ISSN: 0975-833X

*Available online at http://www.journalcra.com*

*International Journal of Current Research*
*Vol. 9, Issue, 02, pp.47254-47263, February, 2017*

**INTERNATIONAL JOURNAL OF CURRENT RESEARCH**

## RESEARCH ARTICLE

# SPATIO-TEMPORAL FOR GROUNDWATER QUALITY ZONES IN THE ARASALARU SUB BASIN, CAUVERY BASIN, TAMIL NADU

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**ARTICLE INFO**

*Article History:*
Received 24th November, 2016
Received in revised form
25th December, 2016
Accepted 05th January, 2017
Published online 28th February, 2017

*Key words:*

SAR, Sodium Percentage, Electrical Conductivity, Magnesium Ratio, Arasalaru River.

**ABSTRACT**

In the present study, the chemical characteristics of groundwater with respect to drinking and irrigation water quality in Arasalaru Sub-Basin have been studied. 50 groundwater sample were collected and analyzed for pH, Total Dissolved solids, Total Hardness, Calcium, Magnesium, Carbonate, Bicarbonate, Chloride, Sodium, Potassium, Sulphate etc. The values analyzed were evaluated in detail and compared with WHO water quality standards. It is observed that, for most of the groundwater quality parameters, the values are not potable for drinking and irrigational use. To understand the spatial distribution of unsuitable zones, ArcGIS was employed. Attributes were linked and spatial interpolation mapping was done. Inverse distance weighted interpolation technique was followed for raster and vector mapping. Finally the overlay analyses were also carried out to locate the worst quality zone.



**Citation: Thamilarasan, T. and Sankar, K. 2017.** "Spatio-temporal for groundwater quality zones in the Arasalaru sub basin, Cauvery basin, Tamil Nadu", *International Journal of Current Research*, 9, (02), 47254-47263.

## INTRODUCTION

Groundwater is used for domestic supply, industries and agriculture in most parts of the world as it is a replenishable resource and has inherent advantages over surface water. Several parts of the Dharwad district are facing an acute shortage of drinking water owing to poor quality of groundwater. Hedge and Puranik (1992, 1996), Hedge *et al*. (1992, 1999), Munuswamy *et al*. (1993), Abbi and Puranik (2000) and Hedge (2003) have discussed the quality of groundwater in certain part of Dharwad district. The Central Groundwater Board (CGWB, 2000) has provided a general account of the hydrogeological aspects of the district. Elsewhere, Munn (1936a), Subhash Chandra and Ganachari (1981) have studied chemical quality of groundwater of extensive black soil zones of Bellary and Raichur districts. Water quality is determined by the solute and gases dissolved in the water. The recent studies (SAC, 1986; NRSA, 1995; Sahai, 1993; Sahai *et al*., 1993, Srivastava *et al*., 1999) have focused on the utility of high resolution satellite imageries to identify and outline the surface features more accurately. In the present study, groundwater samples have been collected and analyzed for various parameters such as EC, pH, TDS, Ca, Mg, HCO3, Cl, Na and K etc., the analyzed results were taken in to GIS environment. The suitability of groundwater for drinking, irrigation and industrial purposes depends upon its quality. Changes in groundwater quality may be caused by variations in climate conditions, residence time of water, aquifer materials, and inputs from soil during recharge (Mitra *et al*., 2007; Giridharan *et al*., 2008; Krishna *et al*., 2009). The uncontrolled applications of fertilizers and manure is often one of the main sources of groundwater pollution, especially in developing countries. Many natural hydrogeochemical processes are also involved in the control of the chemical composition of groundwater, including the dissolution of carbonate, the weathering of silicates minerals and ion exchange reactions (Giridharan *et al*., 2008; Krishna *et al*., 2009; Jalali 2007; Rao 2008)

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### Geology

Geologically, Arasalaru Sub Basin falls under the Ariyalur groups of cretaceous comprised of limestone, kankar, clay, sand, gravels and some of the isolated pockets Cuddalore sandstones are found. Most of the study area open well and tube wells are found. In the western part of the study area groundwater conditions unconfined nature whereas eastern parts semi confined conditions prevailed. Water table are found to be in the open well areas 40-80 feet whereas tube well areas 350-500 feet and the average annual rainfall about 700-800 mm. Most of the Land use/Land Cover are crown are sugarcane, paddy and cotton and rest of the land existing saline/salty nature and it could be seen as a uncultivated lands.

**Hydrogeochemistry**

The groundwater development in Arasalaru River is substantial. Some of the dug and bore wells tapping the phreatic aquifers show salinity. A continuous decline in groundwater level has been observed in many parts of India (Shah 2010; Jin and Feng 2013; World Bank (2011).

**Calcium (Ca)**

In the study area, total concentration of Calcium ranges from 22 to 92 ppm in the groundwater samples within the average value 57. The samples are 90% of falls within the permissible limit and 10% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Sargunashwarapuram, Kovilpathu, Pillaithiruvaasal and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi. Total Concentration of Magnesium ranges from 36 to 140 ppm in the groundwater samples in Arasalaru river. The sample falls more than the permissible limit.

**Chloride (Cl)**

In the study area, total concentration of Chloride ranges from 53 to 245 ppm in the groundwater samples in Arasalaru river. The sample falls more than the permissible limit. In situ measurements of Electrical Conductivity (EC) of water samples from different locations in the Arasalaru River could indirectly indicate the level of mineralization in the phreatic zone. Based on these observations water samples 50 representive water samples were collected and analysed for the Regional Laboratory of Central Groundwater Board, Tamil Nadu (Aris *et al*, 2007). All the major ions in 95% of the samples are well within the standards specified for drinking and other purpose (BIS, 1991). The electrical conductivity of water is an index of mineralization (Hem, 1991). In the study area, total concentration of Electrical Conductivity ranges from 410 to 1970 ppm in the groundwater samples in Arasalaru river. The sample falls more than the permissible limit.

**Bicarbonate ($HCO_3$)**

In the study area, total concentration of Bicarbonate ranges from 24 to 320 ppm in the groundwater samples in Arasalaru river. The samples are 12% of falls within the permissible limit and 88% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Nachiar Kovil, Manandakudi, Vichchiyur, Viluthiyur, Tudapanamulai and Kizhkudi and minimum exists in the areas of Sarukkai, Cholanmaligai, Ariyapuram, Vanniyadi, Thirunallar and Puthudurai. According to Freeze and Cherry (1979), under a nitrification process in the presence of oxygen, ammonium is transformed into nitrate. In the study area, total concentration of Nitrate ranges from 22 to 50 ppm in the groundwater samples in Arasalaru river basin.

The samples are 8% of falls within the permissible limit and 92% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Muthupillai Mandapam, Thukkachi and Thiruvizhimizhalai and minimum exists in the areas of Muthutheruvu, Cholanmaligai, Darasuram, Kidamangalam, Sellur, Serumavilangai and Mel Kasakudi.

**pH**

In the study area, total concentration of pH ranges from 6 to 8 ppm in the groundwater samples in Arasalaru river. Maximum concentration values are found in the areas of Nachiar Kovil, Manandakudi, Vichchiyur, Viluthiyur, Tudapanamulai and Kizhkudi and minimum exists in the areas of Sarukkai, Cholanmaligai, Ariyapuram, Vanniyadi, Thirunallar and Puthudurai. pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. pH was positively correlated with electrical conductance and total alkalinity (Guptaa 2009). The reduced rate of photosynthetic activity the assimilation of carbon dioxide and bicarbonates which are ultimately responsible for increase in pH, the low oxygen values coincided with high temperature during the summer month.

