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A Study On The Drinking Water Quality Index And Groundwater Quality Assessment In Virudhunagar District, Tamilnadu, India

Senthilkumar M[1], Ganesh N[2], Chidambaram S[3], Thilagavathi R[4]

[1,2,4]Department of Earth sciences, Annamalai University, Tamil Nadu, India -608002.
[3]Research Scientist, Water Research Centre, Kuwait Institute for Scientific Research, Safat, Kuwait.

Email:[1] mskgeosenthil@gmail.com

Abstract: The present investigation is aimed toward understanding the hydro geochemical parameters and development of a water quality index (WQI) to assess groundwater quality of exhausting rock space in Virudhunagar district, Tamil Nadu. A study was applied during this district of the province for 2 seasons (Northeast monsoon and Post-monsoon) to assess the drinking water quality and their seasonal differences through DWQI (Drinking water quality index). A total of 144 groundwater samples for two seasons are collected representing the whole district. The Physicochemical parameters considered for the drinking water quality index (DWQI) include pH, TDS, cations such as Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}, anions such as Cl^{-}, SO_4^{2-}, HCO_3^{-}, PO_4^{2-} and NO_3^{-}, were also considered for DWQI. The poor water quality is due to the presence of excess amounts of TDS, Na^{+}, HCO_3^{-} and Cl^{-} with in the study area. The spatial distribution of DWQI indicates that the Excellent to the good water quality of the drink is determined in patches in completely different regions in the study area. The change in DWQI within the region implies to the season of all monsoon could also be due to the activity of ions, weathering, and action processes.

Keywords: Geochemistry, Spatial Distribution, Water quality index.

1. INTRODUCTION

The debility in water quality has come to be a universal problem of panic for the reason that of its essential capability to cause the most important modifications to the hydrological cycle. Many water quality indices have been developed for water quality parameter levels to associate degree integrated indicator value. A drinkable quality index (DWQI) describes the final scenario of groundwater bodies by ever-changing water quality parameters levels into a numerical score exploitation mathematical tools (Boyacioglu 2007; Icaga2007; Ocampo-Duque et al. 2006; Silvert 2000). The dependence on groundwater has accelerated quite in the latest years in lots of components of India. Hence, Physico-chemical evaluation of water is vital to evaluate the excellent of groundwater that affects the suitability of water for domestic, irrigation, and industrial needs (Thivya et al. 2013; Thivya et al. 2014; Prasanna et al. 2011; Thilagavathi et al. 2012; Chidambaram et al. 2011; Singaraja et al 2013). The understanding and observing the causes and quality of water used for a water source are of communal, commercial and environmental importance since water requirements are increasing while accessibility to freshwater availability is continuing to decline. There are many difficulties for the accessibility of groundwater resources in hard rock areas as a large and erratic variation of essential parameters characterizes the groundwater system. Virudhunagar district is such one in all them with hard-rock regions. In this context, a pioneering methodology has materialized in the approach of drinking water quality index over the present study. The primary aim of the current study is to implement the consistent drinking water quality Indexing classification for groundwater in the study area.

2. STUDY AREA

The district of Virudhunagar is derived from the district of Ramanathapuram in Tamil Nadu. The city of Virudhunagar serves as the district seat. The study area is located between latitude 9° 24'27.85 "N to 9 ° 11'10.19" N and longitude 78 ° 24'9.55 "E to 78 ° 5'24.45" E (Figure.1). The study area covers an area of 4,234 square kilometers. The district of Virudhunagar consists of Talks with an average altitude of 102 m above the previous average sea level. This district has a total population of 19, 42,288 (2011) Census. The Vaipar, Gundar, and Arjunanadi are the three main rivers that flow from the northwest to the southeast of the district. The annual temperature ranges from 23.78 ° C to 33.95 ° C. The most important soils in the district are red and black cotton soils. The study area is mainly covered by physiographic units of plains, plateaus, hills and valleys, and waters. Geologically, the entire Virudhunagar district can be roughly divided into hard rock formations and alluvial and tertiary sedimentary. Most of the district originates from a group of gneissic rocks that includes feldspathic gneiss, charnokite, and pink granite. The typical water level during the premonsoon is 12 m below the surface (bgl) and 8 m bgl during the post-monsoon period. In groundwater, it has been observed in porous, sedimentary, and rugged rock formations. The study area is known for the matchbox, fireworks and printing industries.

