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Groundwater Quality Assessment using WQI In South Coimbatore, Tamil Nadu, India

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Abstract: Groundwater quality of South Coimbatore evaluated by Water Quality Index.water Quality Indexis used to determine the suitability of groundwater for drinking purpose conforming to World Health Organisation (WHO) standards was followed. However the present study, the Bureau of Indian Standard values have been adopted. For understanding the quality of groundwater twenty six groundwater samples were collected in pre monsoon (August 2013) and post monsoon (January 2014) seasons via, open wells and bore wells. The samples are tested analyzed physical and chemical parameters. pH range in pre monsoon season is 7 to 11 during 6.9 to 10.9. Total dissolved solids in the study area is relatively high in pre monsoon 84% of groundwater samples in pre monsoon and 76% samples exceed BIS limit. The groundwater quality in the study area major is mixed $CaHCO_3$ type and few samples mixed CaCl type of in both the pre monsoon and post monsoon season. North West part of the study area in pre monsoon under unsuitable category for drinking and post monsoon this category is reduced according to WQI.
Keywords: Groundwater, GIS(Geographical Information System), BIS(Bureau of Indian Standards).

Introduction

Groundwater is one of the great natural resource in the Biosphere (3). Freshwater is a finite and a vulnerable resource, essential to sustain life, development and the environment. Groundwater though contributes only 0.6% of the total water resources on earth, it accounts for nearly 80% of the rural domestic water needs and 50% of the urban water needs in the developing countries like India (10). Water Quality is an important factor to judge environment changes, which are strongly associated with social and economic development. The evaluation of water in the developing countries has become a critical issue in recent years, especially due to the concern that fresh water will be scarce in near future. Water form a certain source may be good enough for drinking without any treatment but it may not be suitable as a coolant in an industry. It may be good for irrigating certain crops but not for certain other crops (11). Water quality index is a means to summarize large amounts of water quality data into simple terms for reporting to management and the public in a consistent manner. Similar to the ultra violet (UV) index or an air quality index, it tells us whether the overall quality of water bodies poses a potential threat to various uses of water. WQI is a set of standards used to measure changes in water quality in a particular river reach over time and make comparisons from different reaches of a river. A WQI also allows for comparisons to be made between different rivers. This index allows for a general analysis of water quality on many levels that affect a stream's ability to host life (12).

The objectives of the present study are (1) To identify the suitability of groundwater for domestic and irrigation purpose (2) To determine the spatial variation water quality by using water quality index.

Study Area

Coimbatore is the second largest Metropolitan city and urban agglomeration after Chennai in Indian state of Tamil Nadu. It is one of the fastest growing tier-II cities in India and major textile, Industrial, Commercial, Educational and manufacturing hub of Tamil Nadu. Coimbatore is situated in the West of Tamil

Nadu, bordering the state of Kerala. It is surrounded by the Western Ghats mountain range on the West and North, with reserve forests and the (Nilgiri Biosphere Reserve) on the northern side. The Noyyal River runs through Coimbatore and forms the Southern boundary of the corporation. The city sits amidst Noyyal's basin area and has an extensive tank system fed by the river and rainwater. The area is elevated from 234m to 420m above the mean sea level and geographical area is 655 km^2. It is located between 10º45′3.6″ N to 11º0′9.72″ N Latitude and 76º52′14.52″ E to 76º59′37.68″ E Longitude. The figure 1 shows the study area map.