**Sulphate ($SO_4$)**

In the study area, total concentration of Sulphate ranges from 22 to 158 ppm in the groundwater samples in Arasalaru river. Maximum concentration values are found in the areas of Nachiar Kovil, Manandakudi, Vichchiyur, Viluthiyur, Tudapanamulai and Kizhkudi and minimum exists in the areas of Sarukkai, Cholanmaligai, Ariyapuram, Vanniyadi, Thirunallar and Puthudurai.

**Total Dissolved Solids**

Groundwater can be divided based on the distribution of total dissolved solids following Wilcox (Op. cit) and WHO (1993), such as up to 18 ppm (permissible for domestic use), 81-2400 ppm (useful for irrigation) and > 2400 ppm (unsuitable for domestic, industrial and irrigation purposes and listed in table). In the study area, total dissolved solids concentration ranges from 81.90 to 2576.70 ppm in the groundwater samples. The samples are 100 percentage of the sample within the permissible limit for domestic use. Shows the Total Dissolved Solids in the Arasalaru Sub- Basin and it could be seen from this figure the maximum concentration are exits in the area of North-Western parts of the study area whereas maximum concentration are seen the area of northwestern parts of the study area.

**Quality of water for irrigation**

Assessment of the suitability of groundwater for irrigation purpose requires consideration of the total dissolved solids, concentration of any other substance that may be toxic to plants and relative amount of certain constituents. The important characteristics or properties of groundwater to be considered for irrigational use are Electric Conductivity (EC), salinity, Percentage Sodium (% NA), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC). EC and Na concentration primarily determine the quality of irrigational water. High EC values were reported from various part of the study area especially from coastal side. An elevated salt content in irrigation water leads to the formation of saline soil. This affects salt intake capacity of plants through their roots. With respect to EC values, Richard (1954) classified irrigation water in to four groups. Ten samples during post monsoon and seven samples during pre monsoon fall in fair category. High salinity water cannot be used on soil where there is restricted drainage. Excess salinity diminish the osmotic activity of plants, capacity of absorption of water and nutrients from the soil (Saleh *et al*., 1999).

**Table 1. Geochemical Characteristics of Arasalaru Sub Basin, Cauvery Basin, Tamil Nadu (in ppm)**

| S.No. | Location | EC | pH | Ca | Mg | Na+K | $HCO_3$ | Cl | $SO_4$ | $NO_3$ | TDS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sarukkai | 450 | 8 | 38 | 66 | 39 | 24 | 128 | 110 | 39 | 81.90 |
| 2 | Vanniyadi | 760 | 7 | 76 | 85 | 71 | 194 | 140 | 158 | 50 | 1549.80 |
| 3 | Mudutheruvu | 610 | 7 | 24 | 79 | 51 | 187 | 53 | 112 | 36 | 384.30 |
| 4 | Vellai Pillaiyam Pettai | 470 | 7 | 42 | 73 | 72 | 104 | 75 | 66 | 42 | 151.20 |
| 5 | Swamimalai | 680 | 6 | 43 | 43 | 63 | 143 | 57 | 77 | 43 | 182.70 |
| 6 | Cholanmaligai | 560 | 7 | 38 | 62 | 40 | 153 | 63 | 115 | 38 | 289.80 |
| 7 | Dharasuram | 420 | 7 | 22 | 55 | 38 | 183 | 57 | 99 | 22 | 264.60 |
| 8 | Ariyapuram | 940 | 7 | 25 | 50 | 97 | 148 | 138 | 112 | 25 | 592.20 |
| 9 | Ariyatidal | 700 | 7 | 40 | 44 | 53 | 136 | 57 | 79 | 40 | 441 |
| 10 | Vilvarayanallur | 850 | 7 | 38 | 66 | 51 | 178 | 85 | 112 | 38 | 535.50 |
| 11 | Muthupillai Mandapam | 1000 | 7 | 45 | 64 | 97 | 188 | 110 | 78 | 45 | 680.40 |
| 12 | Chettimandapam | 1500 | 7 | 38 | 39 | 80 | 106 | 113 | 53 | 38 | 957.60 |
| 13 | Kuthanur | 890 | 7 | 28 | 40 | 120 | 148 | 103 | 77 | 36 | 560.70 |
| 14 | Villiyavarambal | 840 | 7 | 60 | 65 | 170 | 188 | 219 | 77 | 31 | 1159.2 |
| 15 | Alagaputhur | 1010 | 7 | 35 | 44 | 110 | 166 | 117 | 65 | 50 | 636.30 |
| 16 | Nachiar Kovil | 610 | 8 | 45 | 36 | 90 | 205 | 83 | 77 | 42 | 384.30 |
| 17 | Tandanthottam | 1000 | 8 | 44 | 45 | 140 | 176 | 160 | 75 | 40 | 630 |
| 18 | Thukkachi | 1800 | 7 | 59 | 70 | 210 | 180 | 176 | 101 | 47 | 1455.30 |
| 19 | Pudukudi | 1700 | 8 | 69 | 116 | 184 | 127 | 117 | 115 | 33 | 1260 |
| 20 | Keerangudi | 1720 | 7 | 30 | 55 | 78 | 144 | 135 | 88 | 34 | 453.60 |
| 21 | Sarguneshwarapuram | 800 | 7 | 79 | 140 | 118 | 181 | 210 | 86 | 38 | 2576.70 |
| 22 | Maruthuvakudi | 410 | 7 | 42 | 75 | 74 | 153 | 153 | 70 | 40 | 258.30 |
| 23 | Thiruvizhimizhalai | 750 | 7 | 44 | 60 | 93 | 129 | 128 | 55 | 46 | 157.50 |
| 24 | Vadugakudi | 960 | 7 | 55 | 70 | 76 | 131 | 135 | 44 | 38 | 107.10 |
| 25 | Manandakudi | 790 | 7 | 34 | 82 | 97 | 244 | 149 | 66 | 44 | 497.70 |
| 26 | Kovilpathu | 1110 | 7 | 84 | 73 | 160 | 189 | 145 | 43 | 35 | 1877.40 |
| 27 | Poonthottam | 1700 | 8 | 60 | 92 | 182 | 170 | 180 | 62 | 40 | 1701 |
| 28 | Injikudi | 990 | 7 | 39 | 52 | 97 | 197 | 124 | 66 | 45 | 623.70 |
| 29 | Andakudi | 1180 | 8 | 42 | 66 | 162 | 127 | 170 | 110 | 33 | 743.40 |
| 30 | Kizhkudi | 1200 | 8 | 56 | 51 | 114 | 320 | 210 | 31 | 40 | 756 |
| 31 | Rettaikudi | 1530 | 8 | 64 | 39 | 117 | 160 | 186 | 43 | 44 | 963.90 |
| 32 | Ambal | 1110 | 7 | 44 | 78 | 120 | 121 | 184 | 29 | 37 | 919.80 |
| 33 | Parakudi | 1600 | 7 | 48 | 90 | 222 | 184 | 138 | 158 | 35 | 1638 |
| 34 | Vichchiyur | 900 | 8 | 42 | 85 | 106 | 210 | 174 | 91 | 30 | 1915.20 |
| 35 | Kidamangalam | 1680 | 7 | 68 | 79 | 149 | 145 | 144 | 34 | 27 | 1058.40 |
| 36 | Naliazhandu | 1480 | 7 | 32 | 85 | 133 | 198 | 132 | 53 | 32 | 1562.40 |
| 37 | Mattur | 1670 | 8 | 40 | 76 | 145 | 188 | 152 | 82 | 33 | 1052.10 |
| 38 | Kokapadi | 1810 | 8 | 70 | 92 | 141 | 150 | 222 | 77 | 37 | 2400.30 |
| 39 | Alayankudi | 1970 | 7 | 30 | 64 | 192 | 158 | 245 | 111 | 37 | 1146.60 |
| 40 | Sellur | 1470 | 7 | 40 | 94 | 129 | 166 | 198 | 76 | 28 | 923.10 |
| 41 | Serumavilangai | 1840 | 7 | 65 | 89 | 155 | 139 | 190 | 99 | 31 | 1159.20 |
| 42 | Mel Kasakudi | 700 | 7 | 44 | 53 | 95 | 114 | 153 | 110 | 33 | 315 |
| 43 | Pillaithiruvasal | 1320 | 8 | 80 | 79 | 162 | 198 | 147 | 22 | 44 | 1461.60 |
| 44 | Thirunallar | 840 | 8 | 46 | 62 | 73 | 127 | 153 | 66 | 41 | 529.20 |
| 45 | Puduthurai | 880 | 7 | 39 | 79 | 92 | 120 | 106 | 99 | 40 | 415.80 |
| 46 | Karaikal | 820 | 7 | 45 | 64 | 98 | 181 | 135 | 55 | 34 | 516.60 |
| 47 | Kilinjumedu | 1670 | 7 | 92 | 112 | 128 | 190 | 123 | 62 | 31 | 1682.10 |
| 48 | Viludiyur | 930 | 7 | 47 | 75 | 75 | 205 | 110 | 73 | 36 | 522.90 |
| 49 | Tudapanamulai | 1200 | 8 | 50 | 42 | 131 | 206 | 184 | 67 | 37 | 718.20 |
| 50 | Uliyapattu | 1700 | 8 | 55 | 73 | 188 | 180 | 169 | 53 | 30 | 1291.4 |

