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Assessment of Groundwater Quality Parameters Using Statistical Analysis, a Case Study of Dindigul City, Tamilnadu, India

Dhayalan V.[1], Ramaraj M.[2], Sathyaseelan M.[3] and Colins Johnny J.[4]
[1]Environmental Engineering, Gnanamani College of Engineering, Namakkal, Tamilnadu, India
[2]Environmental Engineering, MAM College of Engineering, Trichy, Tamilnadu, India
[3]Geo Informatics, Bharathidasan University, Trichy, Tamilnadu, India
[4]University V.O.C College of Engineering, Tuticorin, Tamilnadu, India
geodhaya@gmail.com

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Abstract

The case study was conducted with the aim of defining the range of groundwater pollution caused by the tannery industries and disposal of sewage waste in kodavanar watershed basin region located in Dindigul district, which is a township of having small and large scale tannery industries around 68 industries. The groundwater gets frequent contamination due to untreated effluents which is discharged from the tanneries industries. The untreated effluent does contains *various pollutants such as chromium, nitrates, sulphate, hardness, arsenic, fluorides and microbiological organisms more than its desirable limits. The samples from various sixteen locations were collected during pre-monsoon season in the year 2014 and the collected samples were analyzed in the laboratory. Water quality index map was created in order to display the quality of water in sixteen sample locations of the study area. In this study, correlation analysis, factor analysis and regression analysis were carried out to show the clear substantial relationship between the different sets of groundwater quality parameters in our study area and to determine whether the water quality parameters are ordinarily dispersed and revelation of seasonal pattern. The chemical constraints exposes in the principal component analysis and varimax on three factors that interpret for about 71.819% of the total variance shows the important component of groundwater chemistry in study area.*

Keywords: Pollutant, Pre Monsoon, Water Quality Index, Principal component analysis, Varimax, Tannery.

Introduction

Groundwater is the major source of potable water for every human consumption[1]. Specifically the groundwater are clear and colorless but they are harder than the surface water from which they occur[2]. The water should be fresh and clear for drinking purposes. Now a days the groundwater quality is getting reduced due to sitting of industries discharging effluents which exceeding the prescribed limit of the disposal, increase in growth of population, landfills, deforestation, discharge of sewage into the river or other land disposal[3]. It is realized that the main reason for the poorer quality of groundwater in contaminated area are strongly found to be the untreated effluent that is directly discharging onto the land by means of lagoons or to the river[4]. The discharged untreated effluent is percolating harmful heavy metals into the ground in order to contaminate the groundwater and soil[5].Within a distance of 5 km, a number of 68tanneries in Dindigul city, are positioned from the midpoint of the town. Many of the industries are in Dindigul, functioning for about thirty five to forty years[6]. The foremost chemicals are used in the tanning industries, comprising ammonium chloride, sodium carbonate, lime, caustic soda, sodium chloride, sodium sulphide, ammonium sulphate, chromium sulphate, sulphuric acid, tannins and dyes, pigments, defoamers. However all tanneries are in our study area, based upon their capacity using enormous quantity of water from groundwater sources for their processing, even a small scale industry using up to 1,50,000 liters of groundwater for a day which is equivalent to the requirement of water for 1150 persons per day. The Kodavanar River is polluting by the tannery operation and menacing its use for human consumption, and irrigation. The aim of this case study was to carry out the statistical analysis to define the characteristics of the groundwater quality parameters collected from our study area in pre monsoon season 2014. Statistical analysis is the mathematical measure used to relating the water samples. Using these methods, the features of the data set can be discovered and to study the nourishing nature of dataset, a single numbered output can be derived[7]. The Statistical analysis is used to inspect the water samples collected from the study area. Correlation analysis is used to analyze the significant relationship between two infinite variables. The association between the variables is positive or negative, if the one of capricious is escalation with the escalation of the other[8]. The correlation analysis can detect the co-variation of the water quality parameter. The method used here is Pearson‘s correlation (linear correlation coefficient). It provides the significant relationship between two interrelated variables[9]. Likewise factor and regression analysis were done to show the interdependent relationship of the water quality parameters. In this work seventeen water quality parameters of distributed locations of study area are taken for statistical analysis.