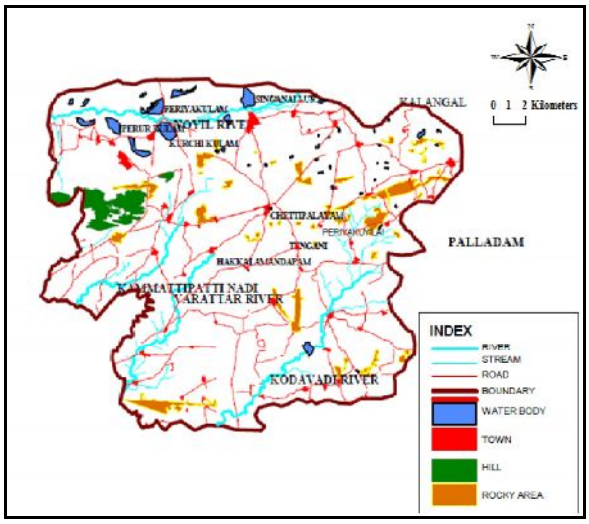

Fig 1. Location of the Study Area Map

The weather is pleasant during the period from November to January. Morning, in general, is more humid than the afternoons, with the humidity exceeding 78% on an average. In the period June to November the humidity in afternoon exceeds 66% on an average. In the rest of the year the afternoon is the driest one. Rainfall variation graph of study area from year 2000 to year 2012 is shown in figure 2

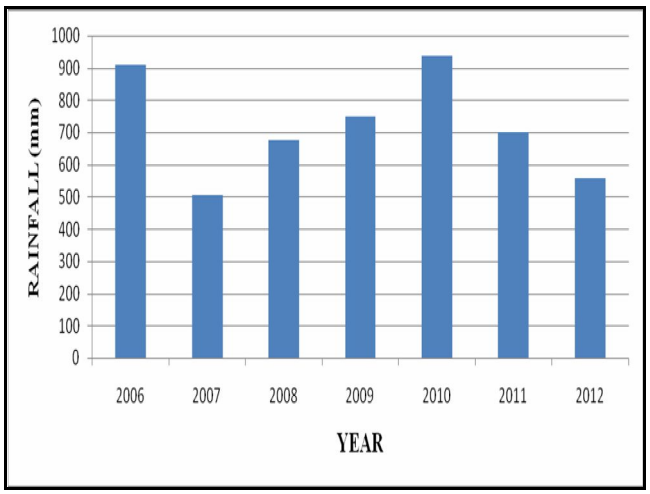

Fig 2 Rainfall Variation of the Study Area

Materials and Methods

Major Elements were analyzed from 26 groundwater samples were collected and analyzed viz open wells, bore wells. The primary data of study are collected through the groundwater samples via open wells, bore wells. The groundwater samples of both pre-monsoon season and post-monsoon season are needed for assessing the seasonal variation of groundwater in study area. The sampling location of groundwater samples shown in figure 3 and groundwater samples collection detail shown in table 1.

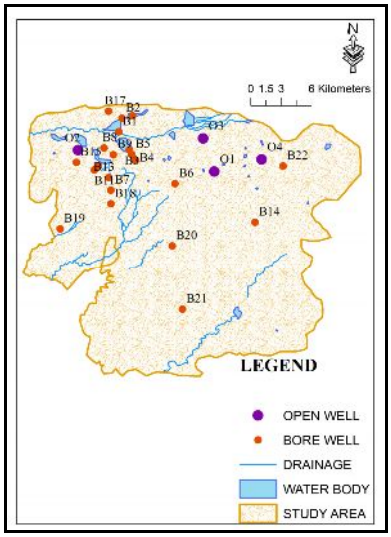

Figure 3 Well Location Map of the Study Area

Table 1 Groundwater sample collection detail

Sl. No	Location	Type of well	Sl. No	Location	Type of well
1	Periyakulam	Bore well	14	Ramachettipalayam	Bore well
2	Ukkadam	Bore well	15	Perur kulam	Open well
3	Kurchikulam	Bore well	16	Perur	Bore well
4	Gandhiji road	Bore well	17	Tellungupalayam	Bore well
5	Sundarapuram	Bore well	18	Chokkan pudhur	Bore well
6	Kurchi housing unit	Bore well	19	Singanallur	Open well
7	Madukarai road	Bore well	20	Elginagar	Open well
8	Niyanapuram	Bore well	21	Sundakamuthur	Bore well
9	Kuniyamuthur	Bore well	22	Madukarai	Bore well
10	Kulathupalayam	Bore well	23	Ettimadai	Bore well
11	Kovaipudhur	Bore well	24	Othkal mandabam	Bore well
12	Valan kulam	Bore well	25	Kinathukadavu	Bore well
13	Sundakkamuthur	Open well	26	Pattanam	Open well