**Table 2. Geochemical Characteristics of Arasalaru Sub Basin, Cauvery Basin, Tamil Nadu (in epm)**

| S.No. | Location | EC | Ca | Mg | Na+K | $HCO_3$ | Cl | $SO_4$ | $NO_3$ | TDS |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sarukkai | 450.00 | 1.89 | 5.42 | 1.69 | 0.39 | 3.60 | 2.29 | 0.62 | 288.00 |
| 2 | Vanniyadi | 760.00 | 3.79 | 6.99 | 3.82 | 3.17 | 3.94 | 3.28 | 0.80 | 486.40 |
| 3 | Mudutheruvu | 610.00 | 1.19 | 6.49 | 2.28 | 3.06 | 1.49 | 2.33 | 0.58 | 390.40 |
| 4 | Vellai Pillaiyam Pettai | 470.00 | 2.09 | 6.00 | 3.13 | 1.70 | 2.11 | 1.37 | 0.67 | 300.80 |
| 5 | Swamimalai | 680.00 | 2.39 | 3.53 | 2.75 | 2.34 | 1.60 | 1.60 | 0.69 | 435.20 |
| 6 | Cholanmaligai | 560.00 | 1.59 | 5.09 | 1.78 | 2.50 | 1.77 | 2.39 | 0.61 | 358.40 |
| 7 | Dharasuram | 420.00 | 1.49 | 4.52 | 1.65 | 2.99 | 1.60 | 2.06 | 0.35 | 268.80 |
| 8 | Ariyapuram | 940.00 | 2.09 | 4.11 | 4.28 | 2.42 | 3.89 | 2.33 | 0.40 | 601.60 |
| 9 | Ariyatidal | 700.00 | 1.99 | 3.61 | 2.37 | 2.22 | 1.60 | 1.64 | 0.64 | 448.00 |
| 10 | Vilvarayanallur | 850.00 | 1.64 | 5.42 | 2.23 | 2.91 | 2.39 | 2.33 | 0.61 | 544.00 |
| 11 | Muthupillai Mandapam | 1000.00 | 1.49 | 5.26 | 4.23 | 3.08 | 3.10 | 1.62 | 0.72 | 640.00 |
| 12 | Chettimandapam | 1500.00 | 1.89 | 3.20 | 3.49 | 1.73 | 3.18 | 1.10 | 0.61 | 960.00 |
| 13 | Kuthanur | 890.00 | 1.39 | 3.28 | 5.23 | 2.42 | 2.90 | 1.60 | 0.58 | 569.60 |
| 14 | Villiyavarambal | 840.00 | 2.99 | 5.34 | 7.49 | 3.08 | 6.17 | 1.60 | 0.49 | 537.60 |
| 15 | Alagaputhur | 1010.00 | 1.74 | 3.61 | 4.88 | 2.72 | 3.29 | 1.35 | 0.80 | 646.40 |
| 16 | Nachiar Kovil | 610.00 | 2.24 | 2.96 | 3.91 | 3.35 | 2.34 | 1.60 | 0.67 | 390.40 |
| 17 | Tandanthottam | 1000.00 | 2.19 | 3.70 | 6.08 | 2.88 | 4.51 | 1.56 | 0.64 | 640.00 |
| 18 | Thukkachi | 1800.00 | 2.94 | 5.75 | 9.89 | 12.78 | 4.96 | 2.10 | 0.75 | 1152.00 |
| 19 | Pudukudi | 1700.00 | 3.44 | 9.53 | 8.1 | 2.08 | 3.29 | 2.39 | 0.53 | 1088.00 |
| 20 | Keerangudi | 1720.00 | 1.49 | 4.52 | 3.49 | 2.35 | 3.80 | 1.83 | 0.54 | 1100.80 |

