A Study to determine the Suitability of Ground Water for Irrigation Purposes in Madurai District, Tamil Nadu, India

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***Abstract*— The ground water is one of the main sources of agriculture but some of the causes for poor water quality are attributable to modern urbanization and industrialization. The study is taken up in Madurai District; Tamil Nadu, India based on the ground water data available with the Public Works Department of Government of Tamil Nadu, for a period 2001 to 2011. In this present study, the authors have restricted their investigations to major ions concentrations, distributions and their variability in ground water chemistry. The water type in Madurai district is generally Na-Mg-Cl-HCO_3. Some quality problems were envisaged with TDS and Chloride in two taluks but still recommended for irrigation purposes.**

***Keywords*— Ground Water, Chemistry, Crop, Irrigation**

I. INTRODUCTION

India is basically a country with agriculture as gainful employment to a significantly large section of people and which provides raw material for a large number of industries in the country. Agriculture provides gainful employment to nearly two-third population and contributes about 30% to national income. In the production of agricultural products, water plays a major role and hence the quality of water is an important criteria, and water of saline or alkali nature is not suitable for irrigation purposes, as the concentration and composition of dissolved constituents in water is a contributing factor to the irrigation quality.

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Madurai district is situated in the southern part of Tamil Nadu, basically an agriculture based district with an ayacut area of 13860Ha of double crop and 49500Ha of single crop. The top soil available is mostly clay loom, red loom and black cotton type. The bottom layers in most of the areas are underlain by hard rock except some few patches of alluvial formation. The source of ground water is more essential in this region for agricultural. But the source is depleted by huge extraction and quality is degrading by pollutions of various sources of rapid urbanisation and industrialisation.

The aim of this study is to determine and comparing the suitability of the ground water samples in the Madurai district for irrigation purposes, and analyse its level of pollution. The study area covers entire seven Taluks of the district.

II. LITERATURE REVIEW

Brindha. K and Elango. L., (2011)[1] stated Groundwater is a natural precious resource that sustains the basic needs of all living creatures. It cannot be created or supplemented electronically or hydrologically or by any other means

Jeevanandam et al. (2007)[2] carried out study in Ponnaiyar River Basin, Cuddalore district and indicated The quality of groundwater at any point below the surface reflects the combined effects of many processes along the groundwater flow path. Chemical reactions such as weathering, dissolution, precipitation, ion exchange and various biological processes commonly take place below the surface. Hydro geochemical study is a useful tool to identify these processes that are responsible for groundwater chemistry.

Baghvand et al. (2010)[3]highlighted that Groundwater has become the major source of water supply for domestic, industrial and agricultural sectors of many countries. Iran is located in a semi-arid area with an average annual precipitation less than one-third of that of the world

Pazand et al. (2011)[4] has explained Intense agricultural and urban development has placed a high demand on groundwater resources, especially in the Bukan region, and these resources are now at greater risk of contamination. The

increasing exploitation due to farming frequently causes deterioration in water quality Therefore; variations in natural and human activities reflect spatial variations in the hydro chemical parameters of the groundwater. Also, Pazand et al.(2012) [5] established groundwater in the area studied should not be underestimated because they are sources of water resource for drinking and agricultural purposes.

III. METHODOLOGY

The study area is Madurai district of Tamilnadu, India. It is of 3742 square kilometers divided in to seven Taluks namely Madurai north (T1), Madurai south (T2), Melur (T3), Vadipatti (T4), Usilampatti (T5), Peraiyur (T6) and Tirumangalam (T7). It lies between 090 32' 00" to 100 18' 00" (N) latitude and 770 28' 00" to 780 27' 00" (E) longitude. Water samples are being collected regularly during the months of January and July of every year by the Ground water wing of Public works department of Tamilnadu. They tested the samples at their regional laboratories for the physical, chemical and biological properties immediately to make a study on their quality. The results of the various parameters for different durations are available with the Chief engineer, SG & SWRBC, Tharamani, Chennai 113.

The mean values of the results during the period 2001 to 2011 for the parameters of Total hardness (TH) Calcium (Ca2+), Magnesium (Mg2+), Sodium (Na+), Potassium (K+), Bicarbonate (HCO3), chloride (Cl), Carbonate (CO3) and Sulphate(So4) are studied.

Fig. 1 Madurai District Map

III. RESULTS AND DISCUSSION

The mean values of the cations and anions in the ground water samples of the taluks T1 to T7 (Taluk 1,T2,T3,T4,T5,T6,T7 elate to Madurai north, Madurai south , Melur, Vadipatti, Usilampatti, Peraiyur and Tirumangalam respectively) of Madurai district is given in Table I & II . Classification of waters depends on the principle of the IAH (International Association of Hydro geologist)[4], 1979. Total equivalents of cations and anions were taken as 100% and ions, as more than 20% (meq/L), were evaluated in the classification.