Study Area: The study area kodavanar watershed basin is lies between 10°22'7.04''N and 10°18'32.07'' S latitude, 77°53'2.34'' W and 78°01'E longitude, covering an area about 491 sq.km. In this district there are 7 taluks, 14 blocks, 539 panchayats and 349 villages had the population of 21, 61,367 of which male and female populations were 10, 81,934 and 10, 79, 433[10]. The district is a portion of Cauvery and Capecomerin to Cauvery Basin and parts of Vaigai and Pambar sub basins (Central Ground Water Board). The major type of soil in this area is black cotton soil, red sandy soil and red soil. The annual rainfall in this district is around between 700 mm – 1600 mm and the humidity is varying between 65% - 85 % in the morning and 40 – 70 % in the afternoon. The most important land forms in this district are structured hills which is in the major part of kodaikanal and palani hills[10]. The main important aquifer system come across in this study area are classified according to their Archaean transparent metamorphic compound. They are Sandstone Gneisses and Valley fill sediments consisting of clay, sand, and silt. The specific yield of the aquifer parameters are 1.5 %[10]. Dindigul district is having about 68 tannery industry distributed within the six kilometers surroundings.

The samples were collected in the plastic bottles from various open wells by means of conventional sampling method in the month of pre monsoon season 2014. The sample locations are shown in the study area map. The dissolved oxygen is measured on spot after the collection of samples by using DO meter. The collected samples must be analyzed within 2 days. To measure the meditation of water quality parameters the samples were taken to the laboratory and the parameters were analyzed by the procedures approved by the American Public Health Association. Water Quality Index map was created in the GIS software to show the variations of the parameters along the study area.

To conduct the statistical analysis PSPP software was used. Pearson correlation method is used for correlation analysis, in this analysis a significant relationship between the two independent variables are found out[11].

To identify a small amount of factors that describe most of the inconsistency detected in a larger quantity of variables for data reduction, factor analysis is carried out. It can reduce the enormous quantity of hydrologic substance data into limited chief factors which Eigen values are exceed one. Besides the work of factor analysis using the equation Xij = ℓ j1 x i1 + ℓ j2 x i2 + . . . + ℓ jp x ip + ℓ ij for the process of water quality parameters. Extraction method followed in this work was principal component analysis (PCA) and the rotation method is Varimax. According to A. Jesu *et al*. iterations the rotation here has converged. Small ideals in the rotated component matrix show the variables that do not fit well with the factor solution and can be probably fallen for auxiliary analysis.