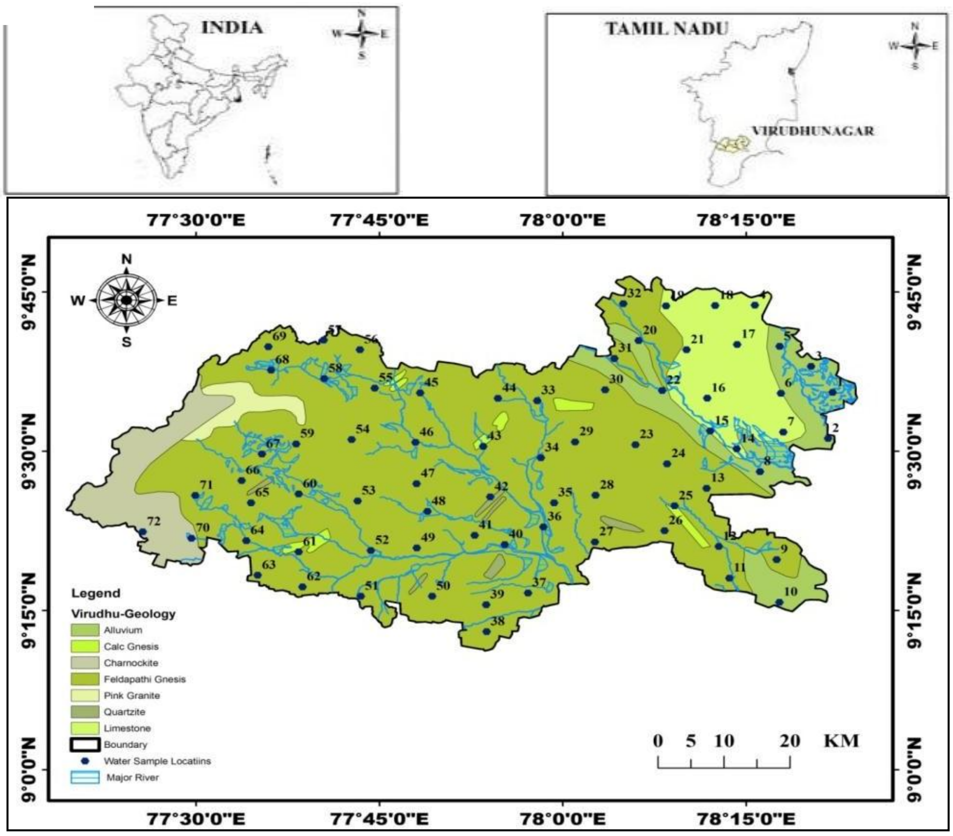


Figure 1: Geology map of the study area with sample location

3. METHODOLOGY

A total of about 144 water samples were collected by hand pumps representing the entire district during the Northeast Monsoon (NEM) and Post-monsoon (POM). The pH, temperature, TDS and conductivity of the water samples were measured in the field using a multi-parameter water analysis kit Sampling and analysis were performed using standard procedures (APHA 1998, Ramanathan 1992; Ramesh and Anbu1996). Calcium, magnesium, bicarbonate and chloride were determined by the titrimetric method. Sodium and potassium were analyzed by flame photometry (ELICO CL 378). Silica, phosphate and sulfates were determined spectrophotometrically. Their liability of the results was determined by the ionic balance of the groundwater samples. A percentage error of 5-10%was detected, Table 1.

Table 1: Weights of parameters Seasons (All values in mg/l except EC in µs/cm and pH.)

	NEM		POM	
Parameters	Weight age	Relative weight	Weight Age	Relative weight
pH	1	0.020	1	0.020
EC	2	0.040	3	0.060
TDS	2	0.040	3	0.060
TH	4	0.080	2	0.040
Ca^{2+}	2	0.040	1	0.020
Mg^{2+}	1	0.020	1	0.020
Na_+	1	0.020	4	0.080
K^{2+}	2	0.040	3	0.060
Cl^-	2	0.040	2	0.040
HCO_3^-	4	0.080	1	0.020
SO_4^-	1	0.020	1	0.020
PO_4^-	1	0.020	1	0.020
H_4SiO_4	1	0.020	1	0.020
	Σw_1=24	Σw_1 =0.480	Σw_1= 24	Σw_1=0.480

