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

International Journal of Current Research
Vol. 4, Issue, 03, pp.069-074, March, 2012

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

INTEGRATED APPROACH FOR WATER QUALITY PARAMETERS USING GIS TECHNOLOGY IN ALANGUDI TALUK PUDUKKOTTAI DISTRICT TAMIL NADU, INDIA.

R. Kayalvizhi* and K. Sankar

Department of Industries & Earth Sciences, Tamil University, Thanjavur

ARTICLE INFO

Article History:
Received 25th December, 2011
Received in revised form
14th January, 2011
Accepted 28th February, 2011
Published online 31st March, 2012

Key words:
Water qualit,
Percentage of Sodium,
Residual Sodium Carbonate,
Alangudi Taluk,
Pudukkottai District,
Tami Nadu.

ABSTRACT

This paper intends to assess the water quality with reference to drinking, agriculture and industrial uses in the ground water in Alangudi Taluk, Pudukkottai District. In this taluk has been evaluated by considering 50 water samples collected from bore wells. In this sampling was carried out using pre-cleaned polyethylene containers, this sampling analyzed the data collected from the Public Works Department (PWD), Ground Water Division (GWD), Thiruchirapalli, Tamilnadu, for the year 2010. The physical and chemical parameters of the analytical results of groundwater were compared with the standard guideline values recommended by the World Health Organization for drinking and Public Health Standard. Thematic map preparing to TDS, EC, Cl, NO_3, SO_4, and Na were maps was developed Using Arc GIS-9.3 platform. The data were used to compute chemical parameters as non-carbonate hardness, sodium absorption ration percentage of sodium, residual sodium carbonate, magnesium ratio, chloro alkaline index found to be used on evaluation of the chemical parameters quality of water is fit for drinking, industrial and agricultural uses, accept in a few isolated locations. According to Wilcox's diagram indicates that less then 95 percent of samples fall in excellent to good and good to permissible types. According to the USSL diagram based on most of the samples fall in the field of C_2-S_2 indicating same salinity and sodium water, which can be used for almost all types of soil with no danger of sodium. Majority of the samples are suitable for domestic purposes and far from drinking water standards.

INTRODUCTION

Due to the ever increasing demand for potable and irrigation water and inadequacy of available surface water the importance of groundwater is increasing everyday. Hydro geochemical study is a useful tool to identify these processes that are responsible for groundwater chemistry. Groundwater is a vital natural resource. Depending on its usage and consumption, it can be a renewable or a non renewable resource. It is estimated that approximately one third of the world's population use groundwater for drinking (Nickson et al. 2005). Groundwater is the major source of water supply for domestic purposes in urban as well as rural parts of India. Among the various reasons, the most important are non-availability of potable surface water and a general belief that groundwater is purer and safer than surface water due to the protective qualities of the soil cover (Mishra et al. 2005). Burston et al. (1993) discussed that the quality of groundwater is often assessed by reference to drinking water standards. Hedge and Puranik (1992 , 1996), Hegde et al (1992,1997) Muniswamy et al (1993).Abbi and Puranik (2000)and hedge (2003) have discussed the quality of ground water in certain parts of Taluk. The central groundwater board (CGWB, 2000) has provided a general account of the hydrological aspects of the Taluk.

Study area

The study area Alangudy taluk is situated in pudukkottai district of Tamilnadu, India (Figure 1), covering a total area of 717.22 Sq km, and bounded by 10^0 17' to 10^0 25' North latitudes and 78^0 52' TO 79^0 8' East longitude. In this study area is in the survey of India Toposheets No 58J/15, 58N/2, and 58N/3 in the district pudukkottai, state of Tamilnadu, India, in the scale of 1:50,000. It is 26m above mean sea level. The climate of the study area is characterized by four distinct seasons, viz., winter from January to February,Summer from March to May, south west monsoon from June to September, and the north east monsoon from October to December. In this takuk receives an annual rainfall of 165 mm and the average temperature is high varying from 24^0 C to 36^0 C No perennial river exist in the area, except for short distance river encompassing second and third-order drainage (Barker et al. 2001). The river runoff from precipitation within the taluk flowing towards the main river vellor. The taluk is characterized by an undulating topography almost a level of plain, sloping towards the west to east. The soil type of the study area are red non calcareous and red calcareous soils. Alangudi taluk has a population of 156918 inhabitants and their main occupation is agriculture.