*Continue……*

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 21 | Sarguneshwarapuram | 800.00 | 3.94 | 4.52 | 5.28 | 2.96 | 5.92 | 1.79 | 0.61 | 512.00 |
| 22 | Maruthuvakudi | 410.00 | 2.09 | 11.51 | 3.26 | 2.50 | 4.31 | 1.45 | 0.64 | 262.4 |
| 23 | Thiruvizhimizhalai | 750.00 | 2.19 | 4.93 | 4.06 | 2.11 | 3.60 | 1.14 | 0.74 | 480.00 |
| 24 | Vadugakudi | 960.00 | 2.74 | 5.75 | 3.3 | 2.14 | 3.80 | 0.91 | 0.61 | 614.40 |
| 25 | Manandakudi | 790.00 | 1.69 | 6.74 | 4.95 | 3.99 | 4.20 | 1.37 | 0.70 | 505.60 |
| 26 | Kovilpathu | 1110.00 | 4.19 | 6.00 | 7 | 3.09 | 4.08 | 0.89 | 0.56 | 710.40 |
| 27 | Poonthottam | 1700.00 | 2.99 | 7.56 | 8.03 | 2.78 | 5.07 | 1.29 | 0.64 | 1088.00 |
| 28 | Injikudi | 990.00 | 1.94 | 4.27 | 4.23 | 3.22 | 3.49 | 1.37 | 0.72 | 633.60 |
| 29 | Andakudi | 1180.00 | 2.09 | 5.42 | 7.06 | 2.08 | 4.79 | 0.20 | 0.53 | 755.20 |
| 30 | Kizhkudi | 1200.00 | 2.79 | 4.19 | 5.74 | 5.24 | 5.92 | 0.64 | 0.64 | 768.00 |
| 31 | Rettaikudi | 1530.00 | 3.19 | 3.20 | 5.43 | 2.62 | 5.24 | 0.89 | 0.70 | 979.20 |
| 32 | Ambal | 1110.00 | 2.19 | 6.41 | 5.61 | 1.98 | 5.18 | 0.60 | 0.59 | 710.40 |
| 33 | Parakudi | 1600.00 | 2.39 | 7.40 | 9.75 | 3.01 | 3.89 | 3.28 | 0.56 | 1024.00 |
| 34 | Vichchiyur | 900.00 | 2.09 | 6.99 | 4.6 | 3.44 | 4.90 | 1.89 | 0.48 | 576.00 |
| 35 | Kidamangalam | 1680.00 | 3.39 | 6.49 | 6.47 | 2.37 | 4.06 | 0.70 | 0.43 | 1075.20 |
| 36 | Naliazhandu | 1480.00 | 1.59 | 6.99 | 5.8 | 3.24 | 3.72 | 1.10 | 0.51 | 947.20 |
| 37 | Mattur | 1670.00 | 1.99 | 6.25 | 6.3 | 3.08 | 4.28 | 1.70 | 0.53 | 1068.80 |
| 38 | Kokapadi | 1810.00 | 3.49 | 7.56 | 6.18 | 2.45 | 6.26 | 1.60 | 0.59 | 1158.40 |
| 39 | Alayankudi | 1970.00 | 1.49 | 5.26 | 8.34 | 2.58 | 6.90 | 2.31 | 0.59 | 1260.80 |
| 40 | Sellur | 1470.00 | 1.99 | 7.73 | 5.6 | 2.72 | 5.58 | 1.58 | 0.45 | 940.80 |
| 41 | Serumavilangai | 1840.00 | 3.24 | 7.31 | 6.78 | 2.27 | 5.35 | 2.06 | 0.49 | 1177.60 |
| 42 | Mel Kasakudi | 710.00 | 2.19 | 4.35 | 4.13 | 1.86 | 4.31 | 2.29 | 0.53 | 454.40 |
| 43 | Pillaithiruvasal | 1320.00 | 3.99 | 6.49 | 7.04 | 3.24 | 4.14 | 0.45 | 0.70 | 844.80 |
| 44 | Thirunallar | 840.00 | 2.29 | 5.09 | 3.19 | 2.08 | 4.31 | 1.37 | 0.66 | 537.60 |
| 45 | Puduthurai | 880.00 | 1.94 | 6.49 | 4.02 | 1.96 | 2.98 | 2.06 | 0.64 | 563.20 |
| 46 | Karaikal | 820.00 | 2.24 | 5.26 | 4.36 | 2.96 | 3.80 | 1.14 | 0.54 | 524.80 |
| 47 | Kilinjumedu | 1670.00 | 4.59 | 9.21 | 5.61 | 3.11 | 3.46 | 1.29 | 0.49 | 1068.80 |
| 48 | Viludiyur | 930.00 | 2.34 | 6.16 | 3.31 | 3.35 | 3.10 | 1.51 | 0.58 | 595.20 |
| 49 | Tudapanamulai | 1200.00 | 2.49 | 3.45 | 5.69 | 3.37 | 5.18 | 1.39 | 0.59 | 768.00 |
| 50 | Uliyapattu | 1700.00 | 2.74 | 6.00 | 8.22 | 2.94 | 4.76 | 1.10 | 0.48 | 1088.00 |

