Assessment of Groundwater Quality in Tirupur Environs, Tamil Nadu, India

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***Abstract* – Groundwater is a valuable and the widely dispersed resource of the earth. This most valuable resource is sometimes inadequate due to improper use of surface and groundwater aquifers. The wide-range of textile industrial process and urbanization activities in the study area affects the groundwater. For groundwater examination, sixty two bore well water samples have been collected and analyzed for different physic-chemical parameters. Along with major cation and anions, fluorde, and total hardness were evaluated. Quality of groundwater for drinking purpose and irrigation are evaluated. Based on Gibb's diagram, evaporation and chemical weathering of rock-forming minerals are influencing the quality of groundwater. On the basis of Richard classification and sodium percentage, the suitability of groundwater for irrigation purpose is presented in this paper.**

Keywords: Groundwater chemistry – Sodium adsorption ratio - Tirupur – India

I. INTRODUCTION

Water is vital for all life forms on the earth. Groundwater is a valuable and the most extensively distributed resource. Depends on its consumption and usage, it can be a non-renewable or renewable resource. Due to various reasons, the most important are the scarcity of potable surface water. Frequent failures and uneven spatial variation of rainfall, in additional to insufficient water management technologies, fast developmental activities are not only making demand for groundwater but also contaminating the existing water resources due to improper discharge of effluents into the river course [1].

Quality of groundwater evolves quickly as it passes through the pathways of subsurface within the soil and unsaturated rock zone and thence to the saturated rock zone of aquifers. General belief is that groundwater is safer and purer than surface water owing to the protective qualities of the soil cover. Hydogeochemistry is chiefly a function of the composition of minerals of the aquifer through which it enters. The hydrogeochemistry and hydro chemical processes of the groundwater differ temporally and spatially, depending on the chemical properties and geology of the aquifer. The hydro geochemical processes such as precipitation dissolution, ion exchanging processes and the residence time along the flow path affects the chemical composition [2, 3]. Chemistry of groundwater depends on various factors viz., general geological settings, weathering of the rock types and recharge water quality other than water-rock interaction process which results complex groundwater value [4, 5]. Water is considered as being contaminated when it is in poor condition for its intended utilize. Groundwater self-purification process is a function of the absorption of pollutant in the percolating water and the depth of soil [6]. Hydro-geochemical studies of groundwater offer a better understanding of potential changes in value as development progress [7]. In the present study, the objectives are to ascertain the hydro-chemistry of groundwater for determination the process and identifying the anthropogenic factors which affect the quality of groundwater in the region.

II. STUDY AREA

The study area is in between the latitudes $11^{0}00'10''$N to $11^{0}13'31''$N and longitudes $77^{0}13'10''$E to $77^{0}29'31''$E (Fig. 1) with geographical extension of 455 km^{2}. It is an undulated topography with the height range from 291 m to 323 meter above the mean sea level and sloping gradually towards east direction. Temperatures vary between 22^{0}C and 43^{0}C with a mean rainfall of 630 mm. The study region is located at 52 km east of Coimbatore city. The study region is an industrial centre for the textile sectors. Tirupur accounts for 90% of India's yarn knitwear and it is referred as textile valley of India. There are about 2100 producing units manufacturing different varieties of textile goods. The textile industrial units in the study region use a variety of chemicals which are likely to be from the red list cluster which are said to be destructive and unhealthy for all living beings [8]. The Noyyal river runs across the study region, almost separating it into two halves. It has been linked with groundwater quality evils and the general practice of discharging the untreated industrial effluents into the tributary of Noyyal river has been alarming. The quality of groundwater in Tirupur region deteriorated rapidly during the last decade. The characteristic of surface and subsurface formation is due to drainage pattern of the area. More runoff is possible in more drainage density area. Dentritic type of drainage pattern is in the study location. A variety of geomorphic units such as pediments, shallow pediments, duri crust, shallow buried pediments etc are in the region. In nature, the area is with wide range metamorphic rocks of gneiss. The familiar rock types are gneiss – unclassified- (hornblende-biotite-gneisses), pink granite and charnockite (Fig. 2).