Corresponding author: rkgeo1986@yahoo.com

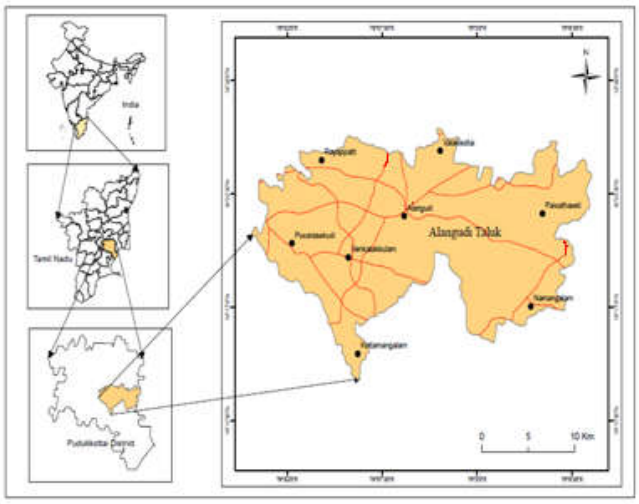

Fig. 1. Key Map of Alangudi Taluk Pudukkottai District, Tamil Nadu

The study area is comprised of partly Granitic rocks and partly sand silt, sand stone formation (fig.2). They are unconformable overlain by Granite and sand silt of recent to sub-recent age. This taluk fully covered in sand stone workalibed. In the taluk are free from occurrences of river sand. The river sand covered in over all part of the study area in sand silt deposits consisting constitute the youngest formation consisting of sand and clays, occurring along the river curses.

METHODOLOGY

Groundwater samples were collected after well inventory survey from 50 representative wells during February 2010 (Fig.3). The depths of wells range from 2 to 67 m below ground level. The samples were collected after 10 min of pumping the tube well and stored in polyethylene bottles at 4_C until the analyses were finished. All bottles washed well had been rinsed with deionizer water before sampling. Immediately after sampling, pH, EC, TDS, and temperature were measured in the field by a portable pH (Hanna) and an EC/TDS meter (Hanna). Sodium (Na) and potassium (K) were measured using flame photometer. Calcium (Ca) and magnesium (Mg) were determined titrimetrically using standard EDTA. Chloride (Cl) was determined by ion selective electrode method. Bicarbonate (HCO_3) concentrations of the groundwater were determined by potentiometric titration method. Sulphate (SO_4), analyses of the water samples were carried out using UV–visible spectrophotometer. Nitrate (NO_3) was measured by using ion selective electrode methods. High purity analytical reagents were used throughout the study, and chemical standards for each element when necessary were prepared separately. In addition to this, US Salinity Laboratory hazard diagram and Wilcox diagram were employed to classify and determine the suitability of groundwater for irrigation by sodium absorption ratio/electrical conductivity and percent sodium/electrical conductivity, respectively.

Calcium ion concentration in ground water samples in the period more than the permissible limit of 75 ppm for drinking water, occurs in the samples no's 5,26, whereas high concentrations are found to be in the north and eastern parts in the study area. During period magnesium concentration north and north, west, eastern part of the study area. Magnesium contents range from 6 – 170 ppm in the study area respectively season (Fig.6). Sodium concentration is various from 7-177 ppm. The season is sodium is low, particularly in the south western parts of study area (Fig.7). Potassium contents ranges from 1-25ppm in the study area respectively. Potassium is high in the south eastern parts of the study area during the period. Bicarbonate is varies from 49-397ppm in seasons respectively. During season low HCO_3 occur in the high level of bicarbonate located in north eastern part and south western part in the study area respectively. The high bicarbonate concentration was obtained in the following groundwater samples no's 8, 9,14,29,42,48,49,50 during period.

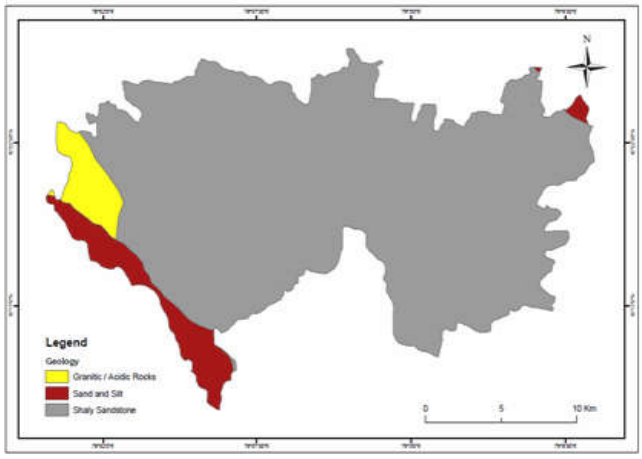

Fig. 2 Geology Map of Alangudi Taluk Pudukkottai District, Tamil Nadu.

