# AN EVALUATION OF GROUNDWATER QUALITY FOR IRRIGATION PURPOSE IN REDDIYARCHATRAM BLOCK OF DINDIGUL DISTRICT, TAMIL NADU

**Dr.C.Florence Annal**

Assistant Professor, Department of Geography, M.V.Muthiah Government Arts Collegefor Women, Dindigul

---

## Abstract

Groundwater samples were collected from 24 sample locations and analyzed for hydrochemistry of groundwater in the study area. The hydro chemical parameters selected for the present study namely Alkalinity, PH, EC, TDS, CL, $SO_2$-, Na, Ca, Mg using Arc GIS to show the variations in the distribution of each ion in the study area. SAR ratio, SSP Ratio, Kelly's ratio , RSC ratio and USSL ratio also calculated to demarcate the groundwater samples locations for irrigation purpose.

***Keywords:*** *Ground water, hydro chemical parameters, irrigation spatial distribution,GIS.*

## Introduction

Water quality, soil types and cropping practices play an important role for a suitable irrigation practice. Irrigation water quality varies greatly upon the types and quantity of dissolved salts. Thus, water for irrigation Suitability is determined not only by the total amount of salt present but also by the kind of salt. Excessive amounts of dissolved ions in irrigation water affect plants and agricultural soil physically and Chemically, thus reducing productivity. The physical effects of these ions are to lower the osmotic pressure in the plant structural cells, thus preventing water from reaching the branches and leaves. The chemical effects disrupt plant metabolism. Water quality problems in irrigation include indices for salinity, Chlorinity, Sodicity and alkalinity. EC and Na+ play a vital role in suitability of water for irrigation. Higher EC in water creates a saline soil. Harmful effects of irrigation water increases with the total salt concentration, irrespective of the ionic composition. The salts apart from affecting the growth of plants also affect the soil structure, Permeability and aeration which indirectly affect plant growth. SAR is the most commonly used for evaluating groundwater suitability for irrigation purposes Ayers and . It is normally expressed as Na content or alkali hazard which is normally expressed in Sodium adsorption ratio SAR .The irrigation water quality is judged by the four most applied criteria. These are: (I) total dissolved solids (TDS) i.e. the total salt concentration measured by EC (II) relative proportion of Sodium to other cations, expresses by Sodium Adsorption Ratio (SAR) (III) concentration of certain specific elements and (IV) residual Sodium Carbonate (RSC). Good irrigation water is the one which will not retard the plant growth. The quality of irrigation water depends upon various types of impurities present in water are Concentration of sediments in water, Total Concentration of soluble salts (known as TDS), Proportion of Sodium ions to other cations, Concentration of toxic elements such as boron Concentration, Concentration of bicarbonate in relation to the concentration of calcium andmagnesium.

## Study Area

Reddiarchtram is one of the revenue block in Dindigul district of Tamilnadu. Reddiarchatram block is located between $10^0$ $36^,$ N latitude and $77^0$ $98^,$ E longitude. It occupies an area of 279.25 sq.km. It is bounded by Oddanchatram in the north, Dindigul in the east, Author in the south and Kodaikanal in the west. The block is divided into 24 revenue villages , 138 hamlets and 2 town panchayats. Geologically the block is covered by crystalline metamorphic rock. Geomorphologically the block is divided into western mountainous terrain and pediment composite plain. The vast pediplain areas of the block have undergone different pediment modification. Reddiarchatram block consists of the dark brown to dark reddish brown and calcareous soils. Dark brown to reddish soils are found in various parts of 18 villages , dak brown soil is found in some parts of 8villages and calcareous soils are distributed in gentle slope of the block. Average annual rainfall to the place is an important factor that could be considered for selection of crop. The highest rainfall 1255.6mm is received during north east monsoon and 40.45mm rainfall is the maximum during south west monsoon season. There are 115 tanks, 6 dams and 9583 wells both open and bore wells, 7 large and 55 small tank are used for irrigation. the total irrigated area is more than 50% of the cultivated land. According to 2011 census the density of population of the Reddiarchatram is 267 per sq. km. . The sex ratio is 998 per 1000 males. The percent of literate population to the total population of Reddiarchatram is 64.8%. Cultivators are the major working groups in this block. Agricultural workers who do not own land but work for wages are dominant in the block. House hold workers dominant in surrounding areas.