III. MATERIALS AND METHODS

For ascertaining the status of the groundwater, sixty two groundwater samples were collected from the study area. Even though sample locations covered the entire area, attention was given to Tirupur area where pollution is highly expected**.** Therefore one third of the sample points are within the city of Tirupur and the remaining sample points are away from Tirupur municipality border. For analysis the required instruments were calibrated according to the commercial grade calibration standards earlier to their measurements. The physic-chemical parameters analyzed are: pH, Total Dissolved Solids (TDS), Electrical Conductivity (EC), calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^{+}), potassium (K^{+}), bicarbonate (HCO_3^{-}), chloride (Cl^{-}), carbonate (CO_3^{2-}), nitrate (NO_3^{-}), sulphate (SO_4^{2-}) and fluoride using the standard procedures specified by means of the American Public Health Association [9]. The results of the physic-chemical parameters are evaluated as per the standard [10] and World Health Organization [11]. The summation of milliequivalents of cation must be equal to the amount of milliequivalents of cation for a liter [12]. They must be electrically neutral. But they are rarely equal in put into practice. Percentage of error in the groundwater samples ranges between ± 1 and 10% [13].

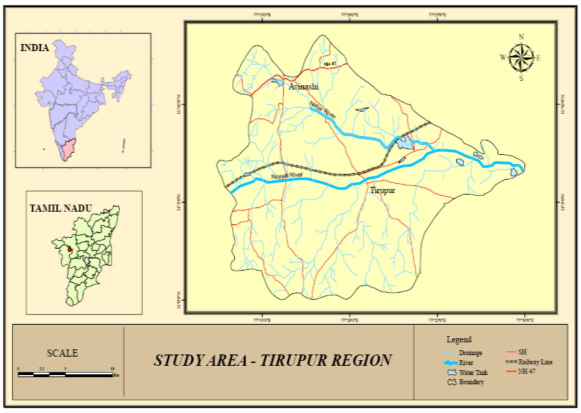


Fig. 1 Location of the study area

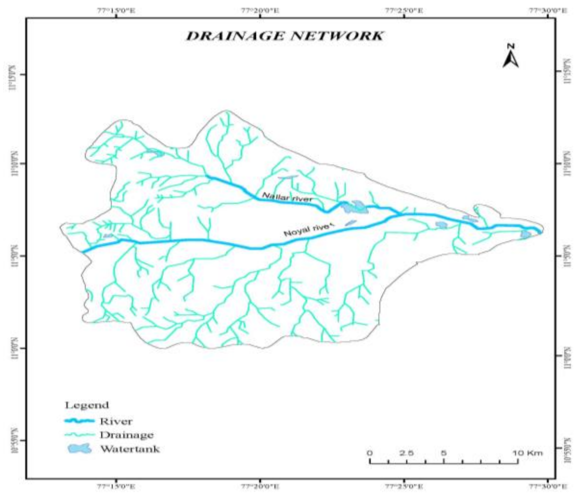


Fig. 2 Drainage system of the study area

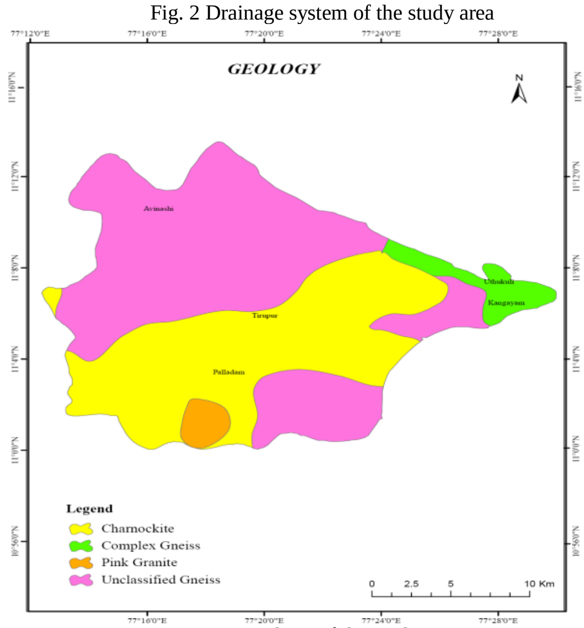


Fig. 3 Geology of the study area

IV. RESULT AND DICUSSION

A. Hydro-geochemistry

Exploration of groundwater chemistry is important for evaluating the groundwater conditions. Understanding the groundwater value is vital as it is the main factor for determining its suitability for domestic, drinking, industrial and agricultural purposes. Physico-chemical parameters and their statistical dealings such as minimum, maximum, mean and median are illustrated in Table 1. Electrical conductivity is a measure of salinity exposure to plants as it reflects [14] the TDS in groundwater.

