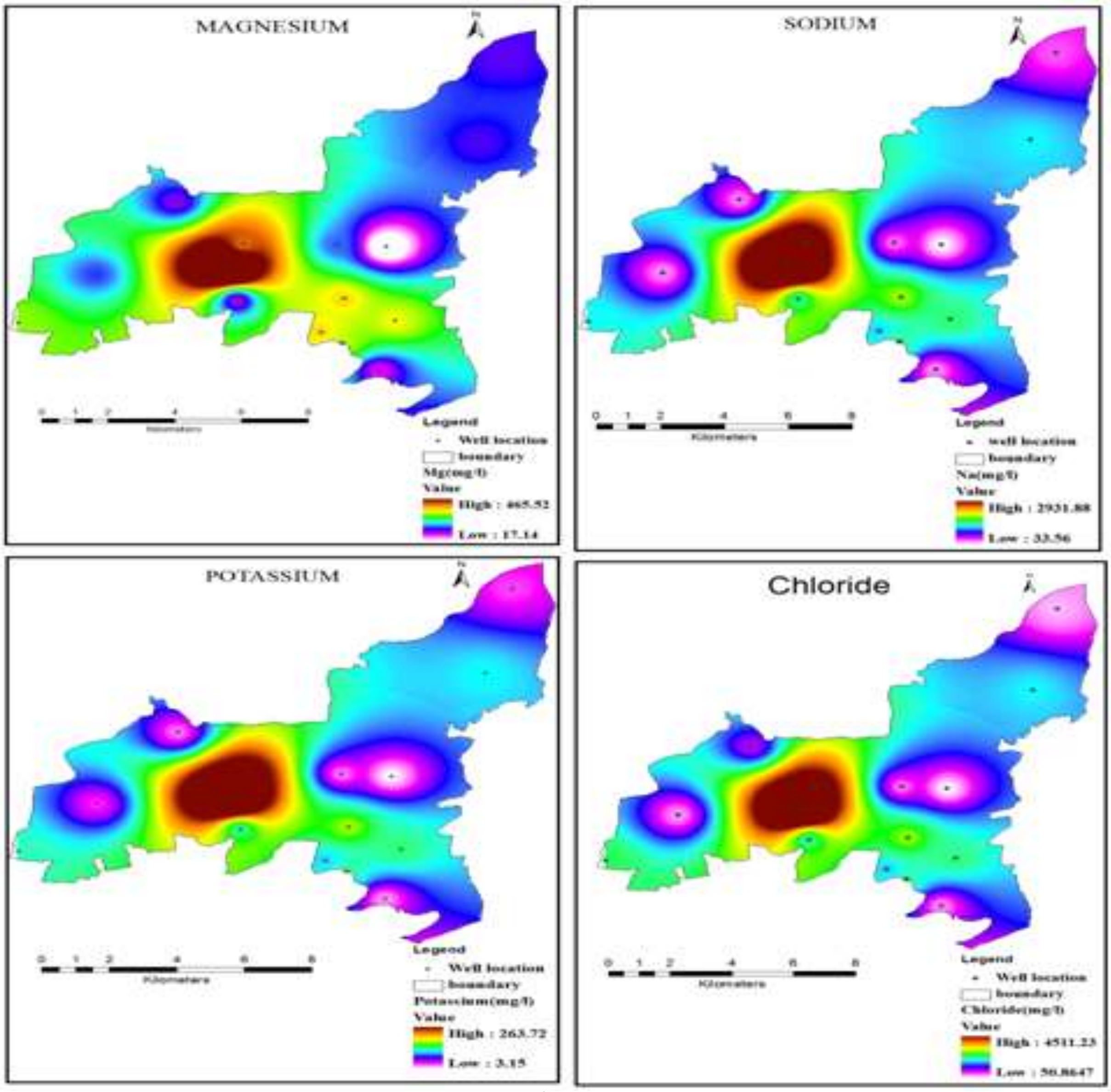

Fig.3: Spatial distribution of Mg^{2+}, Na^{+}, K^{+} and Cl^{-} of groundwater

samples representing brackish water. Most of the groundwater samples are within the maximum permissible limit for drinking as per the BIS standards. Water containing high TDS is of inferior palatability and may produce unfavorable physiological reaction in the transient consumer [13]. Total dissolved solids indicate the salinity behavior of groundwater. The TDS observed from this area is between 111.36-1766.4 mg/l. Based on the classification of Davis and De Wiest [14], 12 samples are below 1000 mg/l having fresh water condition and 3 samples has slightly saline around 1000-3000 mg/l. High levels of TDS would affect water taste and lead to gastrointestinal irritation. The variation of TDS is shown in Figure 2.