TABLE I
IONIC VARIATION (CATIONS) IN GROUND WATER OF MADURAI DISTRICT

Location	Unit	Ca^{2+}	Mg^{2+}	Na+	K^{+}
Taluk(T1)	ppm	75	70	162	30
	epm	3.75	5.74	7.04	0.77
	%	21.68	33.17	40.72	4.44
Taluk(T2)	ppm	77	59	199	9.21
	epm	3.85	4.84	8.65	0.24
	%	21.91	27.52	49.23	1.34
Taluk(T3)	ppm	85	52	175	39
	epm	4.25	4.26	7.61	1.00
	%	24.83	24.90	44.45	5.83
Taluk(T4)	ppm	67	73	83	28
	epm	3.35	5.98	3.61	0.72
	%	24.53	43.81	26.42	5.24
Taluk(T5)	ppm	101	99	189	29
	epm	5.05	8.11	8.22	0.74
	%	22.83	36.68	37.14	3.35
Taluk(T6)	ppm	63	51	109	11
	epm	3.15	4.18	4.74	0.28
	%	25.50	33.85	38.37	2.28
Taluk(T7)	ppm	108	73	162	16
	epm	5.40	5.98	7.04	0.41
	%	28.67	31.77	37.39	2.17

From Table I & II, the concentrations of Ca2+, Mg2+, Na+ and K+ represent 21.68, 33.17,40.72 and 4.44% in T1, 21.91,27.52,49.23and1.34% in T2, 24.83,24.90,44.45 and 5.83% in T3, 24.53,43.81,26.42 and 5.24% in T4, 22.83,36.68,37.14 and 3.35% in T5, 25.50,33.85,38.37and 2.28% in T6, 28.67, 31.77,37.39 and 2.17% in T7 of all the cations respectively. Among the anions, the concentrations of Co3, HCO3, SO4 and Cl represent 0.21, 33.86, 9.15 and 56.79% in T1, 0.95, 39.22, 11.52 and 48.31% in T2, 0.69, 31.37, 9.29and 58.64% in T3, 1.50,55.98,3.98 and 38.54% in T4, 0.85,31.17,12.76and55.23% in T5, 0.73,46.36, 12.57and 40.34% in T6, 0.68, 29.24,14.31and 55.77% in T7 respectively. Thus, the order of cation and anion abundance is Na+ > Mg2+ > Ca2+ > K+ and Cl > HCO3 > SO4 > Co3 respectively.

TABLE III
IONIC VARIATION (ANIONS) IN GROUND WATER OF MADURAI DISTRICT

Location	Unit	Co_3^{2-}	HCO_3	So_4^-	Cl
Taluk(T1)	ppm	1.02	334	71	326
	epm	0.03	5.48	1.48	9.18
	%	0.21	33.86	9.15	56.79
Taluk(T2)	ppm	4.57	385	89	276
	epm	0.15	6.31	1.85	7.77
	%	0.95	39.22	11.52	48.31
Taluk(T3)	ppm	3.22	296	69	322
	epm	0.11	4.85	1.44	9.07
	%	0.69	31.37	9.29	58.64
Taluk(T4)	ppm	4.24	322	18	129
	epm	0.14	5.28	0.38	3.63
	%	1.50	55.98	3.98	38.54
Taluk(T5)	ppm	5.16	385	124	397
	epm	0.17	6.31	2.58	11.18
	%	0.85	31.17	12.76	55.23
Taluk(T6)	ppm	2.43	314	67	159
	epm	0.08	5.15	1.40	4.48
	%	0.73	46.36	12.57	40.34
Taluk(T7)	ppm	3.53	309	119	343
	epm	0.12	5.07	2.48	9.66
	%	0.68	29.24	14.31	55.77

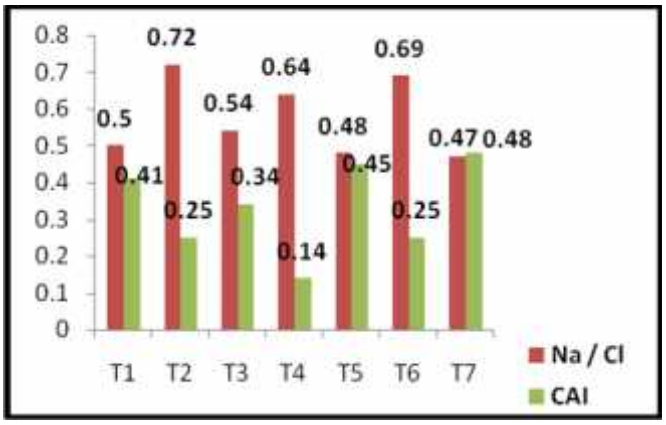

Fig. 2 Na/Cl ratio and CAI index of the ground water samples.