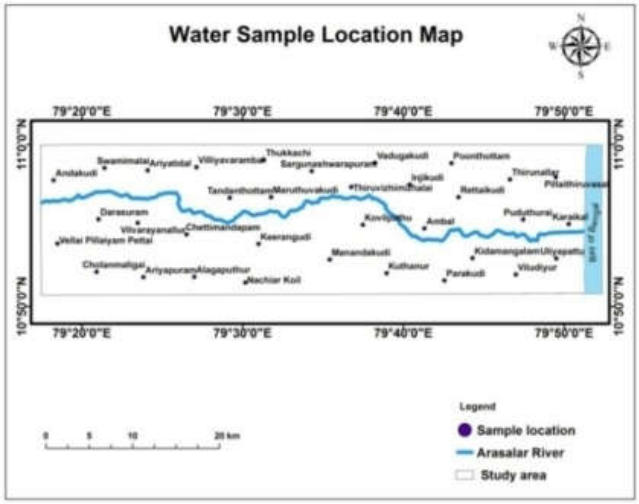


Fig.1. Map Showing Water sample of Arasalaru Sub-Basin, Cauvery Basin

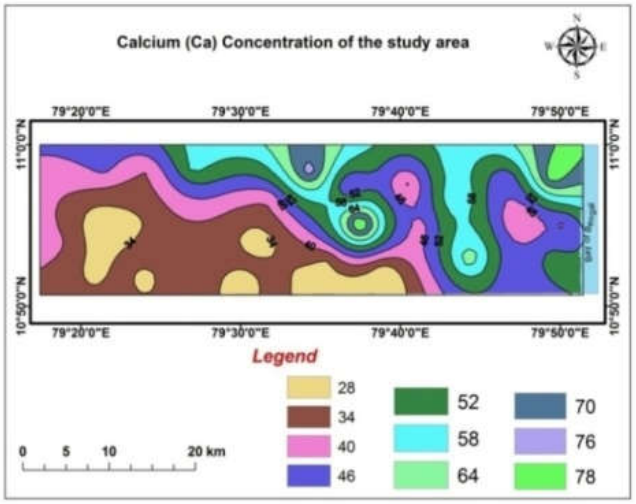


Fig.2. Map Showing Calcium Concentration of Arasalaru Sub-Basin, Cauvery Basin

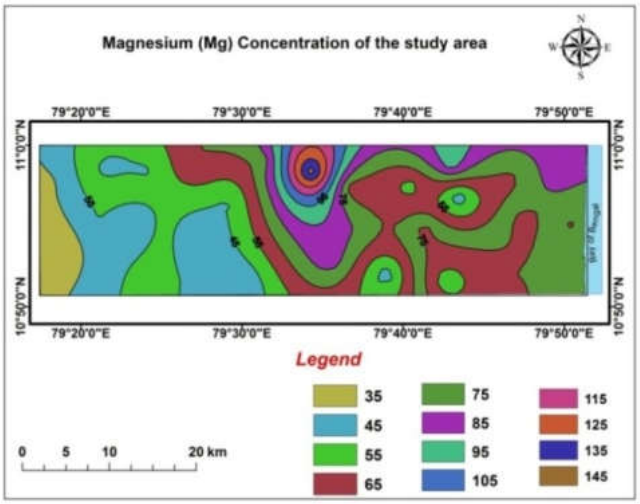


Fig.3. Map Showing Magnesium Concentration of Arasalaru Sub-Basin, Cauvery Basin

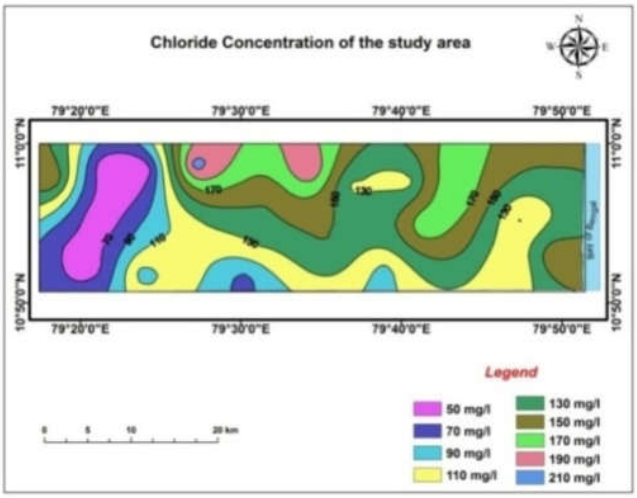


Fig.4. Map Showing Chloride Concentration of Arasalaru Sub-Basin, Cauvery Basin

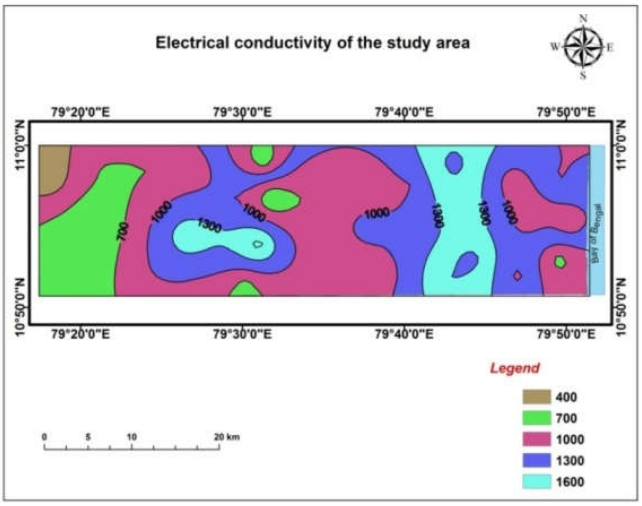


**Fig.5. Map Showing Electrical Conductivity of Arasalaru Sub-Basin, Cauvery Basin**

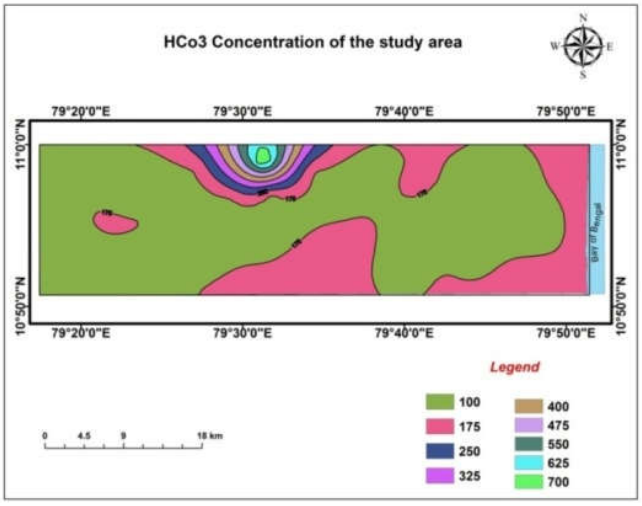


**Fig.6. Map Showing of Bicarbonate Concentration Arasalaru Sub-Basin, Cauvery Basin**

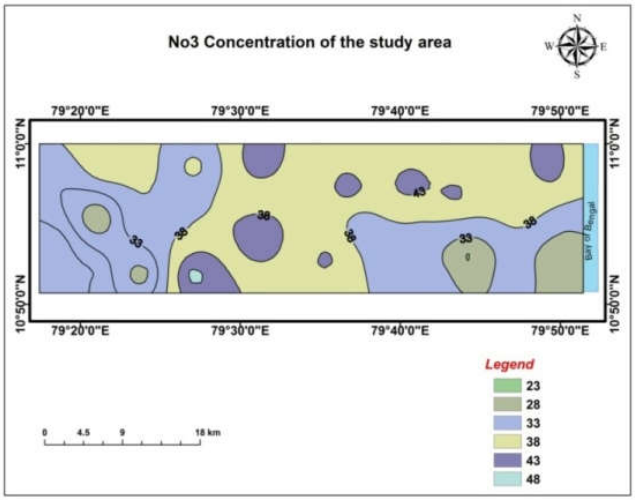


**Fig.7. Map Showing Nitrate Concentration of Arasalaru Sub-Basin, Cauvery Basin**

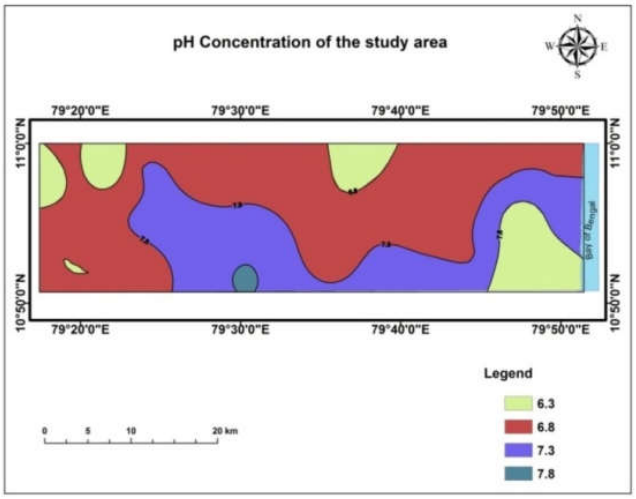


**Fig.8. Map Showing pH Concentration of Arasalaru Sub-Basin, Cauvery Basin**

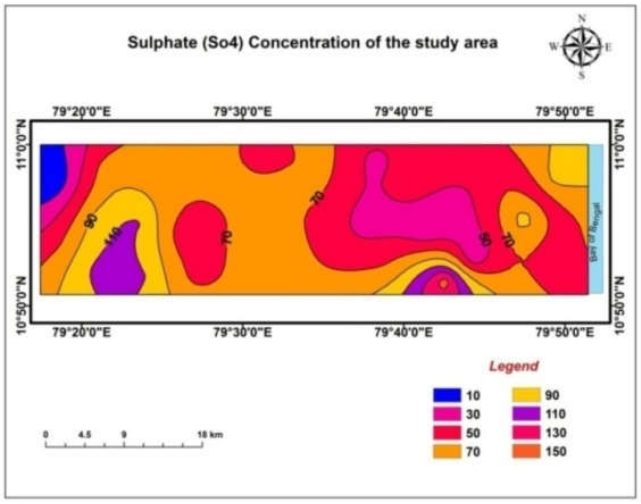


**Fig.9. Map Showing Sulphate Concentration of Arasalaru Sub-Basin, Cauvery Basin**

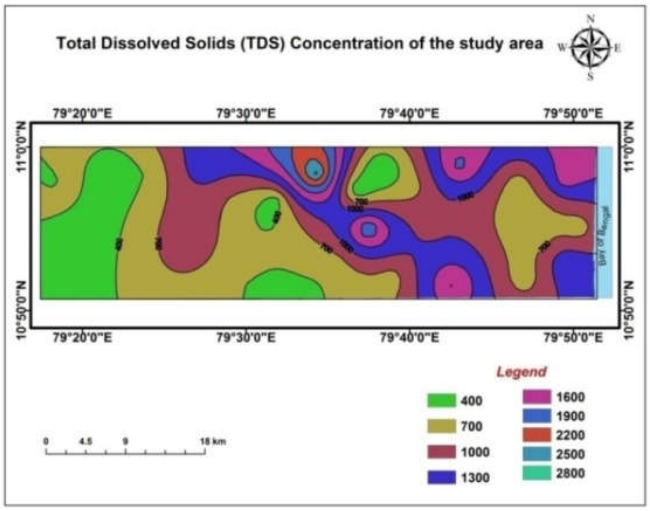


**Fig.10. Map Showing Total Dissolved Solids (TDS) Concentration of Arasalaru Sub-Basin, Cauvery Basin**

**Table 3. Physio-Chemical Characteristics of Arasalaru River Sub - Basin, Cauvery Basin, Tamil Nadu**

| S. No | Location | RSC | SAR | NCH | P.I | TH | NA% | CR | MR | CAI – I | CAI - II | GIBBS I | GIBBS II |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sarukkai | -6.92 | 0.88 | -12.19 | 25.66 | 0.365 | 18.78 | 4.16 | 74.14 | 0.53 | 0.58 | 0.4720 | 0.9022 |
| 2 | Vanniyadi | -6.04 | 1.43 | -147.72 | 39.54 | 0.539 | 26.17 | 4.12 | 75.89 | 0.03 | 0.02 | 0.50197 | 0.5541 |
| 3 | Mudutheruvu | -4.62 | 1.13 | -145.32 | 39.93 | 0.384 | 22.9 | 4 | 84.50 | -0.53 | -0.13 | 0.65706 | 0.3274 |
| 4 | Vellai Pillaiyam Pettai | -6.39 | 1.55 | -76.91 | 39.48 | 0.404 | 27.9 | 4.5 | 74.16 | -0.48 | -0.27 | 0.59961 | 0.5538 |
| 5 | Swamimalai | -3.58 | 1.81 | -111.08 | 49.13 | 0.296 | 31.72 | 4.33 | 59.62 | -0.72 | -0.24 | 0.53501 | 0.4060 |
| 6 | Cholanmaligai | -4.18 | 0.95 | -118.32 | 39.35 | 0.334 | 21.05 | 5 | 76.19 | -0.00 | -0.00 | 0.52818 | 0.4145 |
| 7 | Dharasuram | -3.02 | 0.95 | -143.49 | 43.99 | 0.300 | 21.54 | 4.33 | 75.20 | -0.03 | -0.01 | 0.52547 | 0.3485 |
| 8 | Ariyapuram | -3.78 | 2.39 | -114.8 | 55.33 | 0.31 | 40.84 | 3.75 | 66.29 | -0.10 | -0.07 | 0.67189 | 0.6164 |
| 9 | Ariyatidal | -3.38 | 1.37 | -105.4 | 47.84 | 0.28 | 29.74 | 4.33 | 64.46 | -0.48 | -0.17 | 0.54357 | 0.4188 |
| 10 | Vilvarayanallur | -4.69 | 1.13 | -138.44 | 39.85 | 0.353 | 24.00 | 4 | 71.31 | 0.07 | 0.02 | 0.57622 | 0.4509 |
| 11 | Muthupillai Mandapa | -3.67 | 2.30 | -147.25 | 54.37 | 0.337 | 38.52 | 4.33 | 77.92 | -0.36 | -0.21 | 0.73951 | 0.5016 |
| 12 | Chettimandapam | -3.36 | 2.18 | -81.41 | 55.84 | 0.254 | 40.67 | 4.5 | 62.86 | -0.10 | -0.09 | 0.64869 | 0.6476 |
| 13 | Kuthanur | -2.25 | 3.42 | -116.33 | 68.42 | 0.233 | 52.83 | 4 | 70.23 | -0.80 | -0.51 | 0.79003 | 0.5451 |
| 14 | Villiyavarambal | -5.25 | 3.62 | -145.67 | 58.14 | 0.416 | 47.34 | 4.33 | 64.10 | -0.21 | -0.25 | 0.71469 | 0.6670 |
| 15 | Alagaputhur | -2.62 | 2.93 | -130.65 | 63.37 | 0.267 | 47.70 | 4.66 | 67.47 | -0.48 | -0.33 | 0.7371 | 0.5474 |
| 16 | Nachiar Kovil | -1.85 | 2.42 | -162.3 | 63.00 | 0.26 | 42.92 | 4 | 56.92 | -0.67 | -0.28 | 0.6357 | 0.4112 |
| 17 | Tandanthottam | -3.01 | 3.55 | -138.11 | 64.91 | 0.294 | 50.79 | 4.22 | 62.81 | -0.35 | -0.31 | 0.7351 | 0.6102 |
| 18 | Thukkachi | 4.09 | 4.38 | -630.31 | 71.26 | 0.434 | 53.23 | 4.2 | 66.16 | -0.99 | -0.31 | 0.7708 | 0.2795 |