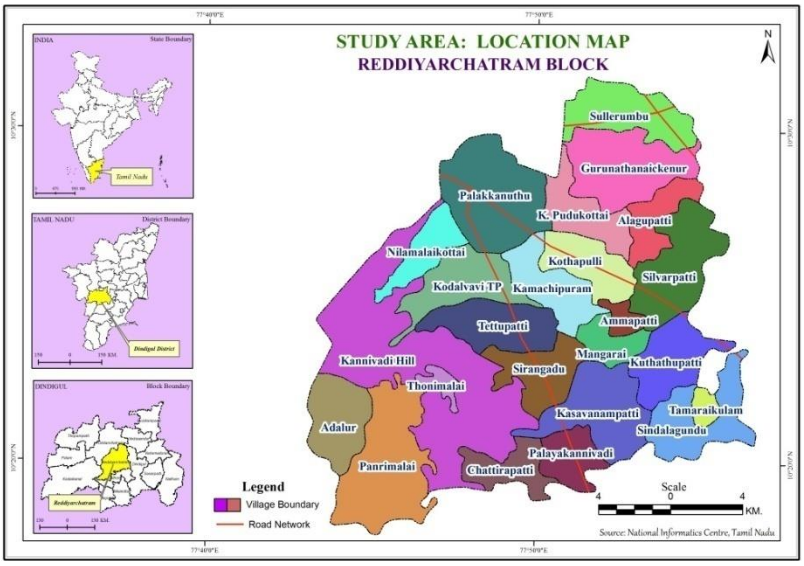


**Fig-1**

## Aims and Objectives

The study aims to assess the groundwater quality through chemical analysis for irrigation purpose in the study area; the objectives of the study are to

- To identify and analyses the Physio – chemical parameters which makewater unfit for irrigation and
- To delineate the area into suitable and unsuitable for irrigation based onthe quality of ground water using GIS thematic mapping.

## Materials and Methods

Ground Water sample were collected from 24 wells and bore wells water analysis of chemical parameters. Sample bottles were cleaned by rinsing them with distilled water followed by their treatment with 1M solution of the preservative acid. In the case of bore wells (hand pumps) the water samples were collected after pumping for 10- 15 minutes in order to remove stagnant groundwater. There are four basic criteria for evaluating water quality for irrigational purposes, viz. salinity hazard, sodium hazard, excessive concentration of toxic elements and excessive presence of other miscellaneous elements.

Various tests were conducted according to the Standard Methods forexamination of water. Water quality parameters which were studied are as follows: total dissolved solids (TDS), electrical conductivity (EC), PH, Calcium (Ca), Magnesium (Mg), Sodium (Na), Potassium (K), Carbonate ($CO_3$), Bicarbonate ($HCO_3$), Nitrate ($NO_3$), Sulphate ($SO_4$) and Chloride (Cl). These parameters mainly consist of certain physical and chemical characteristics of water that are used in the evaluation of agricultural water quality. Numerous water quality guidelines have been developed by many researchers for using water in irrigation under different condition. However, the classification of US Salinity Laboratory (USSL) is most commonly used .Parameters such as EC, TDS, pH, Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP) and Residual Sodium Carbonate (RSC) were used to assess the suitability of water for irrigation purposes.

## Result and Discussion

### Sodium Adsorption Ratio (SAR)

A high salt concentration in water leads to formation of a saline soil and high sodium leads to development of an alkali soil. The sodium or alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of Sodium Adsorption Ratio(SAR). If the proportion of sodium is high, the alkali hazard is high; and conversely, if calcium and magnesium predominate, the hazard is less. Thereis a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. If water used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of the clay particles. A simple method of evaluating the danger of high- sodium water is the sodium adsorption ratio, SAR. Where all ionic concentrations are expressed in milliequivalent per liter. Calculation of SAR for given water provides a useful index of the sodium hazard of that water for soils and crops. A low SAR (2 to 10) indicates little danger from sodium; medium hazards are between 7 and 18, high hazards between 11 and 26, and very high hazards above that. It indicates the degree to which irrigation water tends to enter into cation-exchange reactions in soil. The excess sodium or limited calcium and magnesium content are evaluated by SAR computed as:

$$SAR = Na+ / \surd Ca + Mg / 2$$

The average values of SAR in the study area is ranged 0- 6.3. about 100% of the SAR for groundwater sample of the study area are less then 10 indicates excellent (SI) category while no SAR for groundwater sample of the study area within the range of 10-18 indicates good quality for irrigation.The figure 2 shows that the entire study area are having suitable water for irrigation based on sodium Absorption Ratio.