The groundwater samples were collected by Simple Random Sampling method. The main reason for analyzing the water quality is follow (1) to know the existing quality of Water (2) to compare with its standard. The general procedure for sample collecting, testing and analysis were carried out according to general procedure. The physical observations of the samples are colourless and odourless in natures. The range and mean of physic-chemical parameters of 26 groundwater samples of the study area for both pre-monsoon and post-monsoon seasons are shown in table 2. From the data, the following observations were made for different parameters.

Table 2 Physico-chemical parameters of groundwater samples

Water Quality Parameters	Pre-monsoon		Post-monsoon		BIS standard (2009)	Samples exceeding desirable limits	
	Range	Mean	Range	Mean	Desirable	Pre-monsoon	Post-monsoon
pH	6.9-10.9	7.47	6.9 -7.8	7.26	6.5-8.5	Nil	23
Total Dissolved Solids	345.6-2467.2	1237.10	435.2-2457.6	1329.72	500	1,2,4,5,6,7,8,9,10, 11,12,13,15,16,17, 18,19,20,21,22,24,25 and 26	1,2,4,5,6,7,8,9,10, 11,12,13,15, 16,17,18,19,20, 21,22,25 and 26
Total hardness	180-1660	748.23	140-1460	676.15	300	Except 21,22, 23, 24,25,26	Except 19,20, 21,22, 23,24,25,26
Calcium	60-1280	518.26	60-1280	512.69	75	Except 24	Except 24

Magnesium	0-380	230.73	30-440	163.46	30	Except 6 and 20	Except 20
Sodium	9.6-59.5	70.96	5.2-182.17	100.82	200	5 and 7	Nil
Potassium	2.5-434.5	88.7	2-376.5	165.66	-	-	-
Chloride	45-544.83	218.63	32.65-394.43	200.3	250	1, 2, 5,9, 17, 19 and 26	1, 2, 5, 9,13 and 17
Bicarbonate	366-1689	702.54	122-622	95.63	300	2,3,4,6,7,8,9,1015,16, 1825,26	Nil
Sulphate	8.65-20.6	17.06	10.13-29.7	19.31	200	Nil	Nil

Note: All units are in mg/L except pH

Hydrochemical Facies

A piper diagram is a graphical representataion of the chemistry of water sample developed by A. M. Piper (1944). The cations and anions are shown by separate ternary plots. The apexes of the cations plot are calcium, magnesium and sodium plus potassium. The apex of the anions plot are sulphate, chloride and corbonate plus hydrogencarbonate.

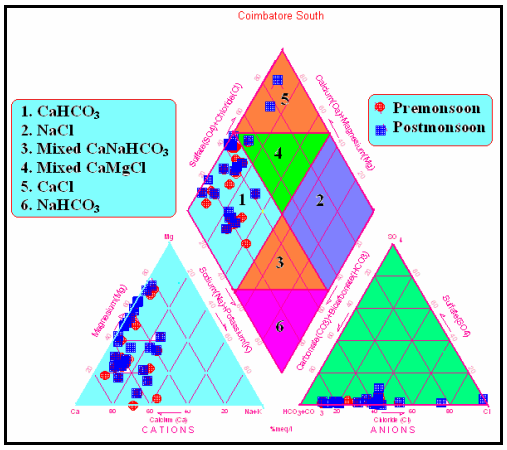

Figure 4 Piper plot for Groundwater Sample in Pre-monsoon and Post-monsoon Season

Chemical data of representative samples from the study area presented by plotting them on piper-tri-linear diagram for pre monsoon and post monsoon in figure 5.5. The plot shows that majority of groundwater samples fall in the field of mixed $CaHCO_3$ type and few samples are mixed CaCl type facies of water in both the pre monsoon and post monsoon season.