Hardness is very important in decreasing the toxic effect of poisonous element. Total Hardness (TH) is caused primarily by the presence of cations such as Ca^{2+}, Mg^{2+} and anions such as CO_3^{2+}, HCO_3^{2+}, Cl^{-}, SO_4^{2-} in water and Eutropication the water containing excess hardness is not desirable for potable water. It consumes more soap during washing of cloths. Water hardness has no adverse effects; however, some evidence indicates its role in heart diseases [15]**.** Jain [16] opined that hardness of 150-300 mg/l and above may cause kidney problems and kidney stone formation, as it cause unpleasant taste an reduce ability of soap to produce lather. Hard water is unsuitable for domestic use. In this region, the total hardness varies between 164 to 3840mg/l (Figure 2). Most of the samples are hard water and in some area hardness was very high, also beyond the permissible limit. BIS has prescribed desirable limit of total hardness is 300 mg/l and permissible limit in the absence of alternate source is 600 mg/l. The incidence of total hardness attributed to the composition of lithounits constituting the aquifers in the area.

Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) in waters are generally used to classify the suitability of waters. Ca^{2+} may dissolve readily from carbonate rocks and lime stones or be leached from soils. It is one of the important nutrients for organisms and as such has no hazardous effect on human health. Depending on the type of rocks, its quantity in natural water varies from 10 to 100 mg/l. Ca^{2+} is an essential nutrition element for human being and aids in maintaining the structure of plant cells and soils. [17] Insufficiency of Ca^{2+} causes severe rickets; excess causes concretions in the body such as kidney or bladder stones and irritation in urinary passages [18]. The value of Ca^{2+} concentration varies in the range of 37 to 760 mg/l (Figure 2). For most of groundwater samples, the Ca^{2+} values are found within the maximum permissible limit (200 mg/l). The continuous high intake of Ca^{2+} may cause stone problem which is also noticed in the area

Magnesium (Mg^{2+}) is present in the groundwater from natural sources like granitic terrain which contain large concentration of these elements. A large number of minerals and rocks contain Mg^{2+} and it dissolves in surface and groundwater. Mg^{2+} generally occurs in lesser concentration than Ca^{2+} because of dissolution of Mg^{2+} rich minerals is slow process and calcium is more abundant in the earth crust [19]. Concentration >500 mg/l impart unpleasant taste to water making it unpalatable. Higher concentration of Mg^{2+} makes the water unpalatable and act as laxative to human beings. It adds up in the environment by use of fertilizer for agricultural practices and from cattle feed [20]. High concentration combined with SO_4^{2-} acts as laxative to human beings. The Mg^{2+} value of all the samples varies in the range of 17 to 466 mg/l (Figure 3). It is confirmed that the Mg^{2+} values most of the groundwater samples is within the maximum permissible limit (150 mg/l).

Na^+ and K^+ are naturally occurring elements in groundwater. These two elements are directly added into groundwater from industrial and domestic wastes and contribute salinity of water. Na^+ is one of the important cations occurring in natural waters and is derived from weathering rocks. Domestic wastes and industrial wastes are rich in Na^+ and are contribute salinity of water. At lower concentration there are no adverse effects on the health. The Na^+ value of all the samples varies in the range of 33 to 2935 mg/l(Figure 3). High concentration of Na^+ ion in drinking water may cause heart problems and high Na^+ in irrigation water may cause salinity problems [21]. So, most of the groundwater samples in the area is within the permissible limit (200 mg/l) suggested by WHO.