| 19 | Pudukudi | -10.89 | 3.14 | -91.03 | 45.44 | 0.648 | 38.44 | 4.66 | 73.47 | -1.46 | -0.96 | 0.7019 | 0.6126 |
| 20 | Keerangudi | -3.66 | 1.95 | -111.49 | 52.34 | 0.300 | 36.74 | 4 | 75.20 | 0.08 | 0.06 | 0.7008 | 0.6178 |
| 21 | Sarguneshwarapuram | -5.50 | 2.50 | -139.54 | 64.92 | 0.423 | 38.43 | 4.16 | 53.42 | 0.11 | 0.12 | 0.5726 | 0.6666 |
| 22 | Maruthuvakudi | -11.10 | 1.23 | -111.4 | 28.49 | 0.68 | 19.33 | 4 | 84.63 | 0.24 | 0.23 | 0.6093 | 0.6328 |
| 23 | Thiruvizhimizhalai | -5.01 | 2.14 | -98.38 | 49.19 | 0.356 | 36.31 | 4.28 | 69.24 | -0.13 | -0.11 | 0.6496 | 0.6304 |
| 24 | Vadugakudi | -6.35 | 1.60 | -98.51 | 40.37 | 0.424 | 27.99 | 4 | 67.72 | 0.13 | 0.14 | 0.5463 | 0.6397 |
| 25 | Manandakudi | -4.44 | 2.05 | -191.07 | 49.05 | 0.421 | 36.99 | 4.37 | 79.95 | -0.18 | -0.12 | 0.7454 | 0.5128 |
| 26 | Kovilpathu | -7.10 | 3.08 | -144.31 | 50.75 | 0.509 | 40.72 | 4.25 | 58.88 | -0.71 | -0.64 | 0.6255 | 0.5690 |
| 27 | Poonthottam | -7.77 | 3.45 | -128.45 | 51.84 | 0.527 | 43.22 | 4.2 | 71.65 | -0.58 | -0.63 | 0.7286 | 0.6458 |
| 28 | Injikudi | -2.99 | 2.39 | -154.79 | 57.58 | 0.310 | 40.52 | 4.14 | 68.76 | -0.21 | -0.14 | 0.6855 | 0.5201 |
| 29 | Andakudi | -5.43 | 3.64 | -96.49 | 58.28 | 0.375 | 48.45 | 4.44 | 72.17 | -0.47 | -0.81 | 0.7715 | 0.6972 |
| 30 | Kizhkudi | -1.74 | 2.66 | -255.02 | 60.60 | 0.349 | 45.12 | 4.16 | 62.02 | 0.03 | 0.03 | 0.6729 | 0.5304 |
| 31 | Rettaikudi | -3.77 | 2.85 | -124.61 | 58.32 | 0.319 | 45.94 | 4.4 | 50.07 | -0.03 | -0.04 | 0.6299 | 0.6666 |
| 32 | Ambal | -6.62 | 2.51 | -90.4 | 47.86 | 0.43 | 39.48 | 4.4 | 74.53 | -0.08 | -0.13 | 0.7192 | 0.7234 |
| 33 | Parakudi | -6.78 | 4.36 | -140.71 | 58.53 | 0.489 | 49.89 | 4.2 | 75.58 | -1.51 | -0.85 | 0.8031 | 0.5637 |
| 34 | Vichchiyur | -5.64 | 2.15 | -162.92 | 47.14 | 0.454 | 33.62 | 4.1 | 76.98 | 0.06 | 0.05 | 0.6875 | 0.5875 |
| 35 | Kidamangalam | -7.51 | 2.91 | -108.62 | 48.92 | 0.494 | 39.57 | 4.25 | 65.58 | -0.59 | -0.69 | 0.6561 | 0.6314 |
| 36 | Naliazhandu | -5.34 | 2.79 | -153.42 | 52.78 | 0.429 | 40.33 | 4.42 | 81.46 | -0.56 | -0.43 | 0.7848 | 0.5344 |
| 37 | Mattur | -5.16 | 3.11 | -145.76 | 56.05 | 0.412 | 43.33 | 4.5 | 75.84 | -0.47 | -0.38 | 0.7599 | 0.5815 |
| 38 | Kokapadi | -8.60 | 2.60 | -111.45 | 44.76 | 0.552 | 35.87 | 4.41 | 68.41 | 0.01 | 0.02 | 0.6390 | 0.7187 |
| 39 | Alayankudi | -4.17 | 4.55 | -122.25 | 65.87 | 0.337 | 55.27 | 4.14 | 77.92 | -0.21 | -0.26 | 0.8484 | 0.7278 |
| 40 | Sellur | -7.00 | 2.54 | -126.28 | 47.25 | 0.486 | 36.55 | 4.27 | 79.52 | -0.00 | -0.00 | 0.7378 | 0.6722 |
| 41 | Serumavilangai | -8.28 | 2.93 | -102.95 | 47.62 | 0.527 | 39.13 | 4.09 | 69.28 | -0.27 | -0.29 | 0.6766 | 0.7020 |
| 42 | Mel Kasakudi | -4.68 | 2.88 | -86.46 | 51.45 | 0.327 | 38.71 | 4 | 66.51 | 0.04 | 0.04 | 0.6534 | 0.6985 |
| 43 | Pillaithiruvasal | -7.24 | 3.08 | -151.52 | 50.45 | 0.524 | 40.18 | 4.37 | 61.92 | -0.70 | -0.66 | 0.6382 | 0.5609 |
| 44 | Thirunallar | -5.30 | 1.65 | -96.62 | 43.69 | 0.369 | 30.18 | 4.5 | 68.97 | 0.26 | 0.27 | 0.5821 | 0.6744 |
| 45 | Puduthurai | -6.47 | 1.95 | -89.57 | 43.44 | 0.421 | 32.29 | 4.16 | 76.98 | -0.35 | -0.22 | 0.6744 | 0.6032 |
| 46 | Karaikal | -4.54 | 2.20 | -140.5 | 50.85 | 0.375 | 36.76 | 4 | 70.13 | -0.15 | -0.12 | 0.6606 | 0.5621 |
| 47 | Kilinjumedu | -10.69 | 2.12 | -141.7 | 37.80 | 0.69 | 28.90 | 4.14 | 66.73 | -0.62 | -0.44 | 0.55 | 0.5266 |
| 48 | Viludiyur | -5.15 | 1.58 | -159 | 43.28 | 0.425 | 28.03 | 4.33 | 72.47 | -0.07 | -0.04 | 0.5858 | 0.4806 |
| 49 | Tudapanamulai | -2.57 | 3.30 | -162.56 | 64.66 | 0.297 | 48.92 | 4.4 | 58.08 | -0.10 | -0.09 | 0.6955 | 0.6058 |
| 50 | Uliyapattu | -5.80 | 3.90 | -138.26 | 58.42 | 0.437 | 48.47 | 4.44 | 68.64 | -0.73 | -0.76 | 0.75 | 0.6181 |

