PAPER • OPEN ACCESS

Surveillance of groundwater quality of selected rural and industrial areas of Coimbatore: A GIS Approach

To cite this article: Sapna Kinattinkara *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **955** 012083

View the article online for updates and enhancements.

You may also like

- Geophysical and Hydrochemical Characteristics of Groundwater at Kerian Irrigation Scheme
M A A Nazri, L W Tan, H Kasmin et al.
- Hydraulic conductivity estimation by using groundwater modelling system program for upper zone of Iraqi aquifers
T S Khayyun and H H Mahdi
- Nanostructured silver sulfide: synthesis of various forms and their application
Stanislav I. Sadovnikov, Andrey A. Rempel and Aleksandr I. Gusev

ECS Membership = Connection

ECS membership connects you to the electrochemical community:

- Facilitate your research and discovery through ECS meetings which convene scientists from around the world;
- Access professional support through your lifetime career:
- Open up mentorship opportunities across the stages of your career;
- Build relationships that nurture partnership, teamwork—and success!

Join ECS! Visit electrochem.org/join

This content was downloaded from IP address 103.196.31.2 on 24/06/2022 at 11:05

Surveillance of groundwater quality of selected rural and industrial areas of Coimbatore: A GIS Approach

Sapna Kinattinkara[1], Thangavelu Arumugam[2*], Kaarmuhil Shanmugam Poongodi[1]

Department of Environmental Science, PSG College of Arts and Science, Coimbatore 64104, India.
Department of Environmental Studies, Mangattuparamba Campus, Kannur University, Kannur 670567, India.

*Corresponding author: thangavelgis@gmail.com

Abstract. Ground water is the water present inside the solid surface in the pore soil space. In cities, the people use ground water for their domestic use, in village the people use ground water for the agriculture process. Industries use ground water for their production purpose. The present study has been carried out to evaluate hydrochemical characteristic of ground water of Coimbatore district, TamilNadu, India. Geographical information system (GIS) has been applied to visualize the spatial distribution of groundwater quality in the study area. Twenty different samples were collected and analyzed for different hydrochemical parameters. The ground water in the study area is alkaline in nature. Nine samples within the area have more than maximum level of total dissolved solids. Five samples are having sodium in above maximum allowable limit. Only six samples have permissible limit in potassium in the area. Based on chloride, 90% of samples are within permissible limit. In total hardness, seven samples were exceed the allowable limit. In this agriculture area and industrial area water qualities are not much different maybe all agriculture area also has some industries or dump yard is a reason. The results obtained in this study and the spatial database established in GIS will be helpful for monitoring and managing ground water pollution in this study area.

Keywords: Groundwater, GIS, Coimbatore, Hydrochemical parameter.

1. Introduction

Water is a universal solvent and it is important for all living organism in the world. Water is present all the three forms like solid, liquid and gas. Water covers 71% of the earth surface, mostly in the seas and oceans. 97% of water is salt water only 3% of water is pure water. Ground water is the water present inside the solid surface in the pore soil space. The ground water also moves in the flow like surface water [1, 2]. In the fresh water level majority of the fresh water is the form of ice glaciers in the polar region. Except the glaciers majority of the fresh water is present in the under-ground as a ground water. The ground water is highly used for domestic purpose agriculture and factory manufacturing. In the rural area majority of the people use only ground water for their need [3, 4].

In India the population is very high but, the fresh water resource is very low that's why the people highly use the ground water for their water need. So, the ground water level is decreasing faster [5]. The ground water recharge level is very low compare to the refreshing level. The south-west monsoon and north-west monsoon give the rainfall it is used for the ground water refreshment. In the coastal region ground water level decrease is the reasons for salt water enter in the ground water space

Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.
Published under licence by IOP Publishing Ltd

IOP Conf. Series: Materials Science and Engineering **955** (2020) 012083 doi:10.1088/1757-899X/955/1/012083

[6, 7]. In cities, the people use ground water for their domestic use, in village; the people use ground water for the agriculture process. Industries use ground water for their production purpose. In Tamil Nadu in Coimbatore the rural peoples highly use the ground water for their need [8, 9, 10]. There are many issues in the ground water.

Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas. According to WHO, about 80% of all the diseases in human beings are caused by water [11].Groundwater crisis is not the result of natural factors. It has been caused by human actions. Variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities. Suitability of groundwater for domestic and irrigation purposes is determined by its geochemical constituents [12, 13].

In most of the industrial cities, the indiscriminate disposal of industrial wastes on to the land is resulting in the deterioration of groundwater quality due to the leachates from these wastes. The dependability on ground water has reached an all time high in recent decades due to the reasons such as unreliable supplies from surface water due to vagaries of monsoon, increase in demand for domestic, agricultural and industrial purposes [14, 15]. The recent global temperature rises to accelerate the hydrological cycle; climate change alters the rainfall patterns which accelerates the floods and droughts all over the world. GIS is identified to be a powerful tool for developing solutions for water resources problems, assessing water quality, determining water availability preventing flooding, understanding the natural environment and for managing water resources on a local or regional scale. GIS has developed in integration and analysis of multi thematic layers in delineating ground water prospect and deficit zones [16].

In the present study, 20 locations selected for rural and industrial areas of Coimbatore were assessed for hydrochemical characteristics of groundwater in 2019. Geographical information system (GIS) was used to identify the hydrochemical analysis in groundwater. Inverse distance weighted (IDW) method were used to interpolate the distance between one point to another point and the hydrochemical data to illustrate the spatial distribution of groundwater into different categories [17]. The collected data were analyzed by using SPSS statistical method. The main objectives of the study are, to compare the ground water quality of selected rural and industrial areas of Coimbatore by using geospatial techniques.

2. Study Area

Coimbatore is the fourth largest city in South India and third in Tamilnadu; it is also called Manchester of South India. It is an important business city in Tamilnadu there are more than 25,000 small, medium, large scale industries and textile mills are situated and it is also important city for automobile industries and it is manufacture textile industry equipments and varied engineering goods and services. It has several numbers of institutions and research and development centre were presented. The boundary with eastern part of Tiruppur and Erode; north side and north western and western side is bounded by Western Ghats, Nilgiris and Kerala. These districts have 6 taluks such as Coimbatore north, Coimbatore south, Mettupalayam, Pollachi, Sulur and Valparai. It is above 411 metre from the sea level. The district lies between 10˚49′10″ and 11˚19′50″ Northern latitude and 76˚42′30″ and 77˚2′56″ Eastern longitude. The elevation of the area is 411 m and total area of district is covered 4732 square kilometres. It is presented in the bed of Noyyal river. The maximum temperature is 37.5˚C and minimum temperature is 19.5˚C. The study area map is presented in figure1.

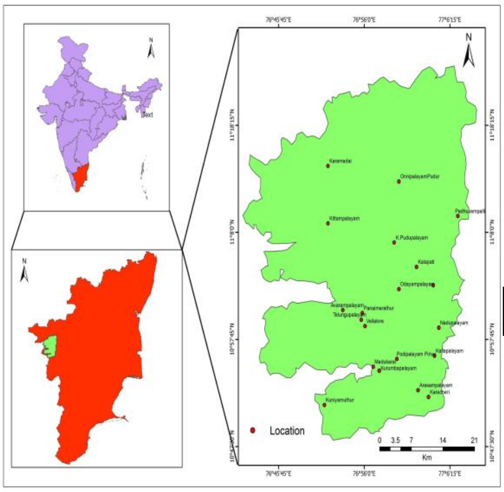

Figure 1: Study area map

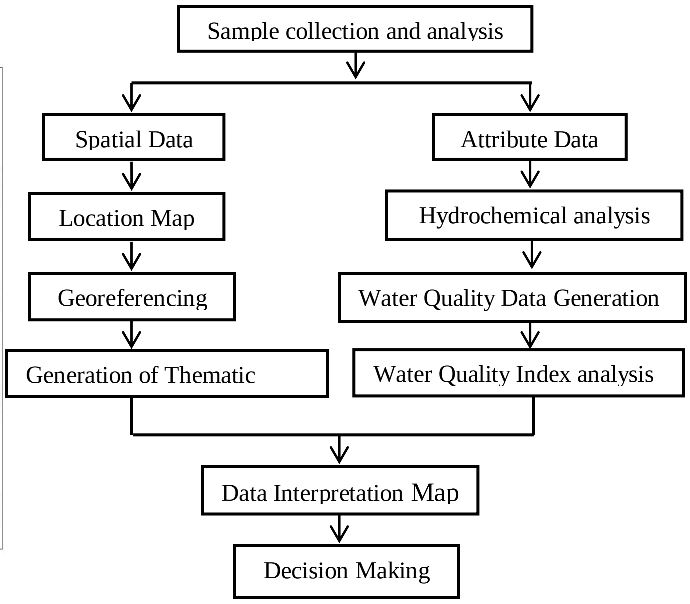

Figure 2: Flow chart of methodology

3. Methodology

3.1. Data sources and analysis

The 25 groundwater samples of 2019 were collected in 1 litre new plastic container and get analyse in laboratory the samples were analysed as per the standard methods of (APHA, 2005) [18]. The analysis was carried out for hydro-chemical analysis. The sampling sites where located using global position system (GPS). The ground water samples were analysed for the water quality determining parameters such as Hydrogen ion (pH), electrical conductivity (EC), total dissolved solids (TDS), total suspended solids (TSS), Acidity and Alkalinity and major cations and anions total hardness (TH), chloride (Cl-), sulphate (SO_4^{2-}), sodium (Na^+), and potassium (K+). Hydrochemical variables were analyzed by the standard procedures followed by APHA (2005). The water samples pH was measured with a digital pH meter of MK-VI, Systronics, EC measured with conductivity meter of MK-509, Systronics, TDS of Systronics TDS Meter of Model 307 and for TSS, Black Portable TSS Meter of Model TSS-200 were used. Acidity or alkalinity can be determined with respect to any pH of particular interest. TH is determined by EDTA titration, chloride is analyzed by Titration against Silver Nitrate. Sulphate was analyzed Nephelometer, Sodium and Potassium were measured in flame photometer chemical analysis by using Digital Flame Photometer 130, SYSTRONICS Model 126. Iron was measured Colorimetric Thiocyanate Method. Interrelationship between chemical parameters was also studied by doing statistical analysis to understand groundwater quality. The quality of the groundwater varies from place to place with the depth of water table. The ranges of each parameter along with observations/comments on groundwater quality are presented in these results. The following ion balance formula was used to calculate the Ionic balance [19]. Ionic Balance = (Σcations - Σ Anions/ Σcations+ ΣAnions) x 100.

3.2. Statistical analysis

Descriptive statistics, and Pearson Correlation bivariate two tailed analysis were executed in SPSS 20 version environment.

3.2.1. Descriptive statistics

Statistical analysis carried out the data collected for the groundwater quality parameters from the 20 sample locations for the period of 2011 Descriptive statistics containing range, minimum, maximum,

IOP Conf. Series: Materials Science and Engineering **955** (2020) 012083 doi:10.1088/1757-899X/955/1/012083

mean, standard variation, variance, skewness and kurtosis of the values to have a general idea about the distribution of the samples.

3.2.2. Pearson Correlation bivariate one tailed analysis

The interactions between different components of groundwater and their relationship with hydrochemical analysis by using Pearson correlation matrix were attempted. The mean and standard deviation of each measured parameter was computed for the twenty five sample locations. This is done to allow for easy comparison of the data from the various sampling sites. Pearson correlation is used to examine the relationship between two variables which gives the indication that the changes in one variable are associated with those in another variable. Once correlation do exist, then by measuring a very few important parameters one can easily calculate, rest of the other parameters can be easily and quickly assessed. The SPSS software was used to perform the statistical analysis at 0.05 and 0.01 confidence intervals. The Pearson product moment correlation coefficient was calculated using formula 1 as given [20,21].

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2]\,[n\sum y^2 - (\sum y)^2}} \qquad \text{---------------- (1)}$$

The coefficient of determination which explains the changes in one variable as explained by the changes in the other variable (r2) was calculated.

3.2.3. Spatial Interpolation of ground water

The ground water data of various sample location were used for interpolation method. Out of major three interpolation techniques, the inverse distance weighted (IDW) method was chosen for the spatial analysis in this study because of its easiness and estimate accuracy compared to other interpolation methods like kriging and spline. This techniques and analysis attempted by using ArcGIS (10.3) [8, 9]). The clarification for using the IDW method is that it computes the spatially interpolated values very smooth and accurately. [11] have applied for the IDW method the similar manner in equation 2,

$$Z_j = \frac{\sum_{i=1}^{n} \frac{z_i}{(h_{ij}+\delta)^{\beta}}}{\sum_{i=1}^{n} \frac{1}{(h_{ij}+\delta)^{\beta}}} \qquad \text{---------------- (2)}$$

Where, Zj is the value at an unsampled location, Zi is the known values, β is the weight, δ is a smoothing parameter, hij separation distance between a known and unknown point is measured with is euclidean distance in equation 3,

$$h_{ij} = \sqrt{(\Delta x)^2 + (\Delta y)^2} \qquad \text{--------------- (3)}$$

Where, Δx and Δy are the distances between the unknown point j and the sampled one i according to reference axes.

3.2.4. Water quality index

Water quality index (WQI) is a mathematical tool useful to transform large quantity of water quality data into a single number which indicates water quality level. It is a system of ranking the quality of water that is easily understood. A single number represents an index integrating all water quality parameters [12]. The water quality index formula is given by equation 4.

$$\text{WQI} = \frac{\sum_{i=1}^{n} q_i w_i}{\sum_{i=1}^{n} w_i} \qquad \text{----------- (4)}$$

$$q_i = 100 \text{ x } \frac{V_i}{S_i}$$

where,

qi = Sub Index, the quality rating for i^{th} parameter, Vi = observed value in laboratory, n = number of parameters taken, Si = standard value of i^{th} parameter, wi = weight of i^{th} parameter.

IOP Conf. Series: Materials Science and Engineering **955** (2020) 012083 doi:10.1088/1757-899X/955/1/012083

3.3. GIS and IDW interpolation method

Geographical information system (GIS) is an effective tool. It is used to process the spatial information and processing broadly grouped into three functional areas, which are computer mapping, spatial database management and cartographic modelling [16]. Interpolation is used to predict unknown values for geographic parameters such as elevation, chemical concentrations and noise levels with a limited number of sampled data points where it is difficult, impossible or expensive to visit every location in the study area [17]. Interpolation has primarily been used in mapping of soils, bedrocks, surface and groundwater and air quality studies. IDW also provides flexibility in performing good and choice interpolation based on the number of samples and their spatial distribution, where the degree of influence or the weight is expressed by the inverse of the distance between points raised by power, the general equation (5) of the IDW is,

$$Z_0 = \frac{\sum_{i=1}^{s} Z_i \frac{1}{d_i^k}}{\sum_{i=1} \frac{1}{d_i^k}} \quad \text{----------------- (5)}$$

Where, Z_0 is estimated value at point 0; $Z_i$is the Z value at control point *i* ; d_i is the distance between control point *i* and control point 0; S is the number of control point used in estimation; k the specified power.

4. Result and discussion

4.1 Descriptive Statistics of groundwater analysis: The statistical analysis helps to assess the correlation between the set of data. The result deals with the organisation and summarisation of data by means of 'descriptive statistics'. The hydrochemical parameters of 20 groundwater samples of 2019 were presented in Tables 3. The following statistical parameters which include range, minimum, maximum, median, standard deviation, variation, skewness and kurtosis were studied. The analysis was carried out keeping view of the importance of the ground water quality which determines its suitability for agricultural, industrial purposes. The statistical interference of the study describes the variation in groundwater of rural and industrial areas. The analytical precision of the ions analyzed was assessed by calculating the normalized ionic charge balance error, which varied within ±5%. The summary statistics of the groundwater quality are compiled in Table 1. The permissible limits of groundwater quality in drinking water by various organizations are given in table 2.

Table 1: Summary statistics of groundwater quality of 2019 (n = 20)

Parameter	Range	Min	Max	Mean	Std. Dev	Variance	Skewness	Kurtosis
pH	1	6.4	7.4	6.905	0.27	0.07	-0.16	-0.61
EC	4.99	0.81	5.8	2.106	1.23	1.53	1.59	3.17
TH	3451	238	3689	704.38	739.68	547139.3	3.77	15.65
TSS	1.8	0.2	2	0.8	0.50	0.25	0.80	-0.05
TDS	3600	400	4000	1570	1014.16	1028526	0.89	0.03
Acidity	45	30	75	49.5	13.85	191.84	-0.23	-1.07
Alkalinity	1140	560	1700	931	255.75	65409.47	1.41	3.11
Cl^-	1295.18	74.01	1369.2	371.24	318.01	101126.2	1.90	4.31
Na^+	281.07	61.57	342.64	146.64	69.50	4830.44	1.17	1.79
K^+	111.06	4.72	115.78	26.91	30.11	906.88	2.03	3.55
SO_4^{2-}	4	0.2	4.2	1.637	1.061	1.12	0.88	0.25

The total numbers of samples are 20, where the minimum statistical value pH were observed low and high ranges in 0.2 and TDS (400), and the maximum statistical value low is 2 (TSS) and high (4000) were presented respectively. The mean value of low (TSS) and high (TH) ranged (0.8, 704.68), and standard deviation were observed in less range in (pH) 0.27 and high range (TDS) 1014.16 respectively. The minimum and maximum statistical values of variance were (pH) 0.27 and TDS 1028526 respectively. The skewness value is low (Acidity) in -0.23 and (TH) high range is 3.77. The minimum and maximum values were found in kurtosis with respective of Acidity (-1.07) mg/l and (TH) 15.65 respectively (Figure 3).

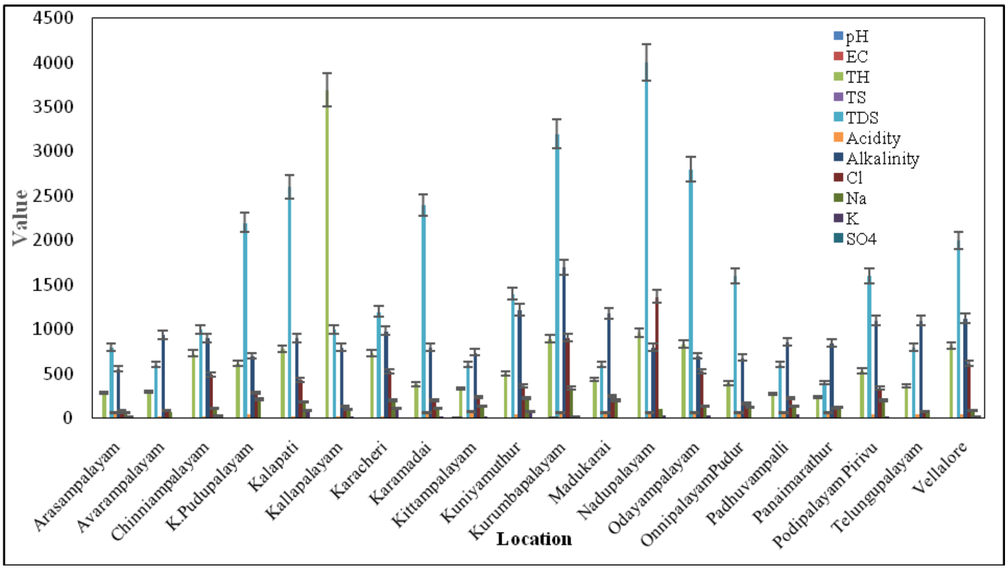

Figure 3: The graph of hydrochemical quality of groundwater

Table 2: Permissible level of fluoride in drinking water by various organizations

4.1.1 Pearson Correlation bivariate two tailed analysis

Parameter	Range		Bureau of Indian Standards (BIS)	World Health Organization (WHO)
	Min	Max		
pH	30	75	6.5 - 8.5	6.5 - 8.5
EC ((µs/cm)	560	1700	300	500
TH (mg/l)	74.01	1369.2	200	0.3
TDS (mg/l)	61.57	342.64	500	500
TSS (mg/l)	4.72	115.78	75	75
Alkalinity	30	45	-	-
Acidity	30	75	-	-
Cl^-(mg/l)	560	1700	250	250
SO_4^{2-}(mg/l)	74.01	1369.2	200	250
Na^+(mg/l)	61.57	342.64	50	200
K^+(mg/l)	4.72	115.78	-	200

The strong ($p < 0.01$) and significant correlation ($p < 0.05$) were observed in the groundwater samples. The correlation analysis from the Pearson correlation output, hydrochemical analysis of ground water are associated with EC – pH (r = 0.084), TSS-pH (r = 0.125), TDS –TH (r =0.106), Acidity - TSS (r =0.056), Alkalinity-TSS (r =0.155), Na-Cl (r =0.333), Cl - TH (r =0.104), K – Na (r =0.302), Na- pH (r = 0.226), and SO_4 - K (r = 0.428) respectively. The low positive correlation parameters were presented EC – pH, TSS-pH, TDS –TH, Acidity – TSS, Alkalinity-TSS and Cl - TH, moderate positive correlation were observed Na-Cl, K – Na and Na- pH, and high positive correlation of SO_4 – K were presented in Table 3. It means No negative correlation was found in groundwater samples, it is either drinking water or water for domestic use. It infers that as water becomes more tested are dissolved from the water minerals into it. The results shows that high positive correlation SO_4 – K (r^2 = 0.18), moderate characteristics were obtained in Na-Cl (r^2 =0.11), K – Na (r^2 =0.091) and Na - pH (r^2 =0.051), low positives were presented EC – pH (r^2 =0.007), TSS-pH (r^2 0.015), TDS –TH (r^2 =0.11), Acidity - TSS (0.003), Alkalinity-TSS (0.024) and Cl -TH (0.01) respectively (Table 4).

IOP Conf. Series: Materials Science and Engineering **955** (2020) 012083 doi:10.1088/1757-899X/955/1/012083

Table 3. Pearson Correlation bivariate two tailed analysis between various parameters

	pH	EC	TH	TS	TDS	Aci	Alk	Cl	Na	K	SO_4
pH	1										
EC	0.084	1									
TH	-0.213	0.099	1								
TS	-.573**	.824**	0.125	1							
TDS	-.571**	.812**	0.123	.991**	1						
Aci	0.162	0.032	-0.392	0.056	0.1	1					
Alk	-.567**	0.353	-0.018	0.155	0.149	-0.113	1				
Cl^-	-.672**	.982**	0.104	.817**	.800**	0.073	0.32	1			
Na^+	-.451*	0.411	-0.026	0.358	0.332	0.055	.644**	0.333	1		
K^+	-0.393	0.248	0.04	0.239	0.147	-0.431	0.096	0.265	0.302	1	
SO_4^{2-}	-0.236	.531*	-0.064	.497*	.448*	-0.27	0.012	0.426	0.35	0.428	1

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

Table 4. Coefficient of determination for groundwater quality parameters (2019)

Parameters	R – Value	Coefficient of determination (R^2)	Shared Variance
EC - pH	0.084	0.007	0.7
TSS- pH	0.125	0.015	1.5
TDS - TH	0.106	0.011	1.1
Acidity - TSS	0.056	0.003	0.3
Alkalinity-TSS	0.155	0.024	2.4
Na - Cl	0.333	0.110	11
Cl - TH	0.104	0.010	1
K - Na	0.302	0.091	9.1
Na - pH	0.226	0.051	5.1
SO_4 - K	0.428	0.18	1.8

4.2 Integrated spatial analysis of groundwater quality in study area

Spatial analysis is used to evaluate the quality of ground water variation in study area. Based on the water quality parameters spatial distribution maps were generated and also maps were integrated the ground water quality by using GIS. This integrated the spatial analysis of ground water quality maps helps us to know the existing ground water condition of the study area.

4.2.1. Hydrogen Ion (pH)

The Hydrogen ion (pH) is used to determine whether a solution is acidic or alkaline. It is the expression of hydrogen ion concentration, more precisely, the hydrogen ion activity. The BIS and WHO limit for drinking water is 7.0 - 8.5 shown in Table 2. The low pH does not cause any harmful effect. The very high values of pH range (7.15-7.39) were presented Panaimarathur and Telungupalayam. The higher values of pH range (6.91-7.14) were obtained in Avarampalayam, Kittampalayam, Madukarai, Karacheri, Arasampalayam, Pudupalayam, Karamadai and Onnipalayampudur. The moderate values of pH range (6.66-6.90) Kalapatti, Chinniyampalayam, Odayampalayam, Podipalayam, Paduvampalli and Kallapalayam. The low values pH ranges (6.41-6.65) were obtained in Nadupalayam, Vallalore, Kuniyamuthur and Kurumbapalayam. The result shows that all the water samples were within permissible limits. As per BIS the standard value of pH is 6.5-8.5. The most of the samples presented in alkaline but within the acceptable limit acidic also there in some of the study area. The pH value is high in the northern side of the district compare to the southern side. It is increased in the direction of east to west. The results shows that the study area not much affected by pH in study area. All the samples pH values are in the standard value, not more than that the value (Figure 4a).

4.2.2. Electrical conductivity

EC is a useful tool to assess the purity of water. EC of the collected samples ranged from 41 to 493.2 µScm. The higher the values of EC were occurred the area include (4.56-5.79) in Kallpalayam. The higher values of EC range (3.32-4.55) were obtained in Kurumbapalayam and Nadupalayam. The moderate values of EC range (2.08-3.31) were presented Odayampalayam, K.Pudupalayam, Kalapatti, Chinniyampalayam, Vallalore, Kuniyamuthur, Madukarai and Podipalayam. The low values EC ranges (0.82-2.07) were obtained in Karamadai, Onnipalayampudur, Avarampalayam, Paduvampalayam, Panaimarathur, Telungupalayam, Karacheri, Kittampalayam and Arasampalayam. The result shows that all the water samples were within permissible limits (WHO). As per BIS the standard value of EC is 500. The most of the samples presented in alkaline but within the acceptable limit acidic also there in some of the study area. All the samples EC values are in the standard value, not more than that the value. The highest value of Conductivity may be highest concentration of ionic constituents (Figure 4b). It shows that the affect of industrialization on the ground water quality. Several factors like temperature, ionic mobility also depends.

4.2.3. Total hardness

Hardness is the property of water which prevents the lather formation with soap and increases the boiling points of water [5]. The very high values (2821.95-3681.31) of total harness were obtained in Kallapalayam. The highest values (1962.58-2821.94) of total hardness to be obtained in the area include Arasampalayam. The moderate (1103.21-1962.57) values of total hardness were observed in Karacherri. The low areas (243.63-1103.20) were observed in Karamadai, Kittampalayam, Onnipalayampudur, Chinniyampalayam, Nadupalayam, Avarampalayam, Panaimarathur, Telungupalayam, Vellalore, Madukarai, Kurumbapalayam, Odayampalayam and Podipalayam as presented in figure 4c. According to WHO limit (0.3) observed that industries are badly affected on ground water source. Industrial areas Chinniyampalayam, Odayampalayam and Vellalore samples are more than standard value. Pudupalayam, Kalapatti, Karachari, Kurmapalayam, Nadupalayam samples TH is more than standard value. The southwest part of the district contains high level of total hardness. The district average value (704 mg/l) of total hardness is high then the permissible level (600 mg/l).

4.2.4. Total Suspended Solids

TSS is the dry weight of suspended particles in a moving body of water. The TSS, very high ranges were (1.56-1.99) obtained in Kallapalayam, high ranges were (1.11-1.98) acquire in Odayampalayam, Kalapatti, Karamadai, Nadupalayam and Kurumbapalayam. The moderate ranges between 0.66-1.1 were presented in Onnipalayampudur, Pudupalayam, Telungupalayam, Vellalore, Avasampalayam and Karacherri. The low ranges between 0.20-0.65 were observed Paduvampalli, Kuniyamuthur, Arasampalaym, Chinniyampalayam, Kittampalayam, Madukarai and Panaimarathur as shown in figure 4d. Western middle part of the area content low amount of TSS compare to other. A few areas in the district contain very high amount of TSS. The main contributor to TSS is the decomposing of plants from agricultural waste and animals. Organic particles from decomposing materials also contribute to the TSS concentration [22]. According to WHO and BIS limits were recommended by 75 mg/l for the maximum range.

4.2.5. Total Dissolved Solids

The industrial areas such as Karamadai, Odayampalayam and Vellalore samples are more than standard value. Rural areas were observed in Pudupalayam, Kalapatti, Kurumbapalayam, Nadupalayam, Onnipalayampudur and Podipalayampirivu more than standard value as obtained in figure 8a &b. The variation in TDS values indicates the effect of due to industrialization. Most of the district contains permissible level (1500) of TDS. Only less area in the district include higher than the permissible level (Figure 4e).

4.2.6. Acidity

The acidity of water is ph, which is a measure of the hydrogen-ion concentration. According to WHO criteria, water for domestic use should have a pH between 5.5 and 9.The north side of the district content high amount of acidity compare to the south side. The acidity is increased in the direction of east to west as presented in figure 4f. The pollution problems include sewer leakage, faulty septic-tank operation, and landfill leachates.

4.2.7. Alkalinity

The industrial area, except Arasampalayam all the sample sites has more than standard value (BIS). All the agricultural areas are more than the standard Alkalinity level as shown in figure 15. The district full of contain more than permissible level (200) of alkalinity. Some places in the district contain acceptable level (600 mg/l) of alkalinity. The southwest corner in the district contains very high level of alkalinity. The north side of the district content high amount of acidity compare to the south side. The acidity is increased in the direction of east to west part as obtained in figure 4g.

4.2.8. Chloride

In the industrial area of Vellalore, Chloride is more than standard value. But in rural areas Kurumbapalayam and Nadupalayam Chloride is more than standard value as shown in figure 11a& b. Most of the areas contain chloride less than the permissible level. Only few areas occurred southeast contain in high amount of chloride in the district. The direction of south to north, the chloride level is decreasing is shown in figure 4h. The high chloride concentration accepted the due to solid waste dumping which in turn is leaching from upper soil layers in dry climates and natural geochemical activities in the area [23]. According to BIS and WHO permissible limits chloride was exceeded in ground water samples. The main reason for chloride concentrations in ground water is due to the infiltration of treated waste water in which chlorine is used for disinfection and flocculation purposes [24].

4.2.9. Sodium

In the industrial area Kuniyamuthur and Madukarai are more than standard value. Rural areas such as Kurumbapalayam, K.Pudupalayam and Karachari were observed more than standard value in BIS limit as shown in figure 16a & b. Northwest side of the district have low amount of sodium compare to other sides of the areas. The southwest side contain high amount of sodium observed in study area (figure 4i). Sodium has been observed the dissolution of evaporated minerals and its subsequent mixing with ground water. The anthropogenic pollution sources from industrial effluents that increase the sodium in groundwater [25]. Several soap and detergent industries are located in Kuniyamuthur and nearby areas. These industries discharging waste effluents directly to the land and nearby small water bodies. According to BIS (50 mg/l) limit less areas area exceeded the permissible limit, and some of the areas exceeding the permissible limit recommended by WHO (200 mg/l) [26].

4.2.10. Potassium

The value of potassium in industrial areas Arasampalayam, Chinniyampalayam, Kallapalayam, Kittampalayam, Kuniyamuthur, Karamadai, Odayampalayam and Vellalore more than standard value. Rural areas Kalapatti, Kurumbapalayam, Nadupalayam, Karachari, Padhuvampalli and Podipalayampirivu have more than standard value as per WHO limit as shown in figure 17a & b. In the direction of south to north, the value of potassium is decreasing in the district. The last parts of southeast surround very high amount of potassium were presented in figure 4j. The major source of potassium in study area is due to weathering of rocks while the quantities increase in the polluted water due to disposal of waste water [27].The another major sources of potassium in the study area is fertilizer industries and foundries were located in Chinniyampalayam, Kittampalayam, Kuniyamuthur and Kallapalayam. The leaching of potassium fertilizer through the soil also contributes to groundwater.

4.2.11. Sulphate

All the industrial and rural areas Sulphate value is in the permissible limit as shown in figure 17a & b. The mid eastern side of the district contain high amount of sulphate. The very few areas are covered in the south side contain in low amount of sulphate were obtained in figure 4k. The sulphate values many locations are found to be below the exceeding WHO limits in ground water [28]. Sulphate enters to natural waters through weathering of sulphide-bearing rock or by direct dissolution of evaporation deposits. Another significant source is from various industries located in the study area which emits airborne pollutants containing oxides of sulphur, which convert to sulphuric acid in precipitation. So these sulphuric acids in precipitation that reaches to groundwater through infiltration. [29].

4.3. Water quality index (WQI)

Water quality index (WQI) indicates the quality of water with reference to an index number which reflects the overall status of groundwater quality for drinking purpose. Based on WQI values the study areas can be divided in to five ranges such as excellent, very good, good, moderate and poor. In 2019, WQI were observed the excellent areas Telungupalayam, Paduvampalli, Kittampalayam, Avarampalaym, Panaimarathur and Arasampalayam. The water quality is very good water in Madukarai, Onnipalayampudur and Chinniyampalayam. The good water quality is observed in Kuniyamuthur, Vellalore, Karacherri, Podipalayam, Pudupalayam and Karamadai. Kurumbapalayam, Kallapalayam, Odayampalayam and Kalapatti were observed moderate water quality. The poor water quality of study area include in Nadupalayam. The overall results of the WQI were observed the most of region in northern part of the district in a good water quality as presented in figure 4l.

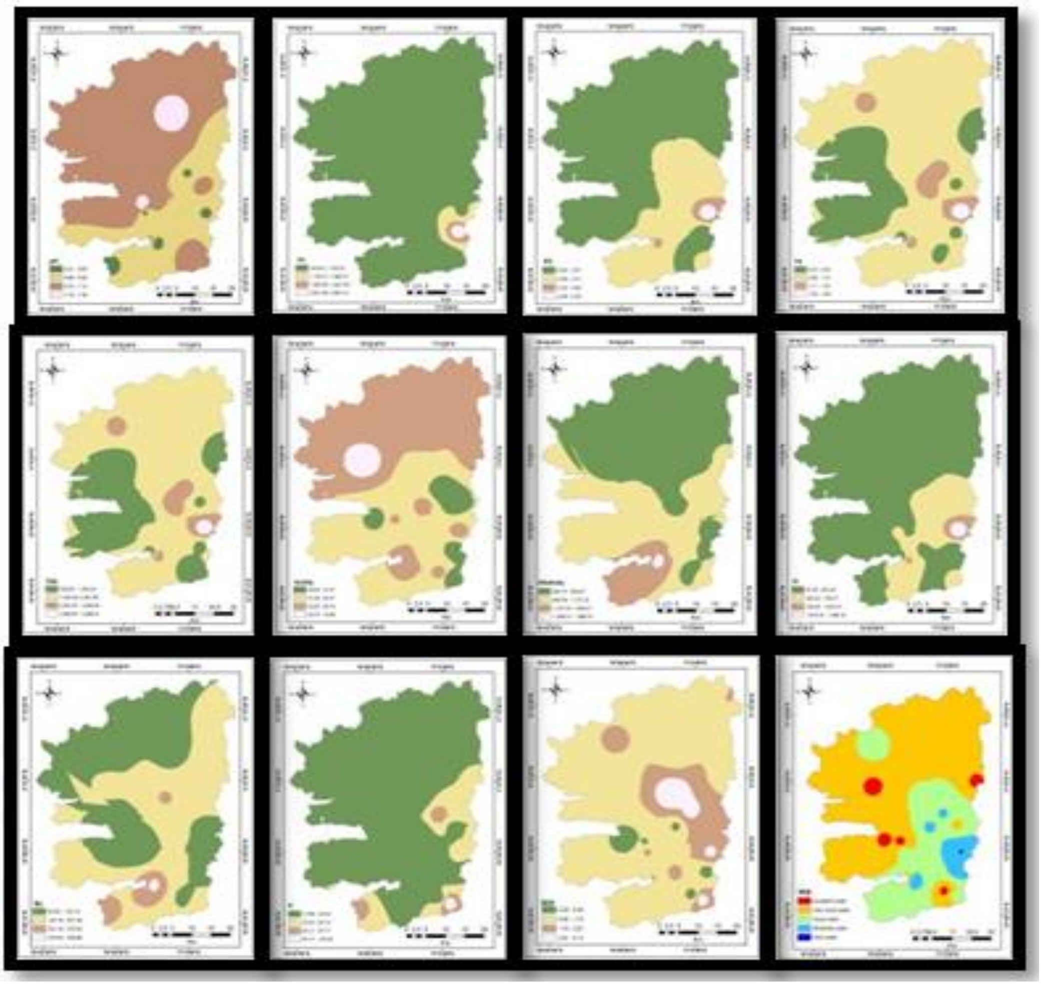

Figure 4a-4l: Spatial distribution map of hydrochemical parameters in groundwater quality

IOP Conf. Series: Materials Science and Engineering **955** (2020) 012083 doi:10.1088/1757-899X/955/1/012083

5. Conclusions

The present study has been carried out to evaluate hydrochemical characteristic of ground water of Coimbatore, Tamil Nadu, India. The statistical method used for Pearson correlation coefficients assist to improve the statistical factors in data variability and thus improve conclusions in environmental impact studies. Pearson correlation matrix was applied to all the collected water samples for identifying the possible statistical relationship between different pairs of ground water quality parameters. A highly strong correlation was observed between sulphate and potassium, which gives us an idea about the hardness of water. It can be concluded that the total hardness and pH are important hydrochemical water quality parameters, because they are correlated with most of the elements in the groundwater. The results demonstrate that anthropogenic sources are controlling factor for affecting groundwater quality in South India.

GIS has been applied to visualize the spatial distribution of groundwater quality in the study area. Twenty different samples were collected and analyzed for different hydrochemical parameters. The ground water in the study area is alkaline in nature. Nine samples within the study area have more than maximum level of total dissolved solids. Five samples, sodium value is above maximum allowable limit. Only six samples, potassium is within permissible limit. Based on chloride, 90% of samples are within permissible limit. The total hardness, seven samples are exceeding the allowable limit. In this agriculture area and industrial area water qualities are not much different because all agriculture area also has some industries or dump yard. The study gives plenty information on physiochemical parameters, water assessment index, feasible source of pollution, controlling factors of groundwater quality and its spatial distribution analysis in study area. The present study focused to describe groundwater quality of rural and industrial areas of Coimbatore with a GIS perspective and geo-referenced groundwater database and maps are developed which are useful for formulating sustainable groundwater use strategies.

6. References

[1] Angaleeswari M and Valliammai A 2017 Assessment of Ground Water Quality Using Water Quality Index in Western Zone of Tamil Nadu India *Chem Sci Rev Lett*. **6**(23) pp 1750-1757.

[2] Shyamala R Shanthi M and Lalitha P 2008 Physicochemical Analysis of Borewell Water Samples of Telungupalayam Area in Coimbatore District, Tamilnadu, India. *E-Journal Of Chemistry*, **5**(4), pp 924-929. doi: 10.1155/2008/152383.

[3] Jebastina N and Arulraj GP 2017 GIS Based Assessment of Groundwater Quality in Coimbatore District, India. *Journal Of Environmental & Analytical Toxicology*, **07**(03) pp 1-16.

[4] Chatterjee PK and Raziuddin M 2007 Studies on the water quality of a water body at Asansol town, West Bengal. *Nature, Environment and Pollution Technology.* **6**(2) pp 289-292.

[5] Dhirendra Mohan Joshi Alok Kumar and Namita Agrawal 2009 Assessment of the irrigation water quality of river Ganga in Haridwar district. *Rasayan J. Chem*. **2** pp 285-292.

[6] Karthik K Mayildurai R Mahalakshmi R and Karthikeyan S 2019. Physicochemical Analysis Of Groundwater Quality Of Velliangadu Area in Coimbatore District, Tamilnadu, India. *Rasayan Journal Of Chemistry*, **12**(02), pp 409-414. doi: 10.31788/rjc.2019.1225005

[7] Maroofi S Toranjeyan A and Zare Abyaneh H 2009 Evaluation of geostatistical methods for estimating electrical conductivity and pH of stream drained water in Hamedan-Bahar Plain. *Journal of Water and Soil Conservation* **16**, pp 169-187.

[8] Thangavelu A 2013 Mapping the groundwater quality in Coimbatore city, India based on physico-chemical parameters. *IOSR Journal Of Environmental Science, Toxicology And Food Technology*, **3**(4), pp 32-40. doi: 10.9790/2402-0343240.

[9] Sapna K Thangavelu A Mithran S and Shanthi K 2018 Spatial Analysis of River water quality using Inverse Distance Weighted Interpolation in Noyyal Watershed in Coimbatore, Tamilnadu, India. *Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences*, **4**(1) pp 150.

[10] Jafar Ahamed A Ananthakrishnan S Loganathan K and Manikandan K 2013 Assessment of groundwater quality for Irrigation use in Alathur Block, Perambalur District, Tamilnadu, South India. *Appl Water Sci* **3** pp 763-771.
[11] WHO 2004 GuidelinesforDrinking-Water Quality, seconded., vol. 2. HealthCriteriaand Other Supporting Information, World Health Organization (WHO), Geneva.231e233.http://www.who.int/water_sanitation_health/dwq/gdwq2v1/en/index1.html.
[12] Thangavelu A Sapna K and Prabitha R 2019 Assessment of Fluoride Hazard in Groundwater of Palghat District, Kerala: A GIS Approach. *Int. J. Environment and Pollution*, **66**, Nos. 1/2/3, pp.187–211.
[13] Ochir Altansukh and Davaa 2011 Application of Index Analysis to Evaluate the Water Quality of the Tuul River in Mongolia. *Journal of Water Resource and Protection* **3** pp 398-414.
[14] Srinivas Y Hudson Oliver D Stanley Raj A and Chandrasekar N 2013 Evaluation of groundwater quality in and around Nagercoil town. *Appl Water Sci*.**3** pp 631–651.
[15] BIS (Bureau of Indian Standards)10500.2012. Indian Standard- drinking water specification.Manak Bhavan.New Delhi.1-16.
[16] Chang K 2002 *Geographic Information System*, Tata McGraw Hill Publishing Company, Delhi, pp 348.
[17] McCoy MD and Johnson R 2001 *Using ArcGISSpatial Analyst*, ESR^{TM}, USA. pp 230.
[18] APHA 2005 Standard methods for the examination of water and waste water,21st edition. *American Public Health Association.*Washington, DC.
[19] Huh Y Chan LH Zhang L and Edmond JM 1998 Lithium and its isotopes in major world rivers: Implications for weathering and the oceanic budget. *Geochimica et Cosmochimica Acta* **62**(12) pp 2039-2051. doi: 10.1016/S0016-7037(98)00126-4.
[20] Puth MT, Neuhäuser M and Ruxton GD Effective use of Pearson's product–moment correlation coefficient. *Anim Behav*. **93** pp 183-189. doi: 10.1016/j.anbehav.2014.05.003.
[21] Shieh G 2010 Estimation of the simple correlation coefficient. *Behav Res Methods*. **42** pp 906–917. doi: 10.3758/BRM.42.4.906.
[22] Shigut DA Liknew G Irge DD and Ahmad T 2017 Assessment of physico-chemical quality of borehole and spring water sources supplied to Robe Town, Oromia region, *Ethiopia. Appl Water Sci* **7** pp 155–164 https://doi.org/10.1007/s13201-016-0502-4.
[23] Javed Mallick 2017 Hydrogeochemical characteristics and assessment of water quality in the Al-Saad Lake, Abha Saudi Arabia, *Appl Water Sci* **7** pp 2869–2882.
[24] Sarala C and Ravi Babu P 2012 Assessment of Groundwater Quality Parameters in and around Jawaharnagar, Hyderabad, *International Journal of Scientific and Research Publications*, **2**(10) pp 148-154.
[25] Napacho ZA and Manyele SV 2010 Quality assessment of drinking water in Temeke District (part II): Characterization of chemical parameters, *African Journal of Environmental Science and Technology* **4**(11), pp 775-789.
[26] Murhekar GH 2011 Assessment of physico-chemical status of ground water samples in Akot city. *Res J Chem Sci* **1**(4) pp 117–124.
[27] Venkatramanan S Chung SY Ramkumar T Gnanachandrasamy G and Vasudevan S 2013 A multivariate statistical approaches on physicochemical characteristics of ground water in and around Nagapattinam district, Cauvery deltaic region of Tamil Nadu, India. Earth Sci Res J **17**(2) pp 97–103.
[28] Mohd Saleem Athar Hussain and Gauhar Mahmood 2016 Analysis of groundwater quality using water quality index: A case study of greater Noida (Region), Uttar Pradesh (U.P), India , *Cogent Engineering*, **3** pp 1237927., http://dx.doi.org/10.1080/23311916.2016.1237927.
[29] Singh CK Kumari R Singh N Mallick J and Saumitra M 2012 Fluoride enrichment in aquifers of Thar Desert: controlling factors and its geochemical modeling. *Hydrological Processes*, **27**(17) pp 2462-2474, doi:10.1002/hyp.9245.