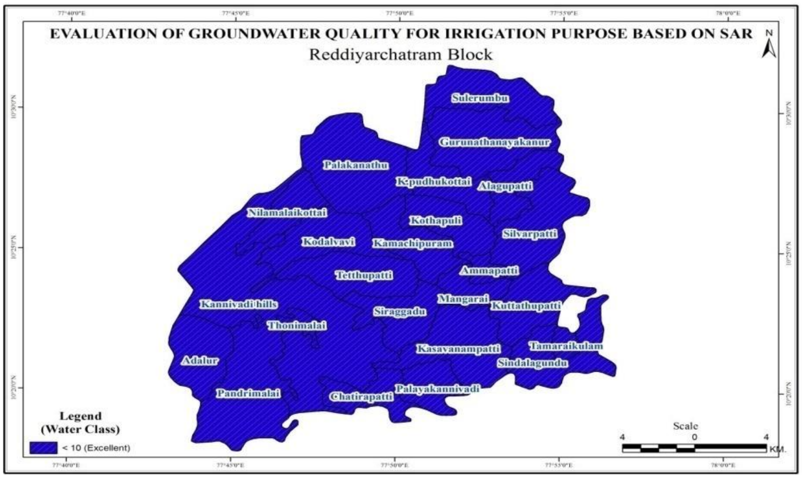


Fig-2

**U.S. Salinity Laboratory Classification**

U.S. Salinity Laboratory classification (Wilcox, 1955) is used to study the suitability of ground water for irrigation purposes. In classification of irrigation waters, it is assumed that the water will be used under average conditions with respect to soil texture, infiltration rate, drainage, quantity of water used, climate and salt tolerance of crop. The US Salinity Laboratory’s diagram is widely used for rating the irrigation waters, where SAR is plotted against EC. The plots of chemical data of the groundwater samples in the US Salinity Laboratory’s diagram are illustrated in the total concentrations of soluble salts in irrigation water can be classified into low (C1), medium (C2), high (C3) and very high (C4) salinity zonesSodium concentration is an important criterion in irrigation-water classification because sodium reacts with the soil to create sodium hazards by replacing other cations. The extent ofthis replacement is estimated by Sodium Adsorption Ratio (SAR). A diagram for use in studying the suitability of ground water for irrigation purposes is based on the sodium adsorption ratio (SAR) and electrical conductivity of water expressed in μS/cm.

Evaluation of ground water quality for irrigation purpose based on EC values is present in figure 3. It reveals that excellent and good quality water for irrigation was found in 4 villages and in 11 villages the water comes under permissible for irrigation category. About 6 villages show the water is suitable for irrigation and the remaining 2 villages have unsuitable water for irrigation.

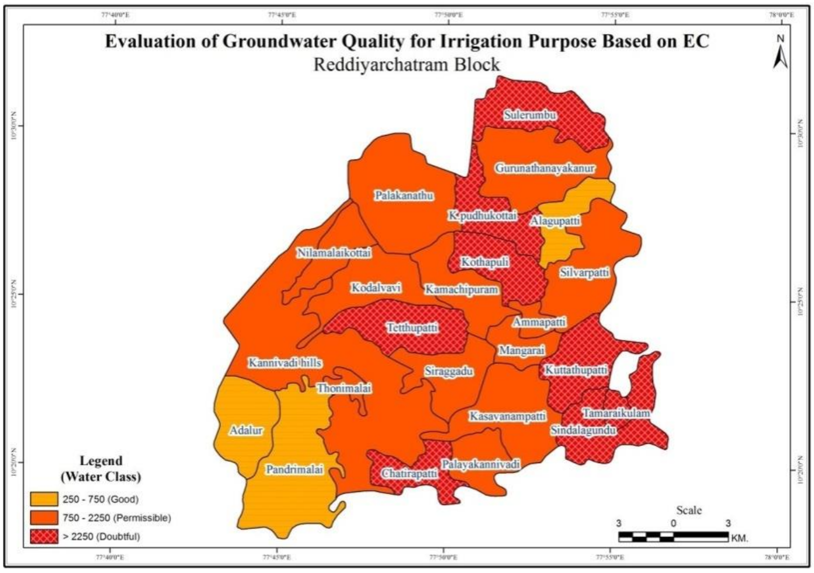


Fig- 3

## Sodium Percentage

The suitability of the groundwater for irrigation depends on the mineralization in water and its effect on plants and soil. The concentration of sodium is highin irrigation water, the sodium ions tend to be absorbed by clay particles, displacing Mg2+ and Ca2+ ions. This exchange process of Na+ in water for Ca2+ and Mg2+ in soil reduces the permeability and eventually results in soil with poor internal drainage. Groundwater was grouped based on average percent sodium as excellent (<20%), good (20-40%), permissible (40-60%), doubtful (60-80%) and unsuitable (>80%). Out of the selected wells, 10% had excellent irrigation water quality, 60% had good irrigation water quality, 25% had permissible irrigation water quality and 5% had doubtful irrigation water quality .Percent sodium can be determined using the following formula:

$$Na\% = \{(Na^+ + K^+) / (Ca^{2+} + Mg^{2+} + Na^+ + K^+)\}\ 100$$

Where all ionic concentrations are expressed in millieqivalent per litre.