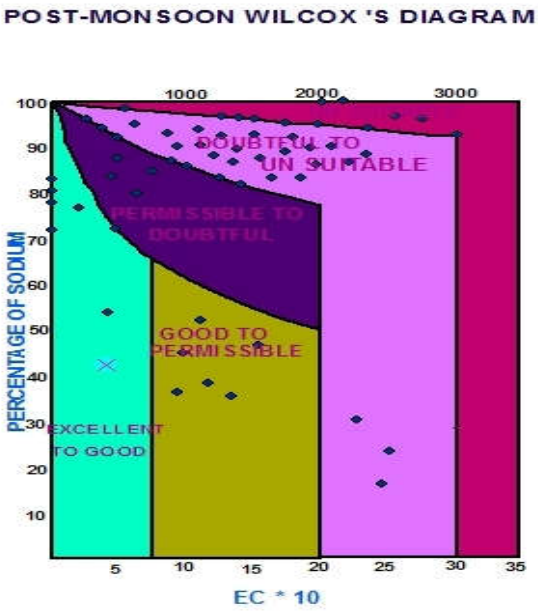


**Fig.11. Map Showing Sodium Percentage of Arasalaru Sub-Basin, Cauvery Basin**

**Table 4. Classification of Sodium Adsorption Ratio in Groundwater**

| SAR | Water Quality | No. of Sample | Percentage |
|---|---|---|---|
| 0-6 | No problems | 40 | 80 |
| 6-9 | Increasing problems | 6 | 12 |
| 7-9 | Severe problems | 4 | 8 |

**Table 5. Residual Sodium Carbonate in Groundwater in the Arasalaru Sub-Basin**

| RSC (epm) | Water category | No. of sample | Percentage of sample |
|---|---|---|---|
| <7 | Safe | 27 | 54 |
| 8-10 | Marginally | 13 | 26 |
| >10 | Unsuitable | 10 | 20 |

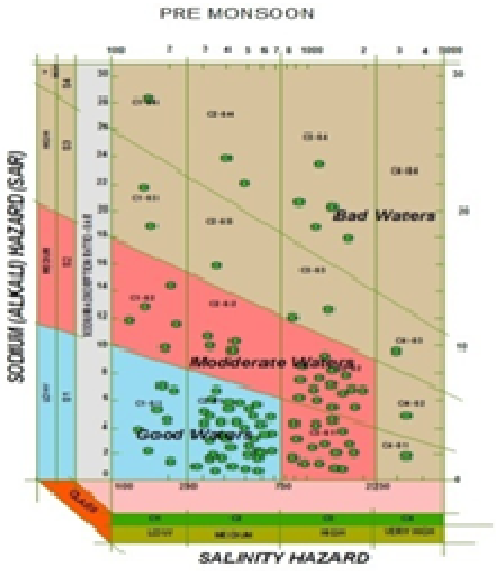


**Fig.12. Map Showing Sodium (Alkali) Hazard of Arasalaru Sub-Basin, Cauvery Basin**

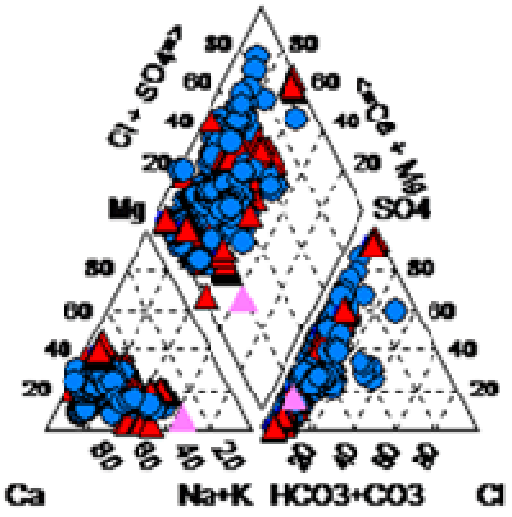


**Fig.13. Map Showing Piper Diagram of Arasalaru Sub-Basin, Cauvery Basin**

## Percentage of Sodium

In all natural waters percent of sodium content is a parameters to assess it suitability for agricultural proposes (Wilcox, 1948), sodium combining carbonate can lead to the formation of alkaline soils, while sodium combining with chloride from saline soils. Both these soils do not help growth of plants. A maximum of 60% sodium in ground water us allowed for agricultural purposes (Ramakrishna, 1998). In the study area, total concentration of Percentage of Sodium ranges from 18.78 to 55.27 ppm in the groundwater samples within the Arasalaru River Basin. The samples are 80% of falls within the permissible limit and 20% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Sargunashwarapuram, Kovilpathu, Pillaithiruvaasal and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi.