The EC values ranges from 310 to 5,960 µS/cm with a mean and mode of 1,810 and 1,412 µS/cm respectively. The pH of groundwater ranges from 7.10 to 8.75 with an average value of 7.78. pH values are within safe limits of standards.

However the groundwater is mostly of alkaline nature. Total dissolved solids values ranges from 198 to 5,125 mg/l with a mean value of 1,166 mg/l.

The spatial variation and distribution of TDS is illustrated in Fig. 4. The Nallar and Noyyal stream – central region of the study area – surroundings are highly affected by TDS. 87% of the samples are exceeding the desirable limit of samples range from 0 to 1.0 mg/l with mean value of 0.4 mg/l. Fluoride study samples range from 0 to 1.0 mg/l with standards for drinking purpose [15] and 47% of the samples belong to brackish type (Table 2).

The order of dominance of ions of cations are: calcium (Ca^{2+}) > sodium (Na^+) > magnesium (Mg^{2+}) > potassium (K^+) and anions are: chloride (Cl^-) > bicarbonate (HCO_3^-) > sulphate (SO_4^{2-}) > nitrate (NO_3^-) > carbonate (CO_3^-) respectively. The concentration of fluoride in groundwater mean value of 0.4 mg/l. Fluoride study reveals that 68 % of the affected.

Table 1 Drinking water standards and summary of physico-chemical parameters

Water quality Parameters	WHO (1993)		ISI (2012)		Analytical results of parameters			
	Most desirable	Maximum permissible limit	Most desirable	Maximum permissible limit	Minimum	Maximum	Mean	Median
EC (µS/cm)	-	-	-	-	310	5,960	1,810	1,412
pH	7-8.5	6.5-9.5	6.5-8.5	6.5-9.2	7.10	8.75	7.78	7.62
TDS (mg/l)	500	1,500	500	1,500	198	5,125	1,166	905
TH (mg/l)	100	500	300	600	114	2,558	696	560
Ca^{2+} (mg/l)	75	200	75	200	18	1,035	151	110
Mg^{2+} (mg/l)	50	150	30	100	15	322	76	71
Na^+ (mg/l)	-	200	-	-	9	222	91	90
K^+ (mg/l)	-	12	-	-	3	92	24	15
HCO_3^- (mg/l)	-	-	-	300	55	653	188	265
CO_3^{2-} (mg/l)	-	-	-	-	0	245	33	29
Cl^- (mg/l)	200	600	250	1000	2	2,255	366	228
NO_3^- (mg/l)	45	-	-	-	0	129	36	33
T.Alk (mg/l)	-	-	300	600	118	699	403	397
SO_4^{2-} (mg/l)	200	400	150	400	10	428	80	54
F^- (mg/l)	-	1.5	0.6	1.2	0	1.00	0.40	0.40

Table 2 Classification of groundwater based on total dissolved solids

TDS (mg/l)	Groundwater classification (after Davis and DeWiest 1966)			TDS (mg/l)	Groundwater classification (after Freeze and Cherry 1979)		
	Classification	Number of samples	Percentage of samples		Classification	Number of samples	Percentage of samples
< 500	Desirable for drinking	08	12.90	< 1,000	Fresh water	33	53.25
500 -1,000	Permissible for drinking	25	40.32	1,000 -10,000	Brackish water	29	46.75
>1,000	Unfit for drinking	29	46.78	>100,000	Saline water	-	-