The sodium percentage in the study area varies from 0 – 67.6 (table 1 ). As per the world health organization ,2011 standards, the sodium percentage of 60 is the maximum recommended limit for irrigation water. Figure 4 shows the evaluation of ground water quality for irrigation purpose based on sodium percentage. It is observed from the figure that entire study area having excellent, good, and permissible water for irrigation. Only4 villages having unsuitable water for irrigation. Irrigation water with high sodium percentage may cause sodium accumulation and calcium deficiency in the soil and hence breakdown of its physical properties.

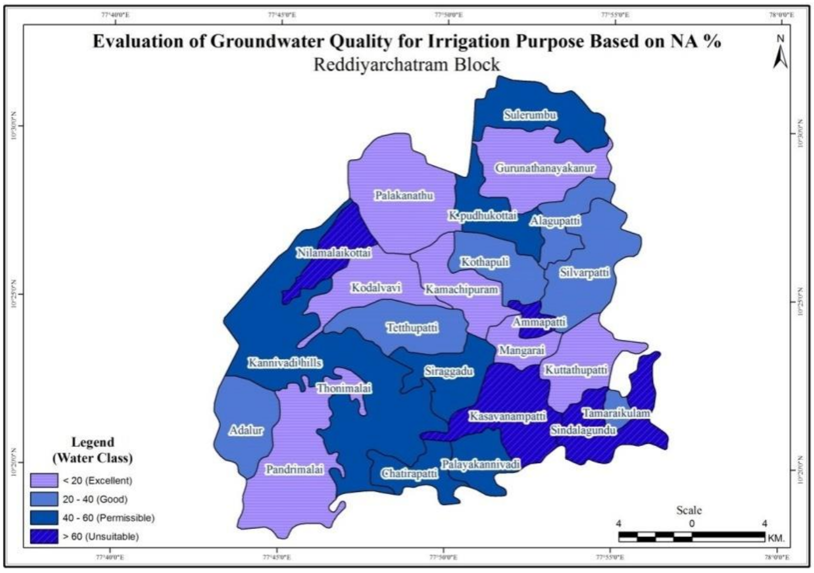


Fig - 4

**Magnesium Hazard**

Although calcium and magnesium ions are essential for plant growth but they may be associated with soil aggregation and friability. Magnesium is washed from rocks and subsequently ends up in water. High concentration of calcium and magnesium in irrigation water can increase soil pH, resulting in reducing availability of phosphorus. Water contains calcium and magnesium concentration higher than 10 meq/l (200mg/l) cannot be used in agriculture. Magnesium ion concentration also plays an important role in productivity of soil. A large number of minerals contain Magnesium. Chemical industries add magnesium to plastics and other materials as a fire protection measure or as filter. Magnesium content is considered as one important criterion in determining the quality of surface water for irrigation. It also ends up in the environment from fertilizer application and from cattle feed . If the Magnesium Ratio is greater than 50 percentage it is considered as unsuitable for irrigation purpose . It has been noted that if magnesium hazard is less than 50, the water is safe and suitable for irrigation. It can be calculated by this formula:

$$\text{Mg content} = \{Mg / (Mg + Ca2)\}\ 100$$

The magnesium ratio in ground water samples varies from 5.88 – 39.5 epm (table 1 ). In the study area about 100% of the groundwater sample shows less than 50% of magnesium ratio and indicates suitable water for irrigation.

**Potential Salinity**

Potential salinity pointed out that the suitability of water for irrigation is not dependent on the concentration of soluble salts. The opinion that low solubilitysalts precipitate in the soil and accumulate with each successive, whereas the concentration of highly soluble salts increases the salinity of the soil. Potentialsalinity is defined as the chloride concentration plus half of the sulphateconcentration. “Potential salinity” was introduced for assessing the suitability of water for irrigation uses which may be defined as the chloride concentration plus half of the sulfate concentration .

$$\text{Potential Salinity} = Cl + \tfrac{1}{2}\ SO4\ .$$

In the study area the potential salinity varies from 1.2 – 41.9. about 4.1% of the ground water sample location shows less then 3 potential salinity values and indicates excellent to good water for irrigation. Nearly 12.5% of the sample location have the potential salinity values of 3- 5 and comes under good to injurious water category for irrigation. The remaining 83.3% have above 5 of potential salinity values and shows injurious to unsuitable water class for irrigation Figure 5 classify the study area based on potential salinity. Excellent water category for irrigation found in only one village of the study area. Good injurious water category for irrigation found in 3 villages and 83.3% unsuitable water found in 20 villages of the study areas.