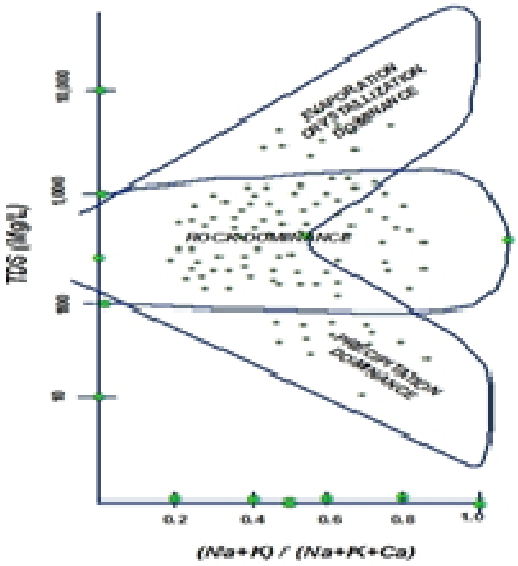


**Fig.14. Map Showing Gibbs Diagram of Arasalaru Sub-Basin, Cauvery Basin**

## Sodium Absorption Radio (SAR)

The reactivity of sodium ion, in exchange reaction, with soil is expressed as sodium adsorption ratio, which is an important parameter for the determination of suitability of water for irrigation. SAR is expressed by Richards (1954). In the study area, total concentration of Sodium Absorption Ratio ranges from 0.88 to 4.55 ppm in the groundwater samples within the Arasalaru River Basin. The samples are 90% of falls within the permissible limit and 10% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Sargunashwarapuram, Kovilpathu, Pillaithiruvaasal and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi.

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

## Residual Sodium Carbonate (RSC)

Residual Sodium Carbonate is defined as

$RSC = (CO_3 + HCO_3) - (Ca+Mg)$

Where all concentrations are expressed in epm.

The water having excess of carbonate an d bicarbonate concentration over the alkaline earth mainly calcium and magnesium, in excess of allowable limits affects agriculture unfavorably (Eaton 1950, and Richards, 1954). In the study area, total concentration of Percentage of Sodium ranges from -1.74 to -11.10 ppm in the groundwater samples within the Arasalaru River Basin. The samples are 90% of falls within the permissible limit and 10% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Sargunashwarapuram, Kovilpathu, Pillaithiruvaasal and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi.

**Permeability Index**

The classification of irrigation waters has been attempted based on the Permeability Index (PI), as developed by Doneen (1964)

$$PI=\frac{Na+\sqrt{HCO3}}{Ca+Mg+Na}X100$$

In the study area, total concentration of Permeability Index ranges from 25.66 to 71.26 ppm in the groundwater samples within the Arasalaru River Basin. The samples are 75% of falls within the permissible limit and 25% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Sargunashwarapuram, Kovilpathu, Pillaithiruvaasal and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi.

**The Piper diagram**

The data plot in the Piper diagram show 50% of the samples in the central part of the diamond field, there by indicating non domination of any of the cation or anion pairs. About 50% of the samples are in the field of permanent hardness and the remaining in the temporary hardness field. The hydro-geochemical observations are not supporting direct seawater ingress though the groundwater samples have a marine signature. Alternative of the diamond field was suggested and he has recommended a rectangular field and it was applied for splitting the triangles (Piper, 1944).

**Gibbs**

The chemistry of the groundwater may to dominated due to rock dominance, evaporation dominance or preciation dominance or the mixture of these factors. In this diagram, two rations have been calculated for anions and cations respectively.

For Anion
Gibbs Ratio I = Cl/(CL+HCO3)
For Cation,
Gibbs Ratio II = (Na+K)(Na+K+Ca)
In both the rations all the ions are expressed in epm.

Gibbs I and Gibbs II respectively shown in indicate that most of the groundwater samples of Arasalaru river reveal that the weathering of parent rocks primarily controls the major ion chemistry of groundwater in the study area. In the study area, total concentration of Gibbs Diagram ranges Gibbs I from 0.47 to 0.84 ppm and Gibbs II from 0.27 and 0.90 in the groundwater samples within the Arasalaru River Basin. The samples are 90% of falls within the permissible limit and 10% of the sample falls more than the permissible limit. Maximum concentration values are found in the areas of Vanniyadi, Sargunashwarapuram, Kovilpathu, Pillaithiruvaasal and Kilinjumedu and minimum exists in the areas of Darasuram, Ariyapuram, Chettimandapam, Kuthanur and Injigudi.

**Total Hardness**

The common denominator of the majority of water problems is hardness. Hardness is one of the folk terms inherited from the past with origins in household use of water for washing. In the study area, Total hardness concentration ranges from 0.26 to 0.69 ppm in the groundwater samples. The samples are found 100 percentage more than the permissible limit. Total Hardness in the Arasalaru Sub Basin could be seen from this figure the maximum concentration are seen in the area North West, South, South Western and North Central part of the study area.

**Magnesium Ratio**

Magnesium ratio may be explained as the excess amount of Magnesium over calcium and Magnesium with will be in condition of equilibrium (Das *et al*., 1988).

It is defined as

$$HR = \frac{Mg\ X\ 100}{Ca+Mg}$$

The Magnesium Ratio of groundwater varies from 50.07 to 84.63 (Table 3). Magnesium Ratio are found to be more than the permissible limit in all water samples area. High Mg ratio is due to surface water and subsurface water more reacted and limestone, kankar, clay, sand, gravels and some of the isolated pockets Cuddalore sandstones are found in the study area.

**Corrosivity Ratio**

When groundwater is supplied through iron pipers and concrete pipes the properties like corrosion and encrustation are to be evaluated in order to safeguard the water supply systems. Corrosion in normally an electrolytic process, which attacks and corrodes away the metal surfaces (Kaiser 1958). The range at which corrosion begins depends upon a number of chemical equilibrium reactions as well as upon specific physical factors such as temperature, pressure and velocity of flow. It has also been noticed by Raman (1985) that the lack of carbonate and sulphate, which increases the corrosion rate. Groundwater is obtained from this Arasalaru Sub-Basin, to augment the surface water facilities and is being transported through conventional metallic pipes those metallic pipes may or may not be suitable for the transport of water this report can be highlighted using the corrosivity ratio suggested.

$$CR = \frac{\left(\frac{Cl}{35.5}\right)+2\left(\frac{SO4}{96}\right)}{\frac{HCO3+CO3}{100}}$$

Where all concentration is expressed in ppm.

## Conclusion

The significant correlation between the score and the salinity of groundwater in three locations (Ariyatidal, Darasuram, Poonthottam) with no significant loading of Na and F1 score could be due to the influence of marine aerosol. The strong correlation between F3 score, pH/ $CO_3$ indicates dissolution of $HCO_3$ gradually into $CO_3$ under high pH conditions. The Na:Cl ratio, and chemical facies study (through piper diagram) did not indicate seawater intrusion into groundwater. The factors that played significant role in shaping the chemistry and quality of groundwater in the phreatic aquifers are attributable to tidal inlets and or contribution from marine aerosols. The hydrogeochemical characterization by factor analyses has revealed that the results of factor analyses and hydrogeological aspects in the area are correctable.

## Acknowledgement

The authors thank Sri B.M. Jha, Chairman, CGWB, New Delhi for giving permission to publish this paper. Dr.V.Prasannakumar, Prof. and Head, Dept. of Geology, University of Kerala is thanked for his encouragement. Dr. Manoj Chacko, Lecturer, Dept. of Statistics, University of Kerala is acknowledged for his statistical inputs.

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