Potassium (K^+) is essential element for humans, plants and animals and derived in food chain mainly from vegetation and soil. The main sources of K^+ in groundwater include rain water, weathering of potash silicate minerals, use of potash fertilizers and the use of surface water for irrigation. K^+ is also naturally occurring element but occurs at lower concentration than sodium, calcium and magnesium. It has similar chemistry like sodium and remains in solution without forming any precipitate. As such, it is not very much significant from the health point of view. The K^+ value of all the samples varies in the range of 3.1 to 264 mg/l (Figure 3). High amount of K^+ in the groundwater sample is due to the presence of silicate minerals from ingenious and metamorphic rocks [22]. It is found that the Potassium values in all the samples are within the permissible limit (12 mg/l).

Chloride in groundwater may originate from both natural and anthropogenic sources. Atmospheric precipitation, dissolution of salt deposits and weathering of halite and evaporate are considered as the major lithogenic source of Cl^- in the groundwater. Possible anthropogenic source of Cl^- are septic, industrial and animal waste, fertilizers leachate from landfill and waste dump [23]. People who are not accustomed to high chloride are subjected to laxative effect. The Cl^- value of all the samples varies in the range 50 to 4516 mg/l (Figure 3). Cl^- imparts a salty taste and some times higher consumption causes the crucial for the development of essential hypertension, risk for stroke, left ventricular hypertension, osteoporosis, renal stones and asthma in human beings [24]. Although, the Cl^- plays an important role in balancing the level of electrolyte in blood plasma, but higher concentration can produce some physical disorders. Soil porosity and permeability also play an important role in building up the chloride value. If the water with high chloride concentrations used for construction purpose, this may corrode the concrete. The large lateral variation and high concentrations of chloride in some groundwater samples may be attributed to the local recharge, leaching of salt, saline residues in the soil and municipal, domestic and animal wastes.

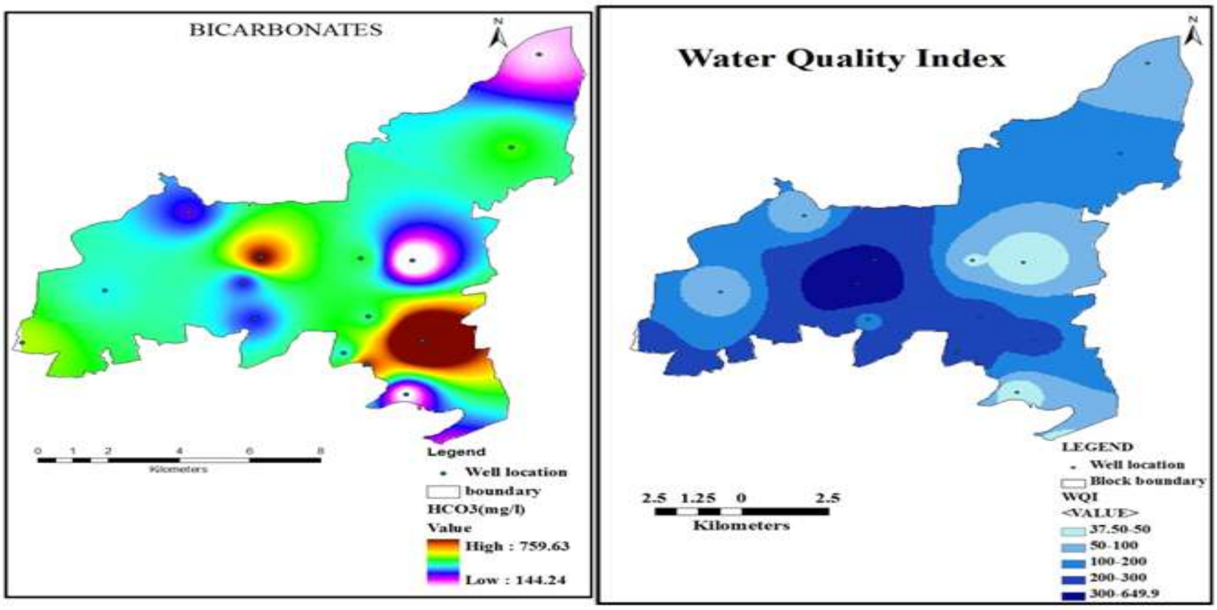

Fig.4: Spatial distribution of HCO3 and WQI of groundwater

The permissible limit of chlorine for drinking is 250 mg/l and for irrigation it is 600mg/l.