4. RESULTS AND DISCUSSIONS

4.1 North East Monsoon

A total of 72 groundwater samples were collected spatially during the North-East Monsoon (NEM) in 2019 based upon the coverage of the study area. The collected samples were studied for different physicochemical parameters like pH, TDS and EC, major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) and major anions (Cl^-, HCO_3^-, SO_4^-, PO_4^-) (Table.2). pH Values Range from maximum 8.4 to minimum 6.8. The maximum to minimum values range from EC 5870 and 273 µs/cm. the TDS high values 4160 to low values 197 mg/l. The major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) ranges maximum to minimum values 892 to 20, 450.4 to 4.8, 944.4 to 9.1, 296.4 to

2.8 all values mg/l. The major anions (Cl^-, HCO_3^-, SO_4^-, PO_4^-) maximum to minimum values 2980.2 to 53.2, 1198 to 134.2, 22.7 to 5.5,35 to 3.7, 84.2 to 9.9 all values mg/l. Na^+ and HCO_3^- are the dominant cation and anion during NEM.

4.2 Post-Monsoon

The water sample was collected post-monsoon (2020). The collected samples analyzed different physicochemical parameters. The major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+), major anions (Cl^-, HCO_3^-, SO_4^-, PO_4^-, H_4SiO_2) and pH, EC, TDS values (Table.2). The Ca^{2+} maximum, minimum values 252 to16 mg/l. Mg^{2+} ranges from 230.4 to 7.2 mg/l and Na^+, K^+ high value to low value 1201 to 3.4, 325.7 to1.9 mg/l. The major anions (Cl^-, HCO_3^-, SO_4^-, PO_4^-) maximum to minimum values 1987.4 to 70.9, 783 to 73.2, 25 to 0.09, 17 to 0, 32.35 to 5.88. During post-monsoon Na^+ and Cl^- are the dominant cation and anion.

4.3. Drinking water quality index

The Water Quality Index is a rating, reflecting the composite influence of water quality parameters. The quality of groundwater for consumption is assessed using the Drinking-Water Quality Index (DWQI). The index was calculated by assigning weights (w) to the water quality parameters (1) based on their perceived threat to water quality

Table 2: Maximum, Minimum and Average of the Chemical Constituents in Groundwater representing all two Sampling Seasons (All values in mg/l except EC in µs/cm and pH.)

	NEM			POM		
Parameters	Max	Min	Avg	Max	Min	Avg
pH	8.4	6.8	7.5	8.68	7.5	8.08
TDS	4160	194	1136	6916	233.8	1585.4
EC	5870	273	1593	6850	235	1621.4
Ca^{2+}	892	20	153.9	252	16	58.18
Mg^{2+}	450.4	4.8	90.7	230.4	7.2	65.15
N^+	944.4	9.1	151.6	1201	3.4	274.12
K^+	296.4	2.8	16.6	325.7	1.9	23.04
Cl^-	2980.2	53.2	441.8	1987.4	70.9	467.14
HCO_3^-	1198	134.2	539.7	783	73.2	286.65
PO_4^-	22.7	5.5	7.1	25	0.09	2.19
SO_4^-	35	3.7	19.5	17	0	1.62
H_4SiO_4	84.2	9.9	49.6	32.35	5.88	23.59

This is achieved by translating the concentrations of the constituents into a single value that reflects the composite influence of water quality parameters. The relative weight (W1) is calculated using

$$W_1 = \frac{W_1}{\sum^{n}_{1=1} W_1}$$

where W1 = weight of the water quality parameter 1 and n = number of parameters. The quality parameters were weighted (W1) out of on a scale of 1 to 5 according to their importance and their role in determining the quality of drinking water as presented in table 2. pH and total dissolved solids have been assigned a maximum weight of 5 due to their greater importance in assessing drinking water quality. Bicarbonate was assigned a weight of 2 because it was not significant in the evaluation of water quality because it does not influence consumption on the water quality in the study area. Other parameters received weights ranging from1to 4 depending on their importance in assessing the water quality of the region (modified from Ramakrishnaiah et al. 2009 and Vasanthavigar et al. 2010). A quality rating scale (QA) for each parameter was calculated by dividing its concentration in each water sample by It's respective WHO standard and is expressed as Where C_1=concentration of water quality parameter (1) in milligrams per litre and Sa= WHO standard for water quality parameter (a) in milligrams per litre. The sub-index (SI) was determined for each parameter, which is then used to determine the DWQI as follows

$$DWQI = \sum SI_1$$

The drinking water quality was classified based on DWQI values of less than 50, 50-100, 100-200, 200–300, >300, and greater than 300 as excellent, good, poor, very poor, and unsuitable, respectively (Table.3).