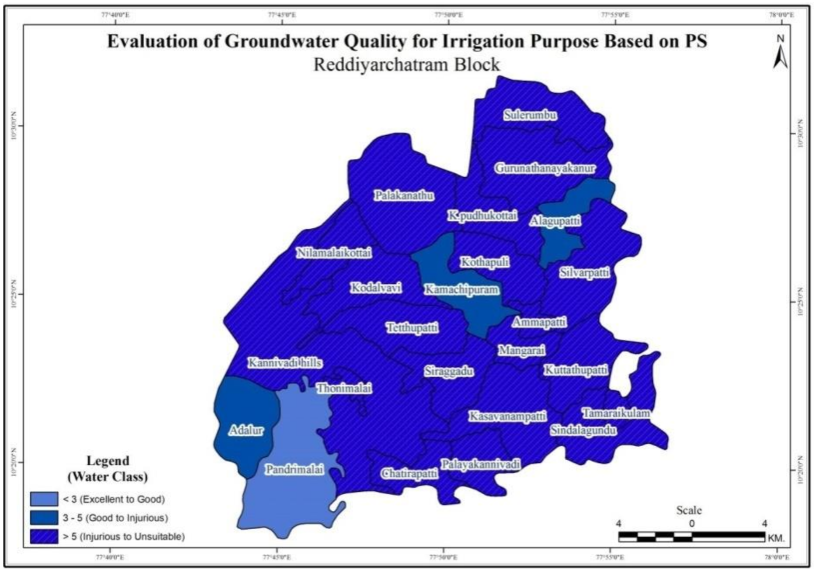


**Fig - 5**

## Residual Sodium Carbonate

The concentration of bicarbonate and carbonate also play a vital role forclassification of irrigation waters. The relative abundance of sodium with respect to excess of carbonate and bicarbonate over alkaline earth affects the suitability of water for irrigation purpose and this excess is donated by residual sodiumcarbonate (RSC) and is determine by the formula(Richards, 1954) as given below.

$$RSC = (CO3+HCO3) - (Ca+Na)$$

Where the concentration of ions is expressed in meq/1.

In general the high concentration of CO3 and HCO3 represents alkaline nature. Bicarbonate and carbonate: bicarbonate occur in low salinity waters and their concentration usually decrease with increase in EC. The proportion of bicarbonates ions is higher then calcium ions and has been considered to be undesirable because after evaporation of irrigation water, bicarbonate ions tend to precipitate calcium ions. The values of RSC in the study area ranges from 0.9 – 37.1. ground water having less then 1.25 or equal to 1.25 epm of RSC is marginally suitable for irrigation purpose where as water having more than 2.5 epm of RSC is not suitable for irrigation purpose. Based on the RSC values 12.5% of sample location have safe water and 87.5% have unsuitable water for irrigation in the study area. (table 1).From the figure 6 It was analyzed that the safe water for irrigation based on RSC values spreads in south western ,part ,marginally suitable water found in west and north western part. Unsuitable water found in central and surrounding villages of the study area.