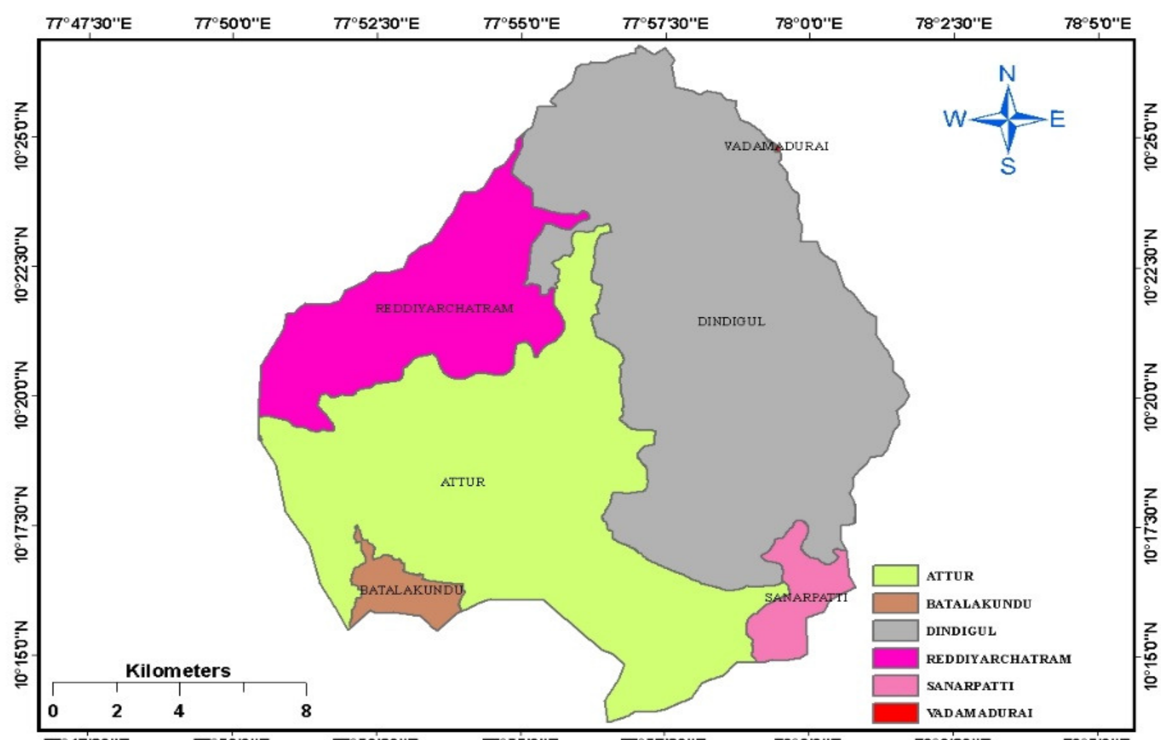

Figure-1
Study Area

Methodology

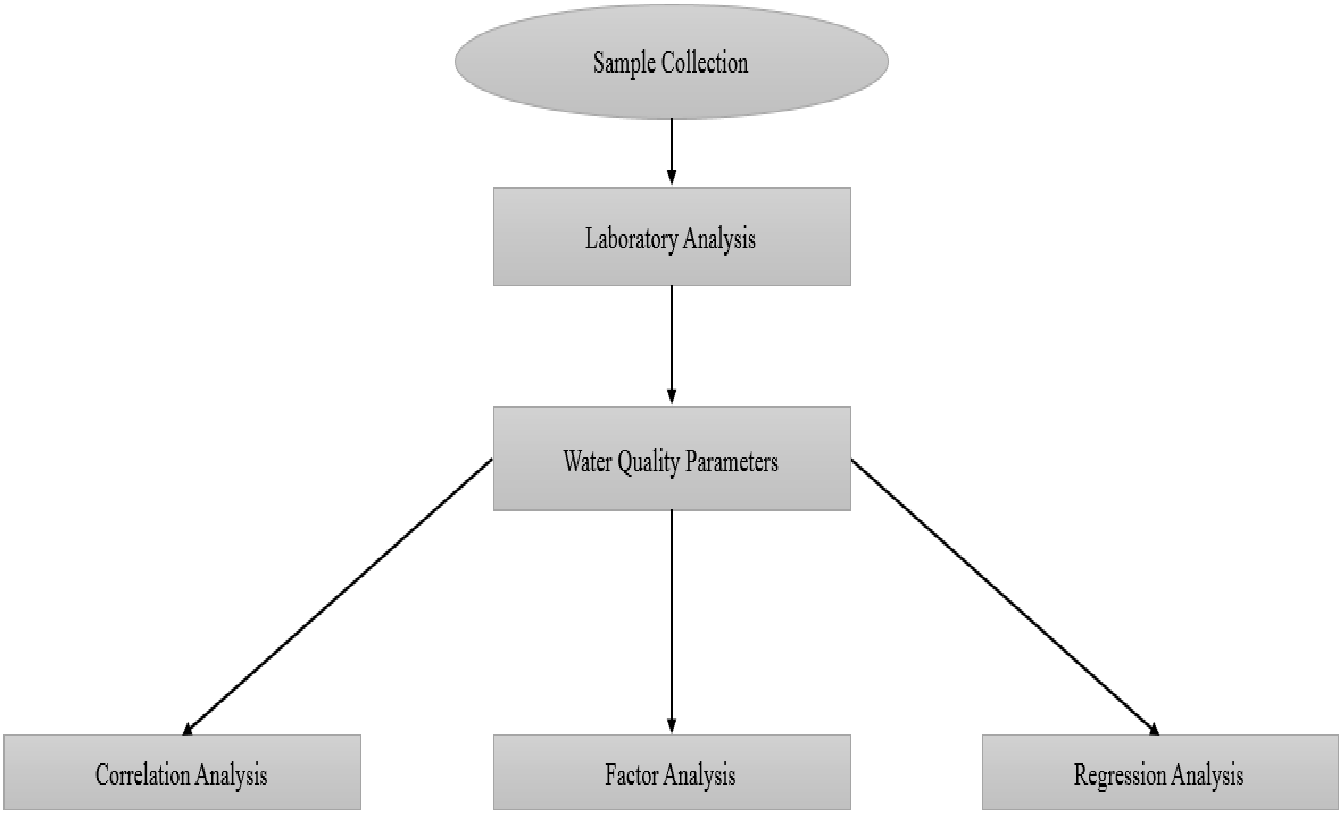

Figure-2
Methodology

Regression analysis was helped to show the significant relationship between the constraints which is taken for the analysis. TDS is considered as the directory of over-all groundwater quality parameters. It is based on all chemical substances that presence in the taken samples. The predominant chemical constraints that stimulus the groundwater chemistry of the study area during the pre-monsoon season are determined from correlation and regression analysis[12]. Using the regression analysis the association between TDS and inducing chemical constraints were developed. The regression equations between TDS and major chemical constraints have also been developed. The software NPSS is used to conduct regression analysis. TDS is considered as the dependent variable. The parameters which have strong correlations with TDS and upper values of factor analysis (Rotated component matrix) are engaged as independent variables for regression analysis.

Results and Discussion

Water Quality Index (WQI): Water Quality Index (WQI) is a beneficial and effective method for evaluating the quality of water. It is very useful tool for relating the information on general quality of water.