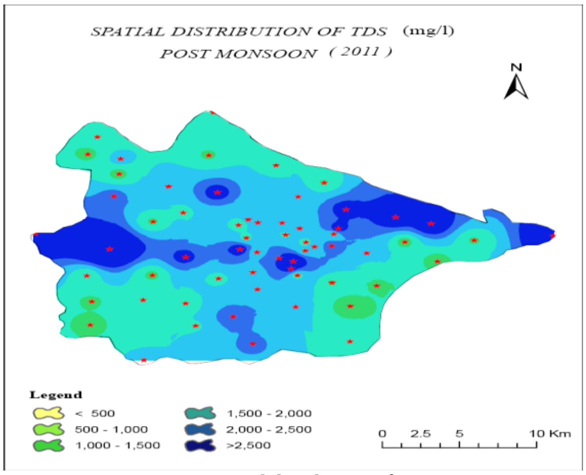


Fig. 4 Spatial distribution of TDS

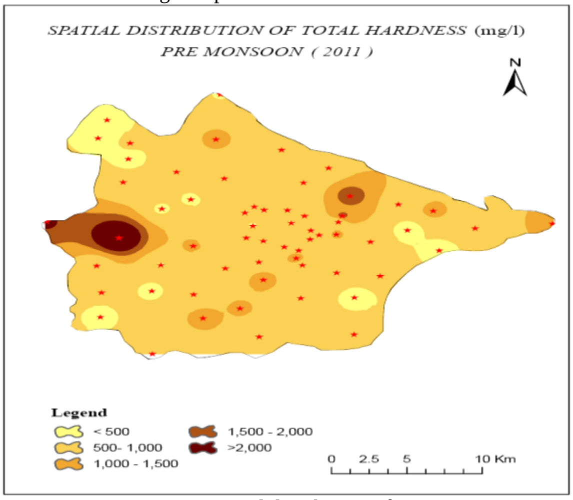


Fig. 5 Spatial distribution of TH

Total Hardness (TH) is caused by concentration of calcium and magnesium ions [16]. TH is defined as

$$TH(as CaCO_3)\ mg/l = (Ca^{2+} + Mg^{2+})\ meq/l \times 50 \quad (1)$$

(1) (1)

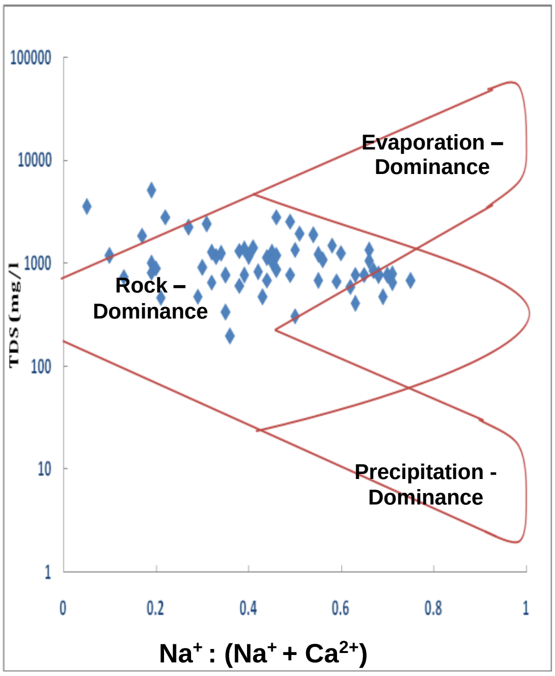
Range of desirable limit of TH is between 80 and 100 mg [12]. TH beyond 300 mg/l is referred as very hard. In the study region 90% of the samples falling under very hard type (Table 3) and their spatial distribution is illustrated (Fig. 5).

B. Mechanism controlling - groundwater chemistry

Gibb's diagram is extensively used for assessing the functional sources of dissolved chemical ions, such as rock dominance, precipitation-dominance and evaporation-dominance [17]. The results of data of groundwater samples of the study region have plotted in Gibbs's diagram (Fig. 6). The diagram reveals that the evaporation and chemical weathering of rock-forming minerals are influencing the quality of groundwater in the area. Evaporation increases salinity by increasing chloride and sodium with relation to increase of TDS. Longer residence time of groundwater, semi-arid climate conditions, gentle sloping and insufficient drainage conditions also controls groundwater quality [18].

Table 3 Classification of groundwater based on TH (after Sawyer and Mc Cartly 1967)

TH	Classification	Number of samples	Percentage of samples
< 75	Soft	-	-
75 – 150	Moderately high	01	01.61
150 – 300	Hard	05	08.06
> 300	Very hard	56	90.32