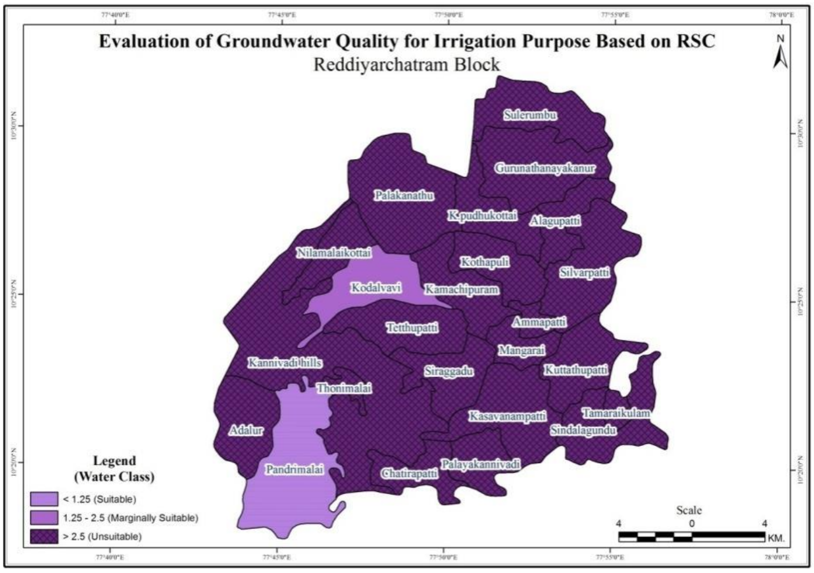


Fig- 6

**Kelly's Index**

Sodium measured against Ca2+ and Mg2+ is used to calculate Kelley's ratio. SAR is a better measure for sodium, and this particular ration is not in common use, but this study also presents a review of all the quality criteria of classification to evaluate the obtained dataset. A Kelly's index of more than 1 indicates an excess level of sodium in waters. Hence, waters with a Kelly's index less than 1 are suitable for irrigation, while those with a ratio more than 1 are unsuitable. the sodium problem in irrigational water could very conveniently be worked out on the basis of the values of Kelley's ratio.'Permeability Index' after conducting a series of experiments for which he has used a large number of irrigation waters varying in ionic relationships and concentration. The following in the formula

Kelly ratio = NA/Ca+Mg

The Kelly's ratio has been calculated for all the water sample of the study area.It varies from 0 – 1.63 epm (table 1). About 87.5% of the Kelly's ratio values for the groundwater of the study area are less than 1 and indicates good quality water for irrigation purpose while remaining 12.5% is more than and indicates the unsuitable water quality for irrigation ( table 1 ). Evaluation of groundwater for irrigation purpose based on Kelly's ratio is presented in (figure 7). Except 3 villages all other villages comes under good water category for irrigation based on Kelly's ratio.

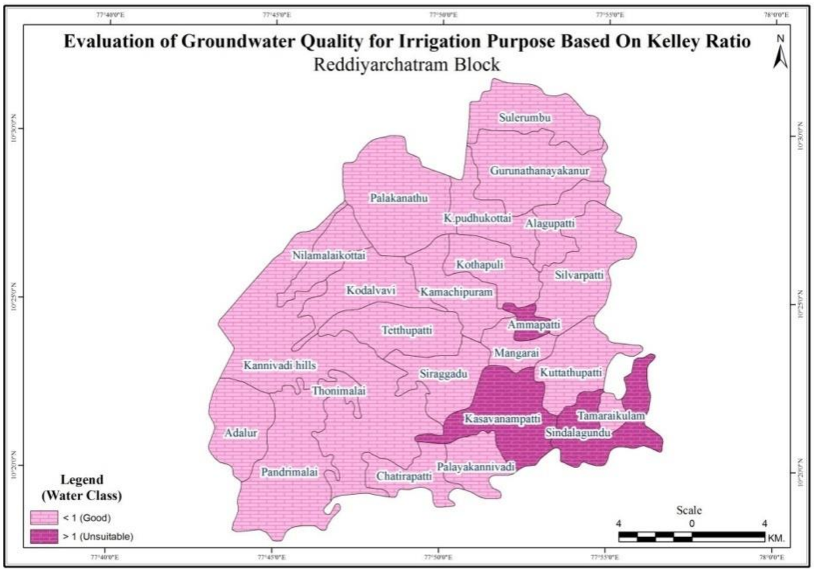


Fig - 7

**Soluble Sodium Percentage (SSP)**

Soluble Sodium Percentage (SSP) is used to evaluate sodium hazard. The concentrations of Ca+2, Mg+2and Na+ are expresses in milliequivalents per liter (epm). Water with a SSP greater than 60% may result in sodium accumulations that will cause a breakdown in the soil's physical properties. The ratio of the exchangeable Na+ to total exchangeable cations (Exchangeable Sodium Percentage, ESP) is a good indicator for soil structure deterioration. High value of ESP means high sodium ion concentration in the water , and high sodium concentration means dispersing soils by replacing the calcium and partly of the magnesium ions from soil exchange complex. The sodium in irrigation waters is also expressed as percent sodium or soluble sodium percentage SSP and can be determined using the following equation :

**SSP** = [Na + / (Ca + Mg + Na ]xl00

The soluble sodium percent values less than 50 or equal to 50 indicates good quality water and if it is more than 50 indicates unsuitable water quality for irrigation. The values of soluble sodium percent range from 0 – 63.5. Nearly 83% of the SSP values for the groundwater locations of the study area are less than 50 andindicates good quality water for irrigation purpose while remaining 17% is more than 50 and indicates the unsuitable water quality for irrigation. The figure 8 Shown the evaluation of groundwater quality for irrigation based on sodium soluble percentage. The analysis shows that 4 villages have unsuitable water for irrigation based on SSP. The remaining entire study areas have good water quality for irrigation.