Water Quality Index

The procedure adopted by Ramakrishnaiah et al., 2009 by developing Water Quality Index to determine the suitability of groundwater for drinking purposes conforming to World Health Organisation (WHO) standards was followed. However the present study, the Bureau of Indian Standards standard values have been adopted. The parameters considered for the calculation of the index included pH, TDS, TH, Ca^{2+}, Mg^{2+}, Na^{+}, HCO_3^{-}, Cl^{-}, SO_4^{2-}. There were three steps to computing the WQI of a water sample. In the first step, each of the chemical parameters was assigned a weight (w_i) based on their perceived effects on primary health. The highest weight of five was assigned to parameters, which have the major effects on water quality. The second step involved computing the relative weight (Wi) of each parameter using the equation given below;

$$Wi = w_i / \sum w_i$$

Where, $\sum w_i$ is the sum of the weights of all the parameters. To compute quality rating scale, q_i by using the equation given below;

$$q_i = C_i / S_i * 100$$

Where, Ci and Si –concentration and the BIS standard for each parameter, in mg/L

$$WQI = \sum SI_i$$

$$SIi = Wi * q_i$$

Where SI i is the sub index of i^{th} parameter

In this study, $\sum w_i$ was 26. Table 3 presents the w_i, Wi and the Bureau of Indian Standards for each chemical parameter used in this study. Computed Water Quality Index is usually classified into five categories as given in 4.

Table 3 Relative weight for Physico-Chemical parameters

Physico-chemical parameters	IS standard Desirable Limit	Weight w_i	Relative weight W
pH	6.5-8.5	4	0.15384
Total Dissolved Solids (TDS)	500-2,000	4	0.15384
Total Hardness (TH)	300-600	2	0.07692
Bicarbonate (HCO_3)	244-732	3	0.11538
Calcium (Ca)	75-200	2	0.07692
Magnesium (Mg)	30-100	2	0.07692
Sodium (Na)	200	2	0.07692
Chloride (Cl)	250-1,000	3	0.11538

Table 4 Classified of Water Quality Index

WQI Value	Classification
<50	Excellent water
50-100	Good water
100-200	Poor water
200-300	Very poor water
>300	Water unsuitable for drinking
>300	Water unsuitable for drinking

The spatial and seasonal variations of WQI are shown in figure 4 by using GIS. It shows that the Northern part of the area is more affected by groundwater quality compared to the Southern part during pre-monsoon season which is due to the geogenic and anthropogenic factors. In Northern part considering anthropogenic , Singanallur, Kurchi areas are highly industrial practicing zone, and they discharge effluent in that areas. In Southern part of the study area categorized between poor to good water quality in pre-monsoon. During post-monsoon season, Northern part, central area water quality changes from poor to good due to rainfall. In Southern part area slightly changed as good category. WQI value of study area shown in table 5.

Table 5 WQI classification for pre-monsoon and post-monsoon seasons

Sample no	WQI (pre-monsoon 2012)	Classification	WQI (post-monsoon 2013)	Classification
1	266.84	Very poor water	236.07	Very poor water
2	330.84	Water unsuitable for drinking	266.822	Very poor water
3	97.61	Good water	95.27	Good water
4	250.86	Very poor water	162.85	Poor water
5	293.6	Water unsuitable for drinking	172.07	Poor water
6	250.86	Very poor water	126.54	Poor water
7	324.41	Water unsuitable for drinking	159.4	Poor water
8	190.95	Poor water	153.30	Poor water
9	323.06	Water unsuitable for drinking	280.23	Very poor water
10	264.23	Very poor water	226.85	Very poor water
11	211.06	Very poor water	116.85	Poor water
12	139.78	Poor water	122.8	Poor water
13	381.65	Water unsuitable for drinking	351.17	Water unsuitable for drinking