$$SI_1 = W_1 \text{ X } Q_1$$

$$Q_1 = (C_1/S_1) \text{ X } 100$$

Table .3: Percentage of samples of DWQI for All Seasons

DWQI	Category	NEM	POM
< 50	Excellent	76%	71%
50-100	Good	18%	18%
100-200	Poor	6%	4%
200-300	Very poor	-	1%

>300	Unsuitable	-	-

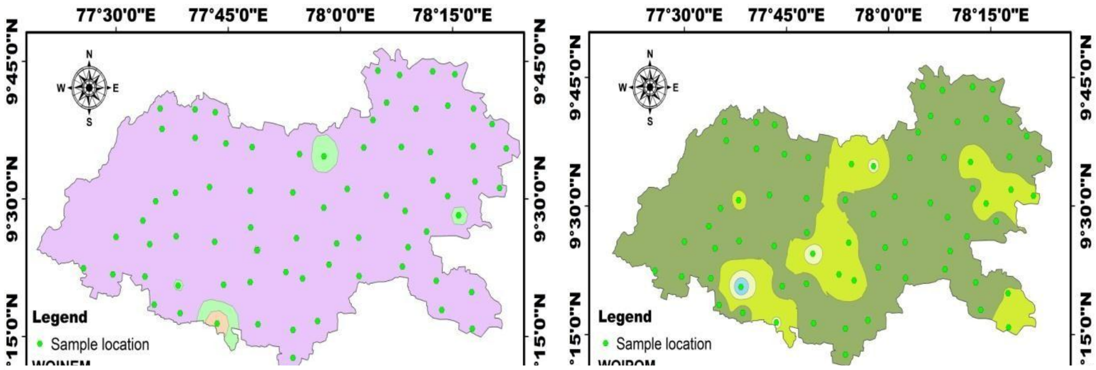
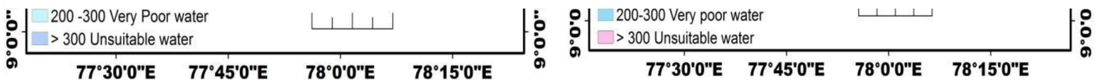


Fig. 2: Spatial distribution of Drinking Water Quality Index for A) NEM, B) POM.



The DWQI maps of the NEM and POM revealed that most of the samples in these seasons are dominated by Excellent and good, poor and very poor categories (Fig.2). In NEM Excellent category drinking water is observed as most of the region, Good category is noted in small observed as south, North and East region, poor categories are noted 1% of the sample observed in South Part of the study area. In POM Excellent, good, poor and very poor category is noted. Excellent category water sample present in the West and East region. The Good category of water samples is present in the South, North and Eastern side of regions. Poor and very poor category water occupied a small area of South and North region. The POM Monsoon whereas poor and very poor category is observed in south and Northern part of the study area. May be due to leaching of ions, overexploitation of groundwater, direct discharge of effluents along Vaippar River and agricultural impact (Jasmin and Mallikarjuna 2013). In NEM it ranges from excellent to poor category whereas in POM it ranges from excellent to very poor category. An increase in the category of good quality water during POM is mainly due to dilution processes during the monsoon. The poor water quality may be due to the presence of excess amounts of TDS, Na^+, HCO_3^-, and Cl^- in the study area.

5. MECHANISM CONTROLLING WATER CHEMISTRY

It is a commonly accepted fact that there is a close relationship between water composition and aquifer (Gibbs 1970). It is a plot of $(Na^+ + K^+) / (Na^+ + K^+ + Ca^{2+})$ Vs. TDS and $Cl^- / (Cl^- + HCO^-_3)$ Vs. TDS. Most of the samples fall into Weathering and some of the samples fall into the evaporation zone. In NEM, most samples fall in the weathering and evaporating regions. In POM, most samples fall within the boundary between the regions of evaporation and weathering (Chidambaram et al. 2008; Srinivasamoorthy et al. 2008). Most of the NEM and POM samples outside of the graph preview, indicating human activities. In this diagram, most of the samples are dominated by rock weathering. This could be attributed to the chemical weathering of rock minerals acting as the main driving force in controlling groundwater chemistry (Chowdhury and Srimanta Gupta 2011, Manikandan et al 2011).