RESULT AND DISCUSSION

The logarithm of the reciprocal of the hydrogen iron concentration (PH) in the water sample varies from 6.6 to 8.2 with an average around 7.5 indicating alkaline nature. As per ISI (1983) standard eighty eight and sixty eight percentages of the samples in the seasons (Fig.4) respectively are within the recommended limits (6.5 to 8.5) or human consumption. The specific conductance values are found to be within the range of 110 – 2320 micromhos / cm at 250 ^{0}C with an average of about 750 micro mhos / cm at 250 ^{0}C in the season (Fig.5). See table.2.

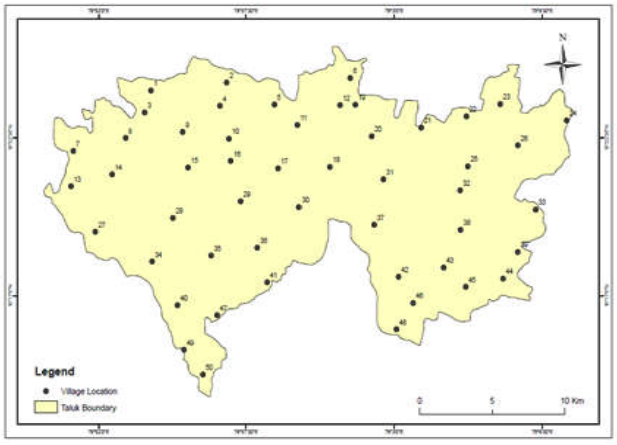

Fig. 3. Sample Location of Alangudi Taluk Pudukkottai District, Tamil Nadu

Table : 1 Geochimecal Parameters of Alangudi Taluk, Pudukkotai District, Tamil Nadu (in ppm)