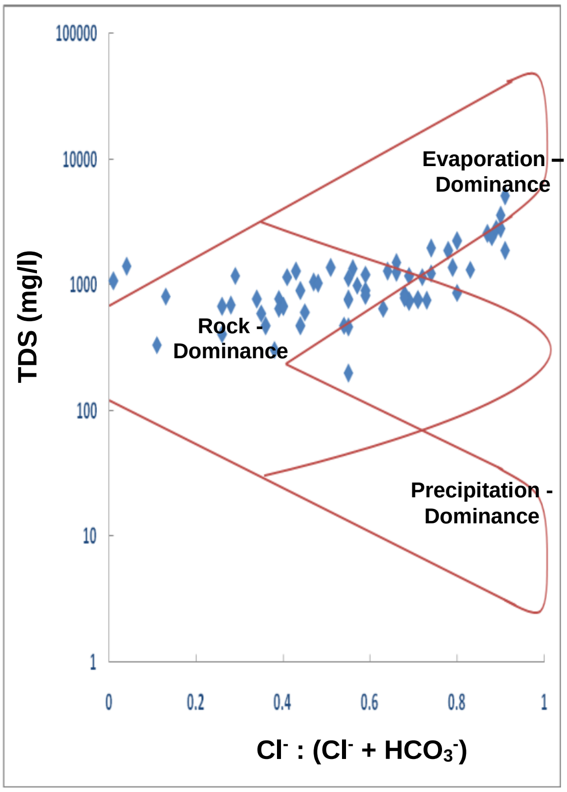


Fig. 6 Mechanism controlling - groundwater quality (after Gibbs 1970)

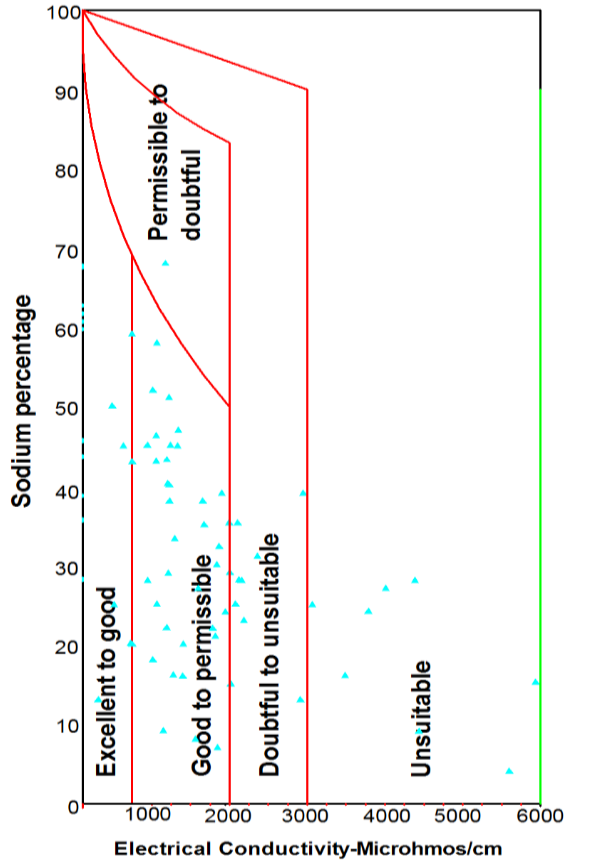


Fig. 7 Groundwater suitability for irrigation (after Wilcox 1955).

C. Irrigation suitability

Groundwater suitability for irrigation was examined by Sodium Adsorption Ratio (SAR). Due to presence of salt in the groundwater, besides affecting the growth of vegetations directly affects soil properties and structure permeability which affects the growth of plants [19]. SAR parameter is important for evaluating the suitability of groundwater for irrigation use. It is defined as

$$SAR = \frac{Na^{+}}{(Ca^{2+} + Mg^{2+})^{1/2}/2} \quad (2)$$

where the ion concentrations are expressed in meq/l. In accordance with the Richard's classification [20], on the basis of SAR, majority the groundwater samples belong to excellent category. Sodium percentage is generally used for assessing the suitability of groundwater for irrigation [21]. The calculation of sodium percentage as follows:

$$Na\% = \frac{(Na^{+} + K^{+}) \times 100}{(Ca^{2+} + Mg^{2+} + Na^{+} + K^{+})} \quad (3)$$

where all the ions are articulated in meq/l. The results of the samples are presented (Fig. 7). On the basis of sodium percentage, 98.38% of the samples came under the category of excellent to permissible.

V. CONCLUSION

The hydro-geochemistry of the groundwater indicates that most of the samples are alkaline in nature. The Nallar and Noyyal stream surrounding area is highly affected by TDS. 87% of the samples are exceeding the desirable limit of standards for drinking purpose and 47% of the samples belong to brackish type. Based on hardness, 90% of the samples falling under very hard type. Gibb's diagram proves that evaporation and chemical weathering of rock-forming minerals are influencing the quality of groundwater in the area. According to Richard's classification on the basis of SAR, majority the groundwater samples belong to excellent category and on the basis of sodium percentage, 98%, of the samples came under the category of excellent to permissible.

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