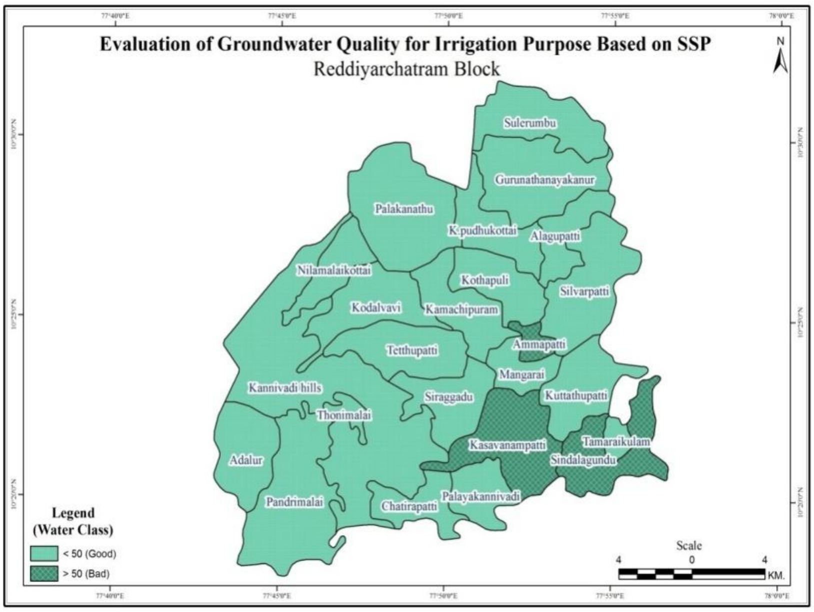


Fig-8

## Conclusion

Groundwater samples from the study area were analyzed for chemical parameters and the data was interpreted to found the groundwater quality for irrigation purpose in the study area. Based on SAR ratio all the sample locations came under suitable water for irrigation purpose. According to EC values nearly 15 percent of the water samples comes under good quality water for irrigation and the remaining water samples comes under permissible and unsuitable categories for irrigation. The analysis revealed that entire study area having excellent, good, and permissible water for irrigation sodium. The evaluation of ground water quality for irrigation purpose based on MG ratio revealed that entire study area having suitable water quality for irrigation purpose. Potential salinity values and indicates excellent to good quality water for irrigation is found in the study area. Based on the RSC values the safe water for irrigation spread in south western part ,marginally suitable water found in west and north western part and unsuitable water found in central part of the study area. Evaluation of groundwater for irrigation purpose based on Kelly's ratio presented that except 3 villages all other villages shown good quality water for irrigation. Nearly 83.3% of the SSP values for the groundwater locations of the study area are less than 50 and indicates good quality water for irrigation purpose while remaining 16.7% is more than 50 and indicates the unsuitable water quality for irrigation. The analysis shown that 4 villages shows unsuitable water for irrigation based on SSP and the remaining study area have good water quality for irrigation.

## REFERENCES

1.Gulshan etal., ( 2019), Evaluation of Groundwater Quality for irrigation and drinking purposes in Barishal District of Bangladesh, Fundamental and Applied Agriculture Journal, Vol 4, No 1, pp 632- 641

2. Haipeng Guo etal, ( 2021) Evaluation of Groundwater Suitability for Irrigation and Drinking purposes in an Agricultural Region of North China Plain, Journal of Water , Vol 13, Issue 23, pp 3426.

3. Lakshmi and Shanthi.T., (2015) Evaluation of Water Quality for Irrigation purpose in dye affected soil in river Noyil region, International Journal of Innovative Science, engineering & Technology, Vol 2, Issue 2, pp 285.

4. Mohammed Amin Bhat (2016), Assessment of Groundwater quality for Irrigation purposes using chemical Indices, Indian Journal of Ecology, Vol 43, No 2, pp 574-579

5. Seam Iamail et al., ( 2015), Hydro chemistry and Evaluation of Groundwater suitability for irrigation and drinking purposes in West El- Mania District, North Upper Egypt, International Water Technology Conference , Vol 12, NO 14, pp 158.

6. Sharma etal ( 2017), Evaluation of Groundwater Quality and Suitability for Irrigation and Drinking purposes , South west Punjab, India Using hydro chemical Approach, Journal of Applied Water Science, Vol 7, Issue 6, pp 3137-3150

7.Sisal Kant Nag etal., (2015) Delineation of Ground water quality for drinking and irrigation purposes: A case study of Chant Block , Bandhura District, West Bengal, International Journal of water resources, Vol III, No 1, pp234.