S.No.	Location	EC	P^H	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	CO_3	TDS
1	Rayappatti	670.00	7.20	16.00	47.00	46.00	2.00	214.00	106.00	9.00	12.00	0.00	428.8
2	Kalabam	600.00	7.50	26.00	33.00	60.00	3.00	234.00	96.00	5.00	7.00	0.00	384
3	Managanampatti	1010.00	7.50	24.00	52.00	115.00	1.00	360.00	152.00	15.00	19.00	0.00	646.4
4	Tavalappallam	490.00	6.90	20.00	28.00	39.00	1.00	189.00	71.00	7.00	8.00	0.00	313.6
5	Namranpatti	2380.00	6.70	80.00	170.00	161.00	1.00	189.00	567.00	163.00	185.00	0.00	1523.2
6	Vellalakkollai	630.00	8.20	24.00	43.00	37.00	1.00	183.00	78.00	33.00	37.00	0.00	403.2
7	Tirukkattalai	480.00	7.10	16.00	18.00	69.00	1.00	183.00	82.00	5.00	4.00	0.00	307.2
8	Veppangudi	830.00	6.70	38.00	47.00	58.00	2.00	165.00	174.00	26.00	16.00	0.00	531.2
9	Malavaranpatti	440.00	6.60	20.00	24.00	37.00	1.00	171.00	53.00	12.00	8.00	0.00	281.6
10	Kulandirakottai	680.00	6.70	34.00	22.00	81.00	1.00	207.00	160.00	12.00	29.00	0.00	435.2
11	Pachikkottai	1220.00	6.80	36.00	55.00	150.00	3.00	183.00	248.00	72.00	78.00	0.00	780.8
12	Pappanakudi	750.00	7.40	30.00	35.00	80.00	1.00	299.00	103.00	9.00	12.00	0.00	480
13	Kaikkurichchi	1820.00	6.80	64.00	78.00	205.00	4.00	281.00	429.00	65.00	31.00	0.00	1164.8
14	Tiruvarangulam	1020.00	6.70	36.00	56.00	94.00	4.00	116.00	269.00	40.00	24.00	0.00	652.8
15	Kalyanipuram	1430.00	6.80	40.00	88.00	124.00	1.00	153.00	337.00	62.00	93.00	0.00	915.2
16	Kovilur	960.00	6.90	34.00	50.00	90.00	4.00	183.00	202.00	37.00	20.00	0.00	614.4
17	Alangudi	580.00	6.80	18.00	41.00	39.00	1.00	201.00	78.00	10.00	21.00	0.00	371.2
18	Chikkappatti	620.00	7.60	18.00	28.00	69.00	1.00	183.00	99.00	15.00	11.00	0.00	396.8
19	Manakkollai	630.00	6.60	34.00	35.00	39.00	1.00	183.00	139.00	12.00	11.00	0.00	403.2
20	Rajamangalam	2320.00	6.90	64.00	75.00	331.00	3.00	232.00	535.00	130.00	155.00	0.00	1484.8
21	Vandanvidudi	750.00	7.10	14.00	52.00	58.00	1.00	360.00	46.00	5.00	13.00	0.00	480
22	Rajakkudiyiruppu	1150.00	6.90	26.00	47.00	129.00	1.00	183.00	248.00	41.00	40.00	0.00	736
23	Taiakkollaitteru	850.00	7.90	12.00	43.00	104.00	1.00	397.00	53.00	22.00	10.00	0.00	544
24	Suryanarayanapuram	1010.00	7.00	24.00	43.00	145.00	6.00	305.00	195.00	16.00	11.00	0.00	646.4
25	Pullanvidudi	760.00	7.90	18.00	49.00	71.00	5.00	342.00	67.00	15.00	16.00	0.00	486.4
26	Kosatteru	1920.00	6.90	86.00	101.00	177.00	1.00	366.00	425.00	67.00	81.00	0.00	1228.8
27	Karaiyappatti	1140.00	6.90	26.00	36.00	179.00	1.00	354.00	206.00	20.00	8.00	0.00	729.6
28	Shanmukhanadapuram	880.00	7.00	20.00	10.00	104.00	1.00	293.00	106.00	41.00	9.00	0.00	563.2
29	Kuppakudi	780.00	6.80	24.00	46.00	64.00	1.00	116.00	177.00	28.00	21.00	0.00	499.2
30	Pallattuvidudi	930.00	6.70	24.00	36.00	117.00	6.00	275.00	197.00	23.00	12.00	0.00	595.2
31	Kilattur	670.00	6.80	24.00	36.00	64.00	1.00	281.00	71.00	9.00	17.00	0.00	428.8
32	Annavayal	730.00	6.60	26.00	45.00	55.00	25.00	183.00	142.00	13.00	15.00	0.00	467.2
33	Kunjankudiyiruppu	530.00	8.20	22.00	23.00	55.00	1.00	183.00	71.00	12.00	14.00	0.00	339.2
34	Nambukuli	730.00	7.10	34.00	44.00	58.00	1.00	214.00	142.00	9.00	11.00	0.00	467.2
35	Terku Agraharam	560.00	6.60	18.00	34.00	41.00	1.00	183.00	74.00	12.00	15.00	0.00	358.4
36	Kuruntadimanai	550.00	7.00	20.00	30.00	55.00	11.00	220.00	71.00	6.00	14.00	0.00	352
37	Kottamangalam	670.00	6.90	20.00	43.00	55.00	1.00	183.00	124.00	12.00	17.00	0.00	428.8
38	Mangadu	790.00	6.70	40.00	34.00	83.00	1.00	244.00	142.00	6.00	19.00	0.00	505.6
39	Karambai	510.00	6.90	22.00	26.00	44.00	1.00	195.00	53.00	8.00	17.00	0.00	326.4
40	Kalingippatti	670.00	6.70	30.00	34.00	64.00	1.00	226.00	106.00	9.00	21.00	0.00	428.8
41	Vellakkollai	820.00	7.00	32.00	32.00	99.00	1.00	287.00	124.00	10.00	12.00	0.00	524.8
42	Kulamangalam	660.00	7.00	28.00	38.00	46.00	1.00	171.00	106.00	26.00	17.00	0.00	422.4
43	Mangadu	910.00	7.00	40.00	45.00	87.00	1.00	305.00	149.00	8.00	11.00	0.00	582.4
44	kottaikadu	670.00	6.90	24.00	38.00	64.00	1.00	214.00	113.00	9.00	23.00	0.00	428.8
45	Sendangudi	540.00	6.90	24.00	32.00	37.00	1.00	201.00	60.00	10.00	17.00	0.00	345.6
46	Panandadu	550.00	6.90	24.00	32.00	46.00	1.00	220.00	64.00	12.00	16.00	0.00	352
47	Kilaiyur	640.00	7.00	24.00	27.00	78.00	1.00	244.00	89.00	10.00	9.00	0.00	409.6
48	Alanjankadu	700.00	6.70	32.00	35.00	60.00	1.00	165.00	142.00	11.00	19.00	0.00	448
49	Siraduseri	120.00	6.70	10.00	6.00	7.00	1.00	55.00	11.00	2.00	8.00	0.00	76.8
50	Nagarampallam	110.00	6.80	8.00	6.00	7.00	1.00	49.00	11.00	2.00	9.00	0.00	70.4