Table-1
WQI categories

Water Quality Index	**Description**
0-25	Excellent
25-50	Good
51-75	Poor
76-100	Very Poor
>100	Unfit for drinking

The WQI map of our study area was created using GIS software.

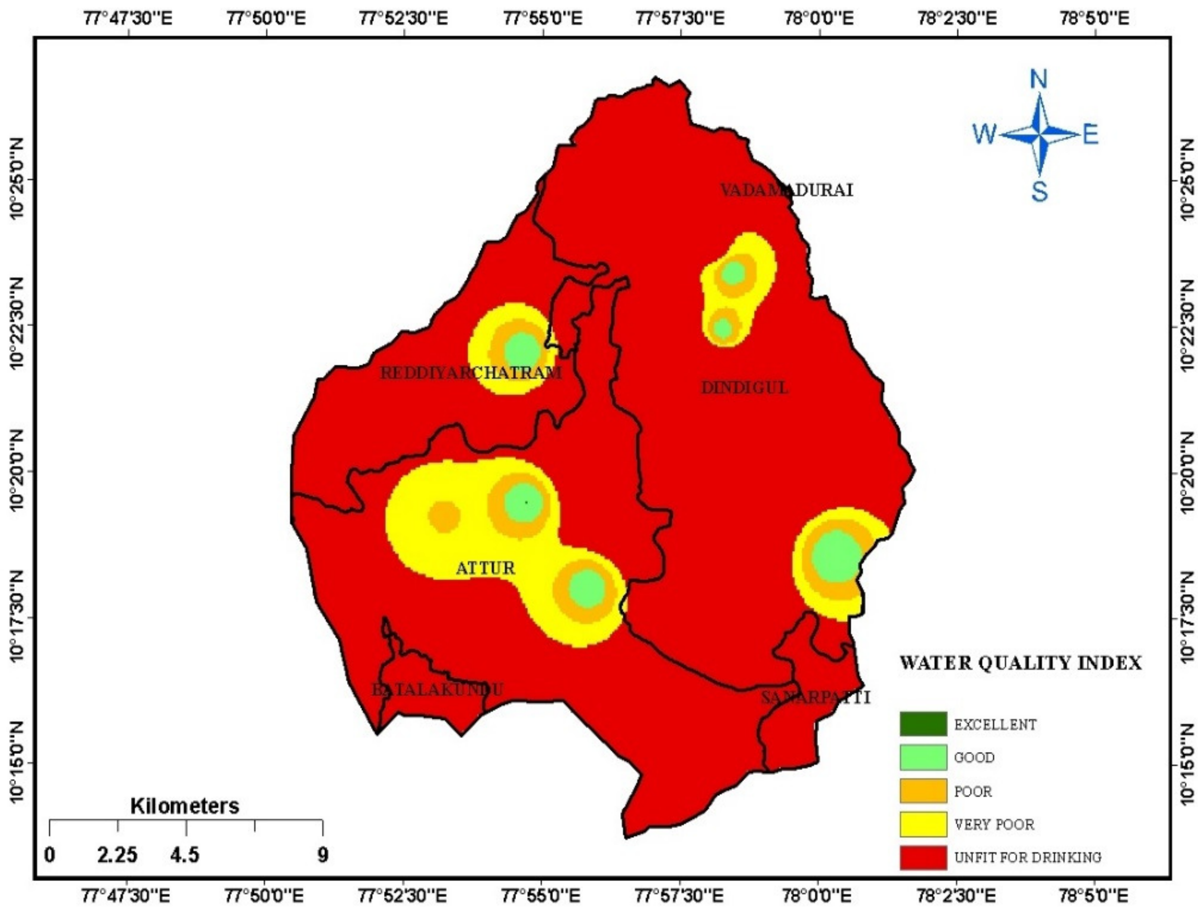

Figure-3
Water Quality Index Map

Correlation Analysis: The correlation coefficients between several water quality parameters of pre monsoon samples were deliberated and presented in Table. The magnitude of relationship or no relationship of any of the hydrological constraints with other constraints of pre monsoon samples could be studied from this analysis[13].

TDS has significant correlations of 0.7943, 0.6992, 0.9124, 0.8655, 0.748, 0.7536, 0.5075, 0.9685, 0.603, 0.8521, 0.5048, 0.699 with NO_2+NO_3, Ca, Na, Cl, SO_4, HCO_3, F, EC_GEN, HAR, SAR, RSC, Na%. But TDS has very low correlations of 0.2461 with Mg. TDS has negative correlations of -0.2701 and \0.4188 with CO_3 and pH_GEN. The value of TDS is independent of CO_3 and pH_GEN.

NO_2+NO_3 have significant correlations of 0.7943, 0.7106, 0.7609, 0.7274, 0.7125, 0.6359 with TDS, Ca, Na, SO, