GROUNDWATER QUALITY ASSESSMENT FOR DRINKING PURPOSE AND IDENTIFICATION OF SOURCES CONTROLLING GROUNDWATER CHEMISTRY IN PARTS OF TIRUPUR DISTRICT, TAMIL NADU, INDIA

Arumugam K[1], Rajesh Kumar A[2], Elangovan, K[3]
[1,2]Department of Civil Engineering,
Kongu Engineering College, Perundurai, Erode,Tamil Nadu, India
[3] Department of Civil Engineering,
PSG. College of Technology, Coimbatore, Tamil Nadu, India

Abstract
Globally groundwater is the most essential for humans as well as for sustaining environment. To ensure sustainable development, the quality is important for safe use and every purpose. The study region is an industrial hub for the textile segment, and forms one of the important export centers in India. The groundwater quality in Aavinashi – Tirupur surroundings have been deteriorating rapidly. The broad-range of textile activities and urbanization process resulted in the pollution of the rock aquifer. For the purpose of quality determination for domestic use and source identification, sixty two subsurface water samples are collected and the important anion and cation parameters are analyzed along with pH and total dissolved solids. The parameter results are evaluated according to the water quality standards. The study area is belonging to alkaline nature. The order of abundance of parameters, Na+ > Ca^{2+} > Mg^{2+} > K^+. = Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-- > CO_3^-. The greater part of the groundwater samples belong to brackish. According to Gibb's diagram, the chemical weathering of rock-forming minerals, evaporation and precipitation effects of the quality of groundwater is determined.

Index Terms: Gibbs' diagram, Salinity, Tirupur, India

I. INTRODUCTION

Water is the most widely distributed natural resource for human use and for the sustain environment. In the last decade, widespread reports of groundwater pollution have increased public worries about the quality of drinking water and for the use of groundwater for domestic usage. The processes of geochemistry within the groundwater and reactions with aquifer mineral components have a reflective effect on groundwater quality. The geochemical processes are accountable for the spatial variations and seasonal changes in groundwater chemistry. Hydro-geochemistry of groundwater depends on the chemical properties of groundwater and its processes in the subsurface. Deviation in groundwater chemistry is primarily a function of the interaction between the mineral components and groundwater of the aquifer materials of the region. The hydro-geochemistry process such as dissolution, precipitation, ion-exchange, adsorption, together with the residence time occurring along the flow path, control the disparity in the chemical components of groundwater [1]. Water is recognized as being polluted when it is flabby for its intentional use. The self-purification progression of groundwater is a function of the concentration of the pollutant in the percolating water and the depth of the soil of the area [2]. Frequently groundwater chemistry interpretation is done with the graphical displays such as Stiff patterns Piper diagrams and Gibb's diagram [3]. Groundwater quality is equally essential to its quantity owing to the appropriateness of water for different purposes [4], [5]. Interpreting the quality of groundwater is significant as its quality since it is the most important factor for determining its suitability for different purposes. The quality of water depends upon the chemical composition of the recharge water, geology of the area and interaction of soil and other substances which are in soluble form within the aquifer. These features are inter-related and important for understanding the hydrological set-up of any area [6].

II. STUDY AREA

The study region is characterized by an undulated terrain with the ranging between 295 and 323 meter above the Mean Sea Level (MSL). The geographical coverage of the study area is 455 square kilometers and lies between latitudes 11^{0}00'03"N to 11^{0}13'33"N and longitudes 77^{0}12'03"E to 77^{0}29'34"E (Fig. 1) which is located at 48 km east of Coimbatore city in Tamil Nadu. Temperature of the study area varies between 22^{0}C and 41^{0}C with average rainfall of 610 mm. The study area is an industrial center for the textile segment and one of the most significant export centers of India and Tirupur accounts for 90% of India's cotton knitwear. More than 2000 producing units manufacturing variety of supplies such as vests, panties, tracks, suits, briefs etc. The use of large varieties of chemicals in bleaching and dyeing render very complex. The textile processing units use a number of chemicals that are probable to be from the red list cluster which is said to be harmful. The Noyyal river runs across the study region. Due to discharge of untreated industrial effluents into the river course, the Noyyal and Nallar rivers, the aquifers are affected [7]. Groundwater quality depletion by anthropogenic activities and textile industrial process are major problem in the study area. Using of dye stuffs in textile processing and the inappropriate system of discharge of effluents create environmental distress. Use of red list group of chemicals are said to be unhealthy and harmful. The dentric drainage network pattern of the study area reflects the geomorphic features. Geologically, the study area is with a wide range of high-grade gneissic complex of metamorphic rocks. They are highly weathered and overlain by current valley deposits. The common rock type is complex gneiss, pink granite and charnockite (Fig. 2).

III. METHODOLOGY

Within the study area sixty two groundwater samples were collected and analyzed. The sample points covered the entire study area. But more attention was given to Tirupur urban area where pollution is highly expected**.** Hence one third of the groundwater sample points are within the Tirupur municipal boundary and the remaining samples cover part of the Avinashi and Palladam taluks. For analyzing, the instruments were calibrated properly according to the commercial grade calibration standard before to the measurements. The groundwater samples are analyzed for the physic-chemical parameters viz., hydrogen ion chemistry (pH), Total Dissolved Solids (TDS), calcium (Ca^{+}), magnesium (Mg^{2+}), potassium (K^{+}), sodium (Na^{+}), chloride (Cl^{-}), bicarbonate (HCO_3^{-}), carbonate (CO_3^{-}), sulphate (SO_4^{2-}), nitrate (NO_3^{-}), fluoride (F^{-}) and Total Hardness (TH) in the laboratory according to the standards given by the American Public Health Association [8]. The parameter results were evaluated according to the water quality standards [9], [10]. The elements of solution should be electrically neutral. However, they are rarely equal in practice. The dissimilarity increases as the concentration of ion increases [11]. Hence the accuracy of the ion concentrations were verified (Fig. 3) by calculating ion-balance errors where the errors are generally around 10% [12].

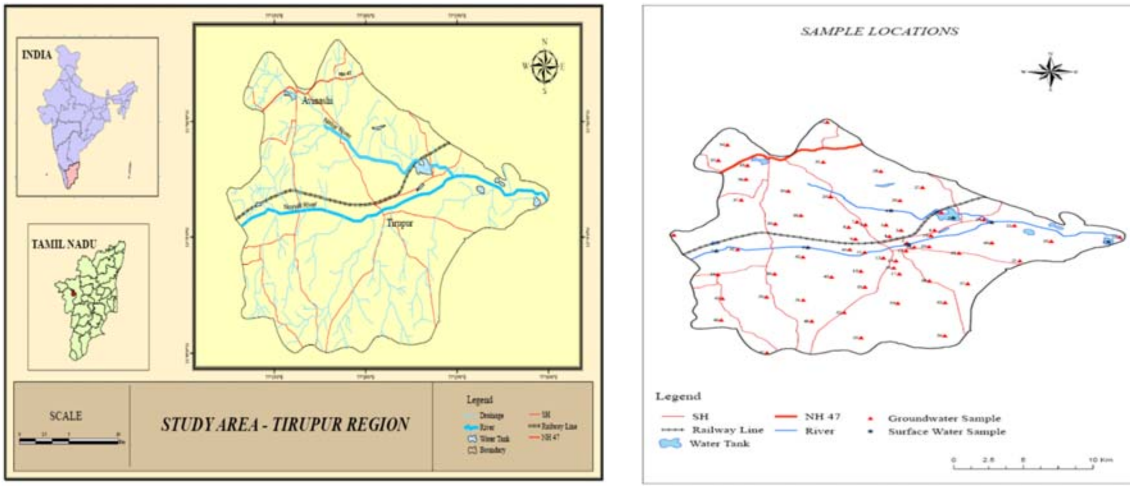

Fig. 1 Study area and sampling locations

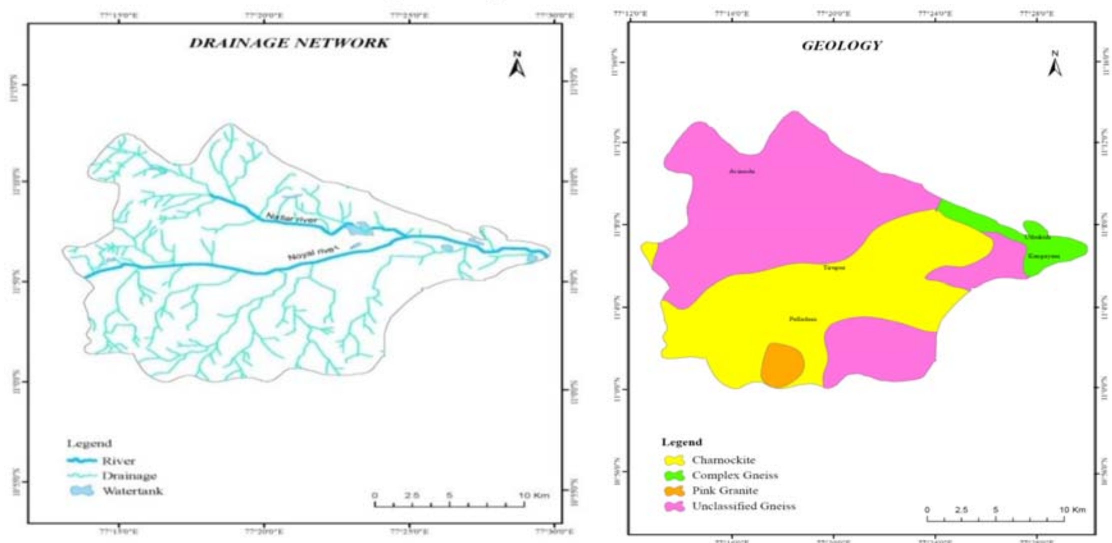

Fig. 2 Drainage network and geology of the study area

IV. RESULT AND DISCUSSION

Quality of groundwater with specific standards informs about the usage of water for different purposes. For domestic use, the water should satisfy specific water quality criterions [13]. The main factor which determines the quality of the groundwater in the study area is textile industrial / anthropogenic activities. For assessing the sources of groundwater chemistry, the cation and anion parameters are analyzed. The analyzed physicochemical parameters of the groundwater results and statistics such as minimum, maximum, mean and median are illustrated in Table 1. The values of pH of the groundwater samples range from 7.08 to 8.87 with the mean value of 7.61. This study reveals that the region is with alkaline nature of groundwater [14]. The total dissolved solids (TDS) of the groundwater samples of the study area have ranges from 205 to 5,215 mg/l with the average value of 1,775 mg/l. The study indicates that 3.23%, 20.63% and 76.14% of the samples belong to desirable for drinking (TDS < 500 mg/l), permissible for drinking (TDS 500 - 1000 mg/l) and unfit for drinking (TDS > 1,000 mg/l) categories respectively. The TDS spatial variation of the study area is illustrated in Fig. 4. The investigation proves that nearly all of the elevated concentration of total dissolved solids (Fig. 4) are near by the Noyyal river-central area from west to east. According to the salinity classification, the greater part of the groundwater samples belong to brackish (TDS > 1000 mg/l) type [15].

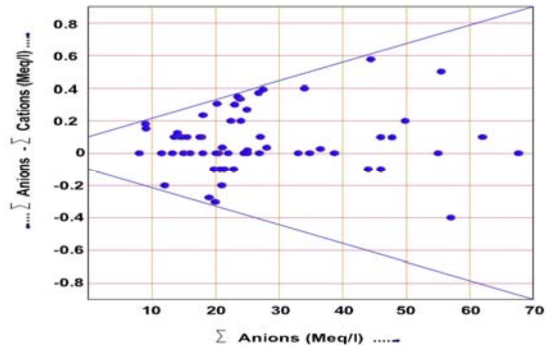

Fig. 3 Anion and cation balances chart - demonstrating the quality of groundwater parameter analysis

Table 1 Drinking water quality standards and summary statistics of the groundwater samples

Parameters	Indian Standards Institution (2012)		World Health Organization (1993)		Results of analyzed parameters			
	Highest desirable	Maximum permissible	Highest desirable	Maximum permissible	Minimum	Maximum	Mean	Median
pH	6.5-8.5	6.5-9.2	7-8.5	6.5-9.5	7.08	8.87	7.69	7.61
TDS (mg/l)	500	1,500	500	1,500	205	5,125	1,175	905
TH as $CaCO_3$ (mg/l)	300	600	100	500	115	2,560	698	562
Ca^{2+} (mg/l)	75	200	75	200	16	1,048	150	110
Mg^{2+} (mg/l)	30	100	50	150	14	325	76	73
Na^{+} (mg/l)	-	-	-	200	10	225	91	90
K^{+} (mg/l)	-	-	-	12	05	92	25	15
HCO_3^- (mg/l)	-	300	-	-	55	655	186	268
CO_3^- (mg/l)	-	-	-	-	10	252	39	28
Cl^- (mg/l)	250	1,000	200	600	20	2,250	280	228
NO_3^- (mg/l)	-	-	45	-	15	130	35	31
SO_4^{2-} (mg/l)	150	400	200	400	07	430	81	53
F^- (mg/l)	0.6	1.2	-	1.5	0	1.0	0.5	0.4

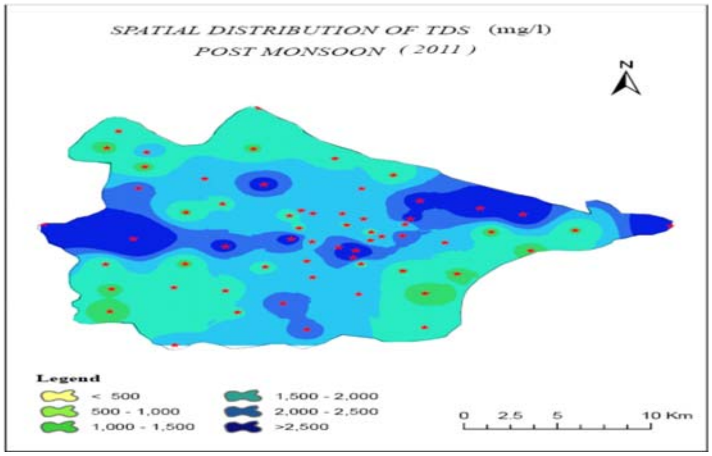

Fig. 4 Spatial variation of total dissolved solids of the study area

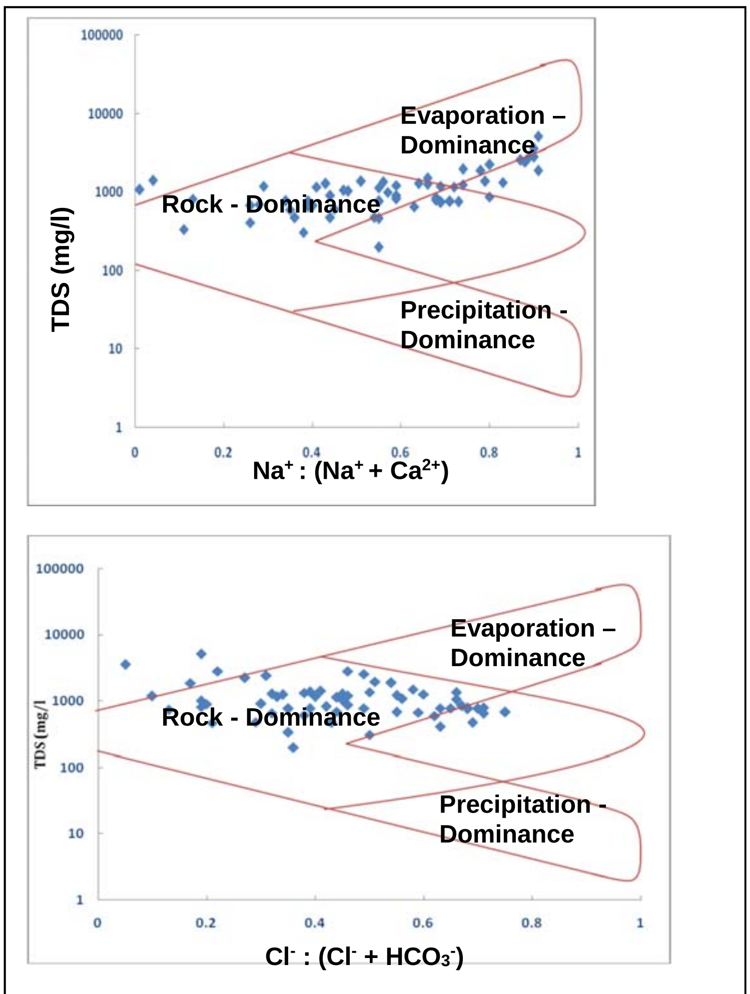

Fig. 5 Mechanism controlling the quality of groundwater (after Gibbs 1970)

The concentration of cations Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} ions ranged from 16 to 1,048, 14 to 325, 10 to 225 and 5 to 92 mg/l with the mean of 110, 73, 90 and 15 mg/l respectively. The order of abundance of the cation parameters are Na+ > Ca^{2+} > Mg^{2+} > K^{+}. The concentration of anions HCO_3^-, SO_4^{2-}, Cl^-, NO_3^- and CO_3^- ranged from 55 to 655, 7 to 430, 20 to 2,250, 15 to 130 and 10 to 252 mg/l with the mean of 186, 81, 280, 35 and 39 mg/l respectively. The order of of abundance of the anion parameters are Cl^- > HCO_3^- > SO_4^{2-} > NO_3^- > CO_3^-.

According to Gibb's diagram, $Na^+ : (Na^+ + Ca^{2+})$ and $Cl^- : (Cl^- + HCO_3^-)$ is a function of TDS. . It is generally used for assessing the functional sources of dissolved chemical process such as rock-dominance, evaporation-dominance and precipitation-dominance [16]. The analyzed chemical data of the groundwater samples of the study area is plotted in Gibbs's diagram (Fig. 5). The allocation of sample points reveals that the chemical weathering of rock-forming minerals and evaporation affects the quality of groundwater.

V. CONCLUSION

The groundwater chemistry reveals that the region is with alkaline nature of groundwater.
The investigation proves that 3.23%, 20.63% and 76.14% of the samples belong to the categories of desirable for drinking, permissible for drinking and unfit for drinking respectively. Nearly all of the higher concentrations of total dissolved solids are near by the Noyyal river-central area from west to east. The greater part of the groundwater belongs to brackish type. The chemical weathering of rock-forming minerals and evaporation affects the quality of groundwater

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