Table: 2 Groundwater samples of study area exgeeding the permissible limits prescribed by WHO for domestic purposes

S.No.	Parameters	BIS (1998)		WHO (1993)		Undesirable Effect on Human
		Permissibe	Excessive	Permissibe	Excessive	
1	pH	6,5	9,2	6,5	8,5	Taste
2	Ec	`-	-	1500	-	-
3	Calcium	75	100	75	200	Scale formation
4	Magnesium	30	100	50	150	Scale formation
5	Sodium	-	-	-	200	-
6	Potassium	-	-	-	12	-
7	Sulphate	200	400	200	400	Laxative Effect
8	Chloride	250	1000	200	600	Salty Taste
9	Phosphate	-	-	-	-	-
10	Nitrate	45	45	-	45	Blue Baby disease
11	TDS	500	1000	300	600	Gastrointestinal irritation
12	Total Hardness	300	600	100	500	Scale formation
13	Total Alkalinity	200	600	-	-	-
14	Fluoride	1	1,5	-	1,5	Fluorosis

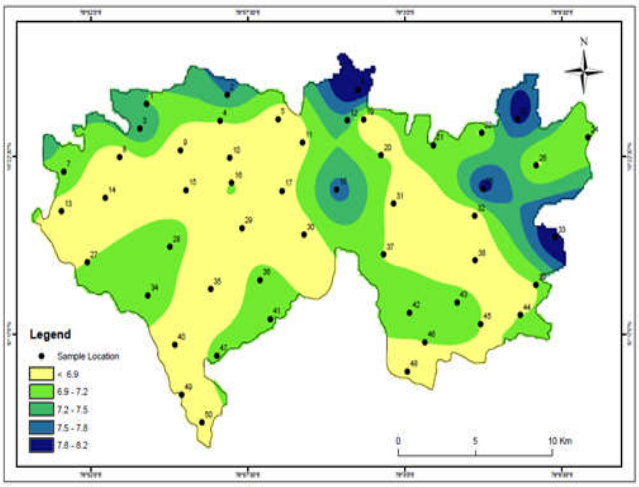

Fig. 4. Power of Hydrogen of Alangudi Taluk Pudukkottai, District, Tamil Nadu

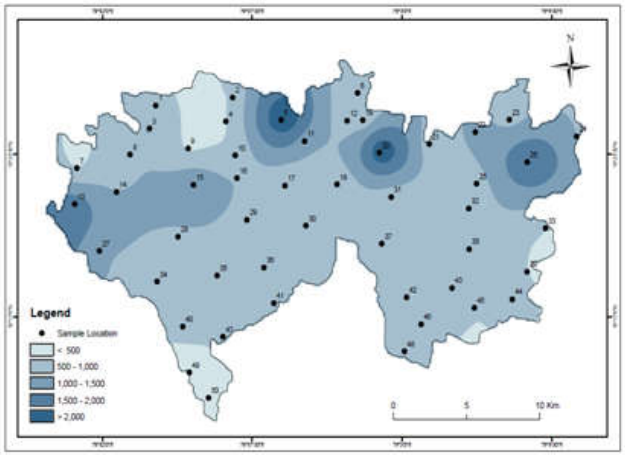

Fig. 5 Electrical Conductivity of Alangudi Taluk Pudukkottai District, Tamil Nadu

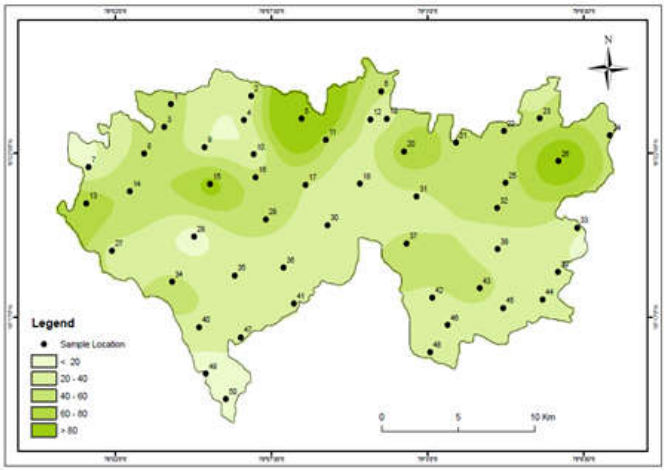

Fig. 6. Magnesium concentration of Alangudi Taluk Pudukkottai District, Tamil Nadu

Chloride concentration ranges from 11-567ppm in the groundwater samples of during season respectively. Low Cl is occur in the parts of north western part and south eastern and south western part of the study area during season. While high chloride values are present in the parts of central, eastern and south eastern in season (sample no's. 4,9,21,23,25,26,31,33,36,39,49 and 50).

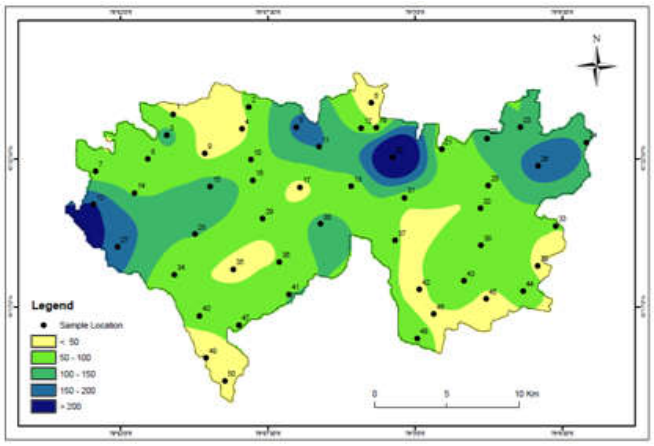

Fig. 7. Sodium concentration of Alangudi Taluk Pudukkottai District, Tamil Nadu

Ground water can be classified based on the distribution of total dissolved solids following ICMR (1975) , Wilcox (1955) and web (1993) such as up to 1000ppm (permissible for domestic use) 1000-2000ppm (useful for irrigation and > 2000ppm (unsuitable for domestic, industrial & irrigation purposes) as shown in about 78% of the samples are with in permissible limits for domestic, industrial and agriculture uses, while the 18% are suitable only for agricultural purpose and remaining samples are not suitable even for salt tolerance crops. Similarly about 4% of the samples are with in permissible limits for domestic, industrial and agricultural uses.

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 dollied from saline soils both these soils do not help growth of plants. A maximum of 68% sodium in ground water is allowed for agricultural purposes (Ramakrishna, 1998). The chemical quality water samples were studied from percentage of sodium vis a vis specific conductance on the Wilcox diagram (Fig.8) out of total 50 samples. 42% samples belongs to excellent to good and good to permissible types during period. The remaining 5% samples permissible to doubtful, doubtful to unsuitable and unsuitable types in the season.

Sodium Adsorption Ratio (SAR)

Sodium concentration in groundwater is important since increase of sodium concentration in waters effect deterioration of the soil properties reducing permeability (Kelly et al. 1951) and (Tijani et al. 1994). The process leading to the caption exchange reactions in soil may be studied from sodium absorption on clay surface as substitute for calcium and magnesium may damage the soil structure making it compact and impervious, SAR is expressed as

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

Where the concentration are expressed in equivalent per million (epm).

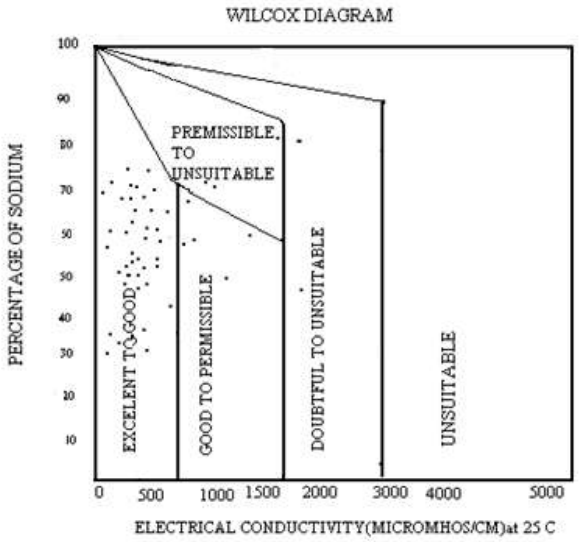

Fig.8. Electrical Conductivity and Percentage Sodium Relationship irrigation of water Alangudi Taluk, Pudukkottai District, Tamilnadu.

Table: 3 Classification of Sodium absorption Ratio in groundwater

SAR	Water Quality	Number of samples
0 – 20	No Problems	42
20 – 30	Increasing problems	6
> 30	Severe Problems	2

Classification of water with reference to SAR (Herman Bouwer,et al. 1978) is presented is Table 1, out of 50 samples, 78 percent of water samples of seasons fall respectively under no problems category. U.S. salinity laboratory diagram (fig. 9). Based on Sodium Absorption Ratio (SAR) vis a vis specific conductance values, the most significant parameters of sodium and salinity he awards indicate usability for agricultural purpose. Table .4 shows that SAR ranges from 6.3 to 39.7 during the study area. About 68% of the ground water samples fall with in c2-s, c2-s2, c3-s2 and c3-s3 categories in the season. This category is predominant are suitable for irrigations purposes. It is found to be all parts and few isolated pockets of entire study area.

Table: 4 Groundwater classification based on USSL diagram

Category	Number of sample
C1-s1	49,50
C2-s1	4,6,9,15,17,45
C2-s2	1,2,3,14,19,27,32,33,35,36,37,38,40,43,46,
C2-s3	7,10,41.48,
C2-s4	20
C3-s2	8,23,27,
C3-s3	14,16,12,26,29,43,
C3-s4	13,22
C2-s4	11,25,28,43,18,15,21,24,
C4-s4	5,20,

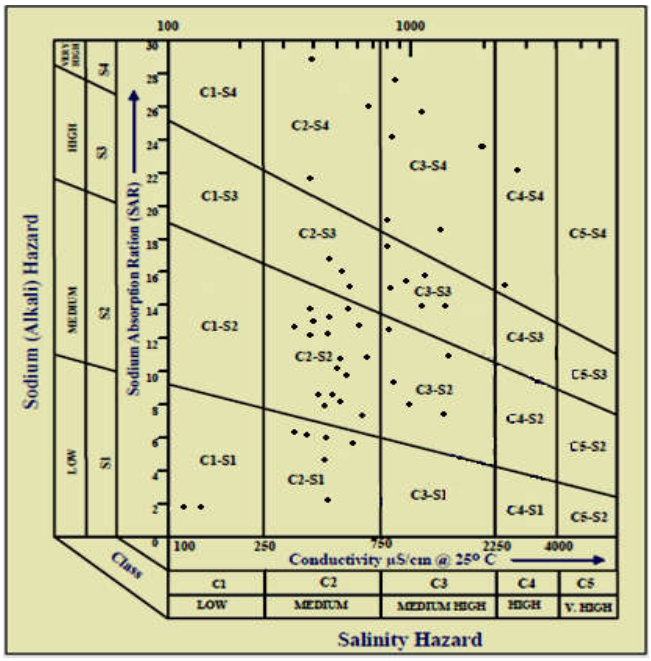

Fig: 9 USSL Classification of Alangudi Taluk Pudukkottai District

Residual Sodium Carbonate (RCS)

Residual sodium carbonate is defined as

$$RSC = (CO^{-}_{3} + HCO^{-}_{3}) - (Ca^{2+} + mg^{2+})$$

Where all concentration are expressed in epm.

The water having excess of carbonate and bicarbonate concentration over the alkaline earth mainly calcium and magnesium, in excess of allowable limit affects agriculture unfavorably (Eaton 1950 and Richards 1954) . (Table.5) Show that 54% samples are safe or marginally suitable for agriculture purpose. The rest are unfit for irrigation use in the season. The range of residual sodium carbonate in groundwater in the investigated area varies from 24 to 342.0 epm, use of sodium water having high RSC values affect the crop yields.

Table: 5 Residual Sodium Carbonate in Groundwater

RSC epm)	Water Category	Bore well	Percentage of samples
< 150	Safe	27	54%
15 – 300	Marginally	22	44%
> 300	Unsuitable	1	2%

Magnesium Ratio (MR)

It is expressed as

$$MR = \frac{Mgx100}{Ca + Mg}$$

Where all the irons are expressed in epm.

It is may be described as the excess amount of magnesium over calcium and magnesium will be in condition of equilibrium (Das et al., 1988) Excess of magnesium effects the quality of soils which is the cause of poor yield of crops. Magnesiu ratio of groundwater in the investigated area in 80 percent of the samples. The magnesium ratio of groundwater

varies from 6 to 170 samples. Magnesium ratio are found to be more than the permissible limit in all water samples all location part north western and north eastern parts of the study area in high mg ratio is dune in the season.