14	193.109	Poor water	163.04	Poor water
15	266.62	Very poor water	193.25	Poor water
16	210.10	Very poor water	167.26	Poor water
17	243.23	Very poor water	199	Poor water
18	281.40	Very poor water	211.54	Very poor water
19	294.5	Very poor water	149.52	Poor water
20	161.36	Poor water	123.6	Poor water
21	189.50	Poor water	166.5	Poor water
22	134.12	Poor water	110.2	Poor water
23	129.4	Poor water	103.07	Poor water
24	54.94	Good water	34.57	Good water
25	261.10	Very poor water	234.01	Very poor water
26	198	Poor water	164.5	Poor water

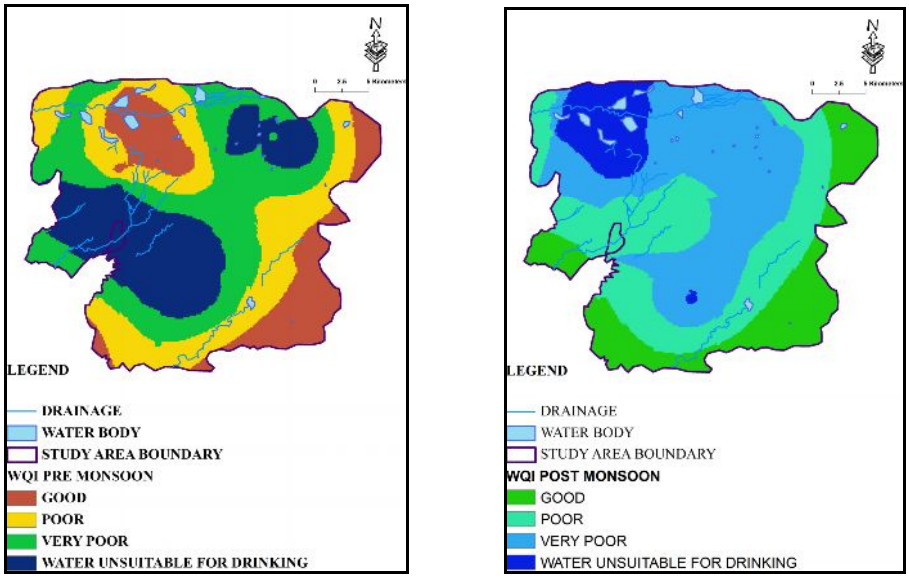

Fig 5 Spatial and Seasonal Variations of WQI in the Study Area

Figure 5 inferenced seasonal and spatial variation WQI in the study area. In pre monsoon season North West part is under unsuitable category and in South part under good category. Industrial activities in Madukarai area are relatively high especially the untreated effluent from cement factory, dying industries. In post monsoon the unsuitable for drinking reduces and it classified as very poor water. In post monsoon season good category of water quality is increased due to rainfall. Industrial activites is moderately less in Southern part of the area than Northern part.

Conclusions

In domestic purpose the water quality in Southern part of the study area water quality comparatively well than Northern part of the study area. Bicorbonate and harness are dominant ions in the study area. Industrial and waste disposal from the area are main reason for this dominate ions. The result of calculation of WQI shows in pre-monsoon season 19% of groundwater samples are under water for unsuitable category while post-monsoon 7% of groundwater samples fall in water unsuitable for drinking. The effect of the topography on the groundwater quality it is noted that there is a lower salt contents in the elevated terrains and higher salt contents in the lower elevation in this area which has steep gradient. From the present study it is evident that groundwater quality is gradually getting deteriorated and it may deteriorate future from spatial and seasonal variations.

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