If halite dissolution is responsible for sodium, the Na+/Cl- ratio should be approximately equal to 1, whereas a ratio greater than 1 is typically interpreted as Na released from silicate weathering reactions [6]. In the present study, the Na+/Cl- ratio of groundwater samples from "TABLE III", it is generally below 1 and varies from 0.47 to 0.72 (Fig. 2). The Na+/Cl- ratio of groundwater samples are 0.50 in T1, 0.72 in T2, 054 in T3, 0.64 in T4, 0.48 in T5, 0.69 in T6 and 0.47 in T7.

The chloro-alkaline index, CAI = [Cl - (Na + K)]/Cl, is suggested by Schoeller (1977)[6], which indicate the ion exchange between the groundwater and its host environment. If there is ion exchange of Na+ and K+ from water with magnesium and calcium in the rock, the exchange is known as direct when the indices are positive. If the exchange is reverse then the exchange is indirect and the indices are found to be negative. The CAI index of the ground water samples of Madurai district are 0.41,0.25,0.34,0.14,0.45,0.25 and 0.48 for T1,T2,T3,T4,T5,T6 and T7 respectively. The positive values of CAI in Madurai district indicates, that the exchange is direct .The sodium and potassium from water are exchanged with magnesium and calcium in rock favouring anion- cation exchange reactions. From TABLE III, the water type in Madurai district is Na-Mg-Cl-HCO3.

TABLE IIIII

WATER TYPE IN MADURAI DISTRICT

Location	Na+ /Cl	CAI	Water Type
Taluk(T1)	0.50	0.41	Na-Mg-Cl-HCO3
Taluk(T2)	0.72	0.25	Na-Mg-Ca-Cl-HCO3
Taluk(T3)	0.54	0.34	Na-Mg-Ca-Cl-HCO3
Taluk(T4)	0.64	0.14	Mg-Na-Ca-HCO3-Cl
Taluk(T5)	0.48	0.45	Na-Mg-Ca-Cl-HCO3
Taluk(T6)	0.69	0.25	Na-Mg-Ca-HCO3-Cl
Taluk(T7)	0.47	0.48	Na-Mg-Ca-Cl-HCO3

TABLE IVV

MEAN VALUES OF WATER QUALITY PARAMETERS

Location	TDS	Cl	Na%	SAR	RSC
Taluk(T1)	965	326	38.51	3.34	0.3
Taluk(T2)	985	276	42.68	4.2	0.4
Taluk(T3)	958	322	41.55	3.65	0.3
Taluk(T4)	753	129	30.93	1.9	0.2
Taluk(T5)	1247	397	35.09	3023	0.1
Taluk(T6)	679	159	35.22	2.55	0.4
Taluk(T7)	1066	343	37.18	3.17	0.3

TABLE V

CLASSIFICATION OF WATER FOR IRRIGATION

Sl no	Constituents	Suitable	Marginal	Inferior
1	TDS(mg/l)	<1000	1000-2000	>2000
2	Chloride(mg/l)	<175	175-350	>350
3	Sodium (%)	<60	60-75	>75
4	RSC	<1.25	1.25-2.5	>2.5

(SOURCE: STATE GROUND AND SURFACE WATER RESOURCES DATA CENTRE, CHENNAI.)

The other parameters of the irrigation water which effects on crop production and soil quality are

- **Salinity hazard** - total soluble salt content
- **Sodium hazard** - relative proportion of sodium to calcium and magnesium ions
- **pH - acid or basic**
- **Alkalinity** - carbonate and bicarbonate
- **Specific ions**: chloride, sulfates, boron, and nitrate**.**

The most influential water quality guideline on crop productivity is the water salinity hazard as measured by TDS. The primary effect of high TDS water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the TDS, the less water is available to plants, even though the soil may appear wet. As per TABLE IV, the TDS values are fall within the suitable level required for irrigation as per the standard in TABLE V, except the water in taluk vadipatti (T5) 1247mg/l and Tirumangalam (T7) 1066mg/l. The other taluks having the TDS value are 965,985,958,753 and 679 in taluk T1, T2, T3, T4, and T6 respectively.

Chloride is a common ion in irrigation waters. Although chloride is essential to plants in very low amounts, it can cause toxicity to sensitive crops at high concentrations. The presence of Chloride Cl in Vadipatti (T4) 129mg/l and in Peraiyur (T6) 159mg/l are fall in the suitable range and in Madurai North (T1)326mg/l, in Madurai South (T2) 276mg/l, in Melur (T3)322mg/l and in Tirumangalam (T7) 343mg/l, which are in the "Marginal level". In Usilampatty (T5) the TDS level is 397mg/l and the quality of water is "Inferior'.