Bicarbonate was observed in the range of 144-480 mg/l (Figure 4), most of the groundwater samples are within the permissible limit (150 mg/l) as per the WHO guidelines. Weathering of carbonate and/or alumino-silicateminerals with a secondary contribution from dissolution of CO_2 gases are the primary source of HCO_3 in the groundwater. This CO_2 can be produced by the oxidation of organic matter and by root respiration in the unsaturated zone, followed by the dissolution in the recharge water to form bicarbonate [25]. In addition, bicarbonate is also be produced by the dissolution of carbonate and the weathering of silicate minerals. The elevated values suggest that the groundwater system is open to soil CO_2, resulting from the decay of organic matter and root respiration, which in turn ,combines with rainwater to form bicarbonate. High amount of alkalinity in water is harmful for irrigation which leads to soil damage and reduce crop yield.

Source of nitrates in groundwater include human activity such as application of fertilizer in farming practices, human and animal waste. The concentration of nitrate in the area is low and ranged between 4.1 to 36 mg/l which is below the permissible limit of 45 mg/l according to Indian standards. Nitrate is an important pollutant in the environment, generally derived from atmospheric precipitation, agricultural fertilizers, human and animal excrete, biological fixation and nitrification of organic N and NH4 [23]. Toxicity of nitrates in infants causes health disorders such as methaemoglobiaemia, goiter, hypertension, cyanosis and asphyxia (blue baby syndrome) in infants less than 3 months [26]. Nitrate-nitrogen (NO3-N) in groundwater may results from point sources such as sewage disposal systems and livestock facilities, non-point sources such as fertilized cropland.

The fluoride values in the study area ranges from 0.09 to 0.34 mg/l. The concentration of fluoride in groundwater is principally governed by climate, the composition of the host rock and hydrogeology [27, 28]. Fluoride is the principle bearer of fluoride and is found in granite, gneiss and pegmatite [29]. Probable source of high fluoride in Indian waters seems to be that during weathering and circulation of water in rocks and soils fluorine is leached out and dissolved in groundwater. High concentration of fluoride is also due to fertilizer usage in agricultural activities for killing the insects. The fluorides concentration in all the samples is below the BIS standards limit 1.0 mg/l. Fluoride is beneficial for human beings as a trace element, this protects tooth decay and enhances bone development. Excess intake of fluoride through drinking water causes fluorosis on human being.

Water Quality Index

Groundwater chemistry has been utilized as a tool to outlook water quality for various purposes [30]. Water quality index were calculated using nine indicator parameters of water quality and the National Sanitation Foundation (NSF). Water quality index (WQI) is an important technique for demarcating groundwater quality and its suitability for drinking purposes [31]. The concept of WQI to represent gradation in water quality was first proposed by Horten [32]. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption [33]. The standard for drinking purposes as recommended by IS-10500 is considered for the calculation of WQI. The spatial distribution of water quality index is shown in Figure 4. The WQI has been calculated is ranged from 37.34 to 650 (Figure 4).The computed WQI values for 15 wells as shown in fig and therefore can be categorized into 5 types "excellent water to unsuitable water". Accordingly 1 water sample class (I) is excellent water,1 water sample in class(II) is good water, 5 samples in class (II) is poor water, 6 samples in class (IV) is very poor water and 2 samples in class (V) is unsuitable for drinking purpose. Hence majority of the water samples are poor to very poor in water quality.