8. Wilcox, L.V. 1948. The Quality of Water for Irrigation Use. U.S. Deptt. of Agri. Tech. Bull., Washington DC., pp. 40.

Annexure – 1

Table – 1- Chemical Parameters

| Sl.No | Name of the Panchayat | SAR | NA% | MR | PS | KR | SSP | PH | EC | TDS | RSC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Adalur | 1.45 | 37.3 | 16.6 | 3.3 | 0.5 | 33.3 | 7.6 | 0.67 | 0.42 | -3.9 |
| 2 | Alagupatti | 0.52 | 22.9 | 38.2 | 3.15 | 0.17 | 14.5 | 7.6 | 0.61 | 0.39 | -2.6 |
| 3 | Ammapatti | 6.3 | 64.2 | 28.5 | 11.7 | 1.62 | 63.5 | 8.2 | 2.10 | 1.34 | -15 |
| 4 | Chattirapatti | 0.52 | 47.9 | 13.8 | 10.5 | 0.10 | 9.2 | 7.4 | 2.44 | 1.56 | -10.1 |
| 5 | Gurunathanaickanur | 1.1 | 12.8 | 18.8 | 7.15 | 0.65 | 20.7 | 7.5 | 1.15 | 0.73 | -8.3 |
| 6 | K.Pudukottai | 3.76 | 49.1 | 17.6 | 14.4 | 0.75 | 42.9 | 6.8 | 2.46 | 1.57 | -4.4 |
| 7 | Kamachipuram | 0.21 | 11.6 | 20 | 4.45 | 0.05 | 5.06 | 7.3 | 0.85 | 0.54 | -5 |
| 8 | Kannivadi kills | 2.96 | 55.4 | 24.3 | 10.5 | 0.73 | 42.2 | 7.7 | 1.84 | 1.17 | -10.5 |
| 9 | Kasavanampatti | 5.43 | 71.7 | 27.2 | 10.6 | 1.63 | 62.0 | 7.8 | 1.95 | 1.24 | -9.85 |
| 10 | Kodalvavi | 0.32 | 9.41 | 20.7 | 9.4 | 0.05 | 5.5 | 7.4 | 1.70 | 1.08 | -2 |
| 11 | Kothapuli | 1.96 | 25.5 | 30.3 | 16.5 | 0.30 | 23.5 | 8.0 | 2.70 | 1.72 | -18.7 |
| 12 | Kulaththupatti | 0.46 | 8.78 | 19.9 | 10.9 | 0.05 | 5.6 | 7.9 | 3.30 | 1.11 | -23.7 |
| 13 | Magarai | 1.84 | 19.1 | 39.5 | 11.5 | 0.22 | 18.2 | 7.5 | 1.94 | 1.24 | -19.7 |
| 14 | Nilamalaikottai | 1.66 | 61.1 | 23.8 | 5.45 | 0.57 | 36.3 | 7.7 | 1.08 | 0.69 | -4 |
| 15 | Palakkanuthu | 0.19 | 8.6 | 16.0 | 7.65 | 0.06 | 3.52 | 7.9 | 1.50 | 0.96 | -8.6 |
| 16 | Palayakannivadi | 3.26 | 46.5 | 15.5 | 8.45 | 0.83 | 45.3 | 6.9 | 1.44 | 0.92 | -11.9 |
| 17 | Pandrimalai | 0 | 0 | 34.4 | 1.2 | 0.0 | 0.0 | 7.9 | 0.29 | 0.18 | -0.9 |
| 18 | Silvarpatti | 1.96 | 29.6 | 15.6 | 6.4 | 0.34 | 25.8 | 8.2 | 1.18 | 0.75 | -7.9 |
| 19 | Sirggadu | 2.83 | 60 | 25. | 5.65 | 1.0 | 50.0 | 8.0 | 1.0 | 0.64 | -5.8 |
| 20 | Sindalakundu | 4.82 | 67.6 | 19.7 | 15.4 | 1.23 | 55.2 | 7.5 | 2.35 | 1.50 | -14.5 |
| 21 | Sullerumbu | 3.08 | 41.8 | 14.8 | 41.9 | 0.39 | 28.2 | 7.2 | 5.30 | 3.39 | -37.1 |
| 22 | Tamaraikulam | 2.97 | 33.5 | 12.5 | 24.9 | 0.47 | 31.9 | 7.4 | 3.01 | 1.92 | -24 |
| 23 | Tettupatti | 2.53 | 32.0 | 35.8 | 17.7 | 0.40 | 28.8 | 7.8 | 2.87 | 1.83 | -19.1 |
| 24 | Thonimalai | 1.08 | 17.0 | 5.88 | 12.5 | 0.18 | 15.8 | 7.4 | 2.05 | 1.31 | -18 |

Source: Primary data Collected from the study area