Representation of samples in the anionic ratio most of the NEM samples are dominated by ion exchange processes. In NEM, HCO_3 is the dominant anion which is mainly due to Weathering or the interaction of rock water. Higher recharge processes and weathering are dominant this season, while in NEM, dissolution and leaching processes with increases with TDS predominate. Most of the POM and NEM samples are observed along the boundary between the rock-water interaction and the evaporation zone, suggesting that the rock-water interaction is dominant. In POM, samples fall along the edge of the spoilage and evaporation zone, reflecting that they are dominated by mixing processes.

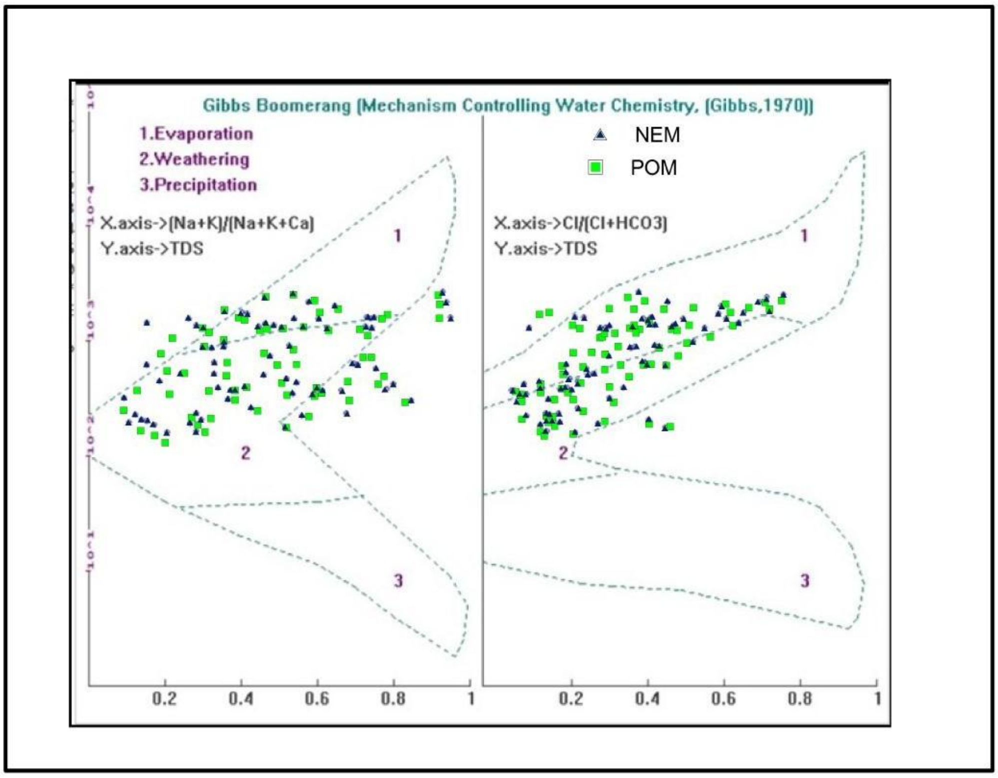


Fig.3: Gibbs Boomerang (Mechanisms Controlling Water Chemistry, (Gibbs, 1970)

6. CONCLUSION

This study indicates that the Na and HCO_3 are the dominant ions during NEM and Na and Cl are the dominant ions during POM. In the current study, the consistent drinking Water Quality Index has been adapted using 13 relevant parameters in the study area for groundwater to reduce the improbability and inaccuracy in the management. The rating of water quality shows that the groundwater in 6% and 5% of the study area is poor for drinking purposes during NEM and POM seasons. The study also highlights the fact that most samples are within allowable limits and can be used for drinking, domestic, and agricultural purposes. There are also anthropogenic influences in the entire study area. The water quality of the NEM shows excellent and the poor category is found in POM, this very poor category is observed in the southern part, possibly due to ion leaching, overexploitation of the groundwater, direct sewage discharge due to effects on agriculture. An increase in the category of good quality water during POM may be due to the dilution processes of the monsoon.

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