Classification of groundwater

The trilinear diagram of Piper are very useful in determining chemical relationships in groundwater is more definite terms than is possible with other plotting methods [34]. Piper's trilinear method is used to classify the groundwater, based on basic geochemical characters of the constituent ionic concentration. The chemical data of the groundwater samples collected from the study area are plotted in the piper's diagram (Figure. 5). The piper diagram shows the type of water present in a region. About 60% of the water samples are Na-Cl type and 33.37% comes under Mixed Ca-Na-Cl type and only one sample in Ca-HCO3 type (Figure 5). It can be inferred from plots that the groundwater was of mixed type with multiple processes involved in its evolution.

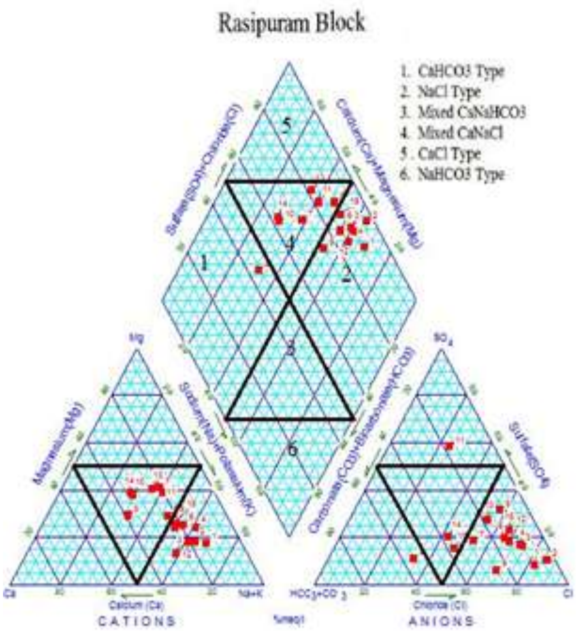

Fig.5: Hydro-geochemical facies

Irrigation Water Quality Assessment

The suitability of water for irrigation purposes depends upon its mineral constituents. Excessive amounts of dissolved ions in irrigation water affect plants and agricultural soil physically and chemically, thus educing the productivity. The physical effects of these ions are to reduce the osmotic pressure in the plant, thus preventing water to reaching the branches and leaves. The chemical effects disrupt plant metabolism. It is the quantity of certain ions, such as sodium and boron, rather than the total salt concentration that affects plant development. The control of salt and alkali in the soil is an important as the supplying of irrigation water for the development and maintenance of successful irrigation project. Parameters such as EC, sodium percentage (Na%), Sodium adsorption Ration (SAR), Residual Sodium Carbonate (RSC) and permeability index (PI) were used to assess the suitability of groundwater for irrigation purposes as shown in Table 1.

Salinity Hazard

Sodium Adsorption Ration (SAR) is an estimate of the degree to which sodium will be adsorbed by the soil. It is used to evaluate the suitability of water for irrigation. High value of SAR means that sodium in the water may replace calcium and magnesium ions in the soil, potentially causing damage to the soil structure and such soil becomes impermeable leading to low fertility and cultivation ability [35]. Sodium-rich water [36] may deteriorate the physical structure of the soil (pore clogging). SAR is an important parameter for determine the suitability of groundwater for irrigation because it is measure of alkali/sodium hazard to crop [37]. Salinity and toxicity problems of irrigation water are attributed to SAR. Sodium adsorption ratio is the proportion of sodium to calcium and magnesium, which affect the availability of water to the crop. The values of SAR of the groundwater samples ranged from 1.12 to 20.65 (Figure 6). The groundwater samples are plotted on the basis of their SAR and EC values according to the diagram published by USSL (Fig2). Sodium hazard of irrigation water can be well understood by knowing SAR which determines its utility for agricultural purposes. The most of the groundwater samples fall in C3S2 (High saline and medium sodium) zone that can be used for irrigational purposes. Most of the analyzed groundwater samples are medium sodium waters meaning that the water is most suitable when used on coarse-textured or organic soil with good permeability and plants with good salt tolerance. A Graph is plotted between Electrical Conductivity and Sodium Adsorption Ratio, from the graph it is inferred that about 80% of the sample have good water infiltration capacity and only 20% have Poor Water Infiltration capacity.