Conclusion

The analysis of groundwater in the investigated area shows limited seasonal various in quality. The logarithm of the reciprocal of the hydrogen iron concentration (PH) in the water sample varies from 6.6 to 8.2. The sample can be classified based on the 84% of the samples are within permissible limits for domestic industrial and agriculture uses, while the 12% are suitable only for agricultural purposes and remaining samples are not suitable even for salt tolerance crops. Similarly about 4% of the samples are within permissible limits for domestic, industrial and agricultural uses. The chemical quality water samples was studied from percentage of sodium vis a vis specific conductance on the Wilcox diagram out of total 50 samples, 95 percent belongs to excellent to good and good to permissible types during period. The remaining samples permissible to doubtful, to unsuitable and unsuitable type in the season. Based on the USSL classification around 68 percent of the samples in the season belong to C2 – S1, C2 – S2, C3 – S2 and C3 – S3 categories in the season. In this category is predominant are suitable for irrigation purposes. It is found to be all parts few isolated pockets of entire area. In genera south western. Eastern, north western and southern parts of the study area are found to have good quality of ground water, whereas moderate quality water exists in the northern north eastern and south eastern parts of the study area. Poor water quality is identified in the area of northern and south western parts of the Pudukkottai District Alangudi Taluk.

REFERENCES

Abbi, A.K. and Puran, S.C, (2000) Groundwater exploration in Chikka Halla basin, Dharwad district, Karnataka, Jour.Appli Hydrology, v.xiii, Nos. 3&4, pp. 14 - 19.

Burston, M. W., Nazaari, M. M., Bishop, K. P., & Lerner,D. N. (1993). Pollution of ground water in the Coventry region (UK) by chlorinated hydrocarbon solvents. *Journal of Hydrology, 149*, 137–161.

Cgwb (2000) Groundwater resources and development potential of Dharwar district, Karnataka, Brochure, central Groundwater Board, Ministry of water Resources, Govt, of India, Bangalore.

Eaton, E. M. (1950) Significance of carbonate in irrigation water. Soil. Sci., v.69, pp. 123-133.

Herman BOUWER (1978) Groundwater Hydrology, International Student Edition

Hegde, S.N. and Puranik, S.c. (1992) Trace elements in groundwater of Hubli city, Karnataka, India. Curr.sci.v.63, no.1,pp.43-44.

Hegde,S.N. and Puranik, S.c (1996) Ground water quality studies of Hubli – Dharwad municipal corporation Area, Karnataka. Proc. Ix conv. India geological congress, pp.236-239.

Heage, S.N., Torgalmath,N. and Puranik, S.C. (1999) Evaluation of groundwater, quality in Dog and Bore wells, Hublicity, Karnataka. Groundwater and watershed Management, Sess.Vol.Dept. of Geology, jaihind college, Deopur, Dhule (Ms), pp.89 -96.

Hegde, G.V. (2003) study of the brackish water track in parts of Hubli, Kundagol and Navalagund taluks, Dharwad district. Groundwater studies, DMG, Bangalore, Dharwad district. Groundwater studies, DMG, Bangalore, No. 427, 27p.

IMCR (1975) Indian Council of Medical Research: Manual of Standards of Quality for Drinking water supplies.

Kelley,W.P (1951)Alkali soils- Their formation properties and Reclamation, Reinold Publ. corp., New york.

Muniswamy, M., Bhat, S.K, More, R.M., Nidagundi, S.R., Groundwater resources of Dharwad district, Govt, Karnataka, DMG, GWs, Dharwad, 40P.

Mishra, P. C., Behera, P. C., & Patel, R. K. (2005). Contamination of water due to major industries and open refuse dumping in the steel city of Orissa–a case study. *Journal of Environmental Science & Engineering,47*(2), 141–154

Nickson, R. T.,McArthur, J.M., Shrestha, B., Kyaw-Nyint, T. O., & Lowry, D. (2005). Arsenic and other drinking water quality issues, Muzaffargarh District, Pakistan.*Applied Geochemistry, 20*, 55–68.

Rama Krishna(1998) Groundwater, Hand Book, India, 556p.

Tijani. J. (1994) Hydrochemical assessment of Groundwater in Moro area , Kwara state Nigeria, Environmental geology, v-24, pp.194-202.

U.S Salinity Laboratory (1954) Diagonisis and Improvement of Saline and Alkali Soils. U.S Dept. Agriculture Hand Book- 60, Washington D.C. 160p.

Who (1993) Guidelines for drinking – water quality, v.1. Recommendations , Geneva: WHO, pp. 1-4.

Wilcox, L.V. (1955) Classification and use of irrigation water, U.S. Dept. of Agriculture. Circular 969.

****