TABLE VI

GUIDELINES FOR ASSESSMENT OF SODIUM HAZARD OF IRRIGATION WATER BASED ON SAR AND EC^2

Sl no	SAR	Sq of EC (dS/m)		
		Suitable	Marginal	Inferioe
1	0 to 3	<0.2	0.2-0.7	>0.7
2	3 to 6	<0.4	0.4-1.2	>1.2
3	6 to 12	<0.5	0.5-1.9	>1.9
4	12 to 20	<1.0	1.0-2.9	>2.9
5	20 to 40	<3.0	3.0-5.0	>5.0

Modified from R.S. Ayers and D.W. Westcot. 1994. Water Quality for Agriculture, Irrigation and Drainage Paper 29, rev. 1, Food and Agriculture Organization of the United Nations, Rome.[7]

Sodium hazard- Even though the plant growth is primarily restricted by the salinity, the application of water with a sodium imbalance can further reduce the yield. When irrigation water contains high sodium relative to the calcium and magnesium contents it will reduce the water infiltration. This condition is termed as"sodicity," results from excessive soil accumulation of sodium. It causes swelling and dispersion of soil clays, surface crusting and pore plugging. This degraded soil structure condition decrease the downward movement of water into the soil and may increase runoff.

The sodium percentage (Na %) of ground water samples in table V shows the values 38.51,42.68,41.55,30.93,35.09,35.22 and 37.18 in respect to taluks Madurai north, Madurai south , Melur, Vadipatti, Usilampatti, Peraiyur and Tirumangalam are below 60 and well within the limit of the irrigation quality of "Suitable" condition

In addition to the SAR and Na%, the excess sum of carbonate and bicarbonate in groundwater over the sum of calcium and magnesium also influences the unsuitability of

ground water for irrigation. This is termed as residual sodium carbonate (RSC) [8]. The RSC is calculated using the formula

$$RSC = (HCO3^- + CO32^-) – (Ca2^+ + Mg2^+)$$

The concentrations are expressed in meq/l. While referring the Tables IV and V, the groundwater samples of Madurai district, all the samples indicates that water is fit for irrigation purposes.

IV. CONCLUSION

From the above studies, it can be concluded that the ground water quality in Madurai district is very well suitable for irrigation and agricultural purposes. The water type in Madurai district is generally Na-Mg-Cl-HCO3. Some abnormalities have been found with Total Dissolved Solids but within the tolerable limits in two taluks. It is also seen that the Chloride content, which is not of good quality in one taluk. This may be due to organic pollution, but this can always be controlled. Encouraging the rainwater harvesting will also reduce this problem, as recharging of water will happen and dilution of water during the process of infiltration will bring a solution to the problems of ground water pollution.

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REFERENCES

- Brindha. K and Elango. L.,(2011) "Hydro chemical characteristics ofgroundwater for domestic and irrigation purposes in Madhuranthakam,TamilNadu, India,"Earth Sciences Research Journal,vol. 15, no. 2, pp. 101–108**.[1]**
- Jeevanandam M, Kannan R, Srinivasalu S, Rammohan V (2007) "Hydro geochemistry and groundwater quality assessment of lower part of the Ponnaiyar River Basin, Cuddalore district, South India". Environ Monit Assess 132:263–274 **[2]**
- Baghvand A, Nasrabadi T, Bidhendi NG, Vosoogh A, Karbassi A,Mehrdadi N (2010) Groundwater quality degradation of anaquifer in Iran central desert. Desalination 260:264–275 **[3]**
- *Pazand K, Hezarkhani A, Ghanbari Y, Aghavali N (2011) Groundwatergeochemistry in the Meshkinshahr Basin of ArdabilProvince in Iran. Environ Earth Sci. 65:871–879**[4]***
- *Pazand K, Hezarkhani A, Ghanbari Y, Aghavali N (2012) Geochemicaland quality assessment of groundwater of MarandBasin,EastAzarbaijan Province, northwestern Iran. Environ Earth Sci.doi:10.1007/s12665-012-1557-7**[5]***
- *Meyback M (1987) Global chemical weathering of surficial rocks estimated from river dissolved loads. Am J Sci 287:401–428**[6]***
- *Ayers R.S. and D.W. Westcot.(1994). Water Quality for Agriculture, Irrigation and Drainage Paper 29, rev. 1, Food and Agriculture Organization of the United Nations, Rome**. [7]***
- *Richard L.A., Diagnosis and improvement of saline and alkali soil, US Department of Agricultural Handbook No. 60, 160, (1954 **)[8]***