Wilcox Diagram

Sodium concentration is important in classifying irrigation water because sodium reacts with soil to reduce its permeability [38]. Wilcox proposed a diagram for irrigation groundwater. The percent sodium is plotted against EC (Figure 7). The Na^+% in the study area ranged between 28% and 68% in the groundwater. The maximum Na content of 60% is recommended for irrigation water. Classifying groundwater based on Na% and EC following Wilcox. Figure shows that about 60% of samples falls in good to permissible and 20% of samples falls in excellent to good category, 13.33% of samples occur in the fields of permissible to doubtful and 6.67% of samples comes under doubtful to unsuitable category.

Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate (RSC) value considers the bicarbonate content of the water. High concentration of bicarbonate leads to an increase in pH value of water that causes dissolution of organic

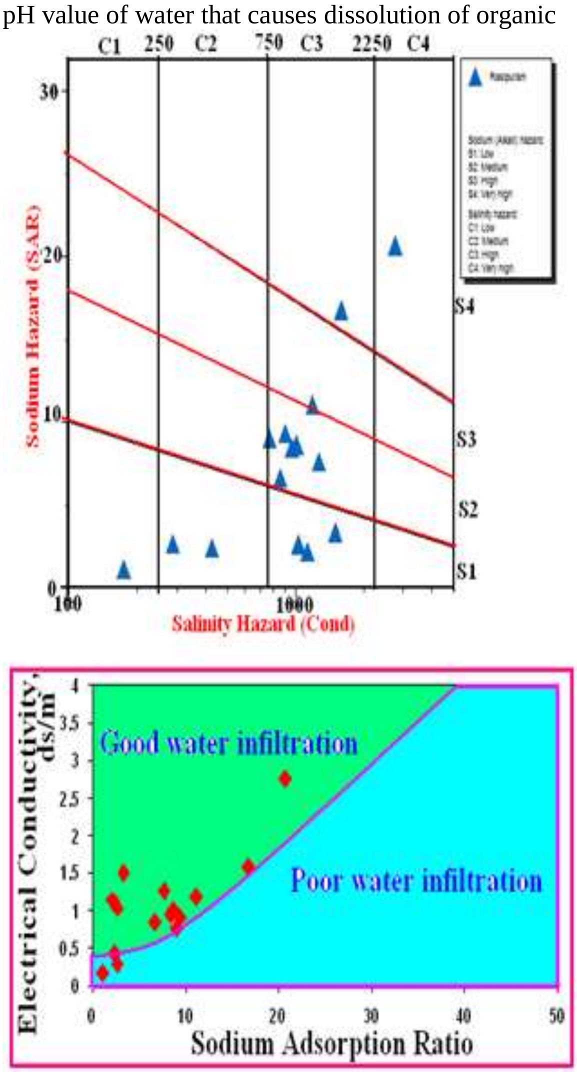

Fig.6: USSL diagram and SAR vs. EC diagram suitability for irrigation

matter. An increase in RSC value leads also to precipitate calcium and magnesium that can cause increase sodium content in the soil. The high concentration of bicarbonate ion in irrigation water leads to its toxicity and affects the minerals nutrition of plant.

According to Eaton's classification, water with RSC greater than >2.5 epm is considered unsuitable for irrigation [39]. The water with RSC of 1.25 to 2.5 is considered as marginal and those with a value less than <1.25 are safe for irrigation purpose. All the water samples analyzed had RSC values of less than 1.25 suggesting that the water can be used for irrigation purpose.

Residual Sodium Bicarbonate (RSBC)

The RSBC was calculated according to [40] using; where, all concentration of the constituents is expressed in meq/l. According to the US Department of Agriculture, water having more than 2.5 epm of RSBC is not suitable for irrigation purposes. All groundwater samples of the study area had RSBC less than 2.5 epm indicating that the water is safe for irrigation purposes.

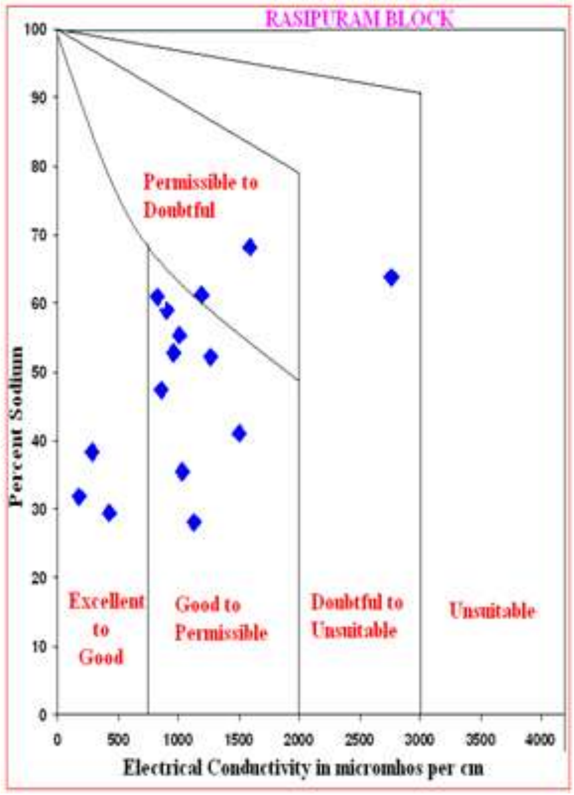

Fig.7: Wilcox diagram suitability for irrigation

Table: 1 Groundwater Classification Based on Agricultural Utilities

Electrical Conductivity(μS/cm)	**Salinity Class**	**Sample Number**
<250	Excellent	1
250-750	Good	2
750-2250	permissible	11
2250-4000	Unsuitable or Very high C4	1
%Na	**Suitability for irrigation**	**Sample Number**
<20	Excellent	Nil
20-40	Good	5
40-60	Permissible	6
60-80	Doubtful	4
>80	Unsuitable	Nil
SAR	**Type of Water Classification**	**Sample Number**
<10	Excellent	12
10-18	Good	2
18-26	Doubtful	1
>26	Unsuitable	Nil
PI	**Type of Water Classification**	**Sample Number**
<25%	Good with 75% max. permeability	Nil
25-75%	Good	15
<75%	Unsuitable with 25% max. permeability	Nil

Permeability index (PI)

The soil permeability is affected by long term use of irrigation water. It is influenced by sodium, calcium, magnesium and bicarbonate contents of soils. Doneen has evolved a criterion for assessing the suitability of water for irrigation based on permeability index [41]. The PI values >75% comes under class I and indicates that the excellent quality of water for irrigation. The PI values between 25% - 75% comes under class II indicates that the good quality of water for irrigation and the PI value less than 25% comes under class III indicates that the unsuitable nature of water for irrigation. In the present study, the PI values range from 36.9% to 71.3% respectively. The above result therefore suggests that water samples fall within class II and can be categorized as good irrigation water.

Kelly's Ratio

Kelly's ratio measuring Na+ against Ca2+ and Mg2+ [42] is known as Kelley's ratio, and it is used to rate irrigation water. 90% of the tested samples classified as good because all the KR values fall within the permissible limit of 1, indicating the good quality of groundwater for irrigation purpose.

V. CONCLUSION

The quality of groundwater in the study area is fresh to brackish, moderately hard to very hard. The piper plot shows that most of the groundwater samples fall in the field of Na-Cl type and mixed CaNaCl. TH is generally high to very high in the study area therefore it is unsuitable for drinking purposes. The information provided in WQI. The concentrations of major ions in groundwater are with in the permissible limits for drinking except in some places. The suitability of water for irrigation is evaluated based on USSL, Wilcox, RSC, PI diagram. On the basis of USSL and Wilcox diagram the groundwater are within the safe limit of irrigation except few locations. This attributes that groundwater in a few places can be used for plants having good salt tolerance cropping patterns to overcome suitability problems for irrigation purposes. However, PI values indicate that most of the groundwater samples are suitable for irrigation. Most of the samples in Rasipuram block fall in the suitable range for irrigation purposes. Natural and anthropogenic activities affect the spatial variation of groundwater quality in the area. Hence continuous monitoring of groundwater quality is essential in order to supply potable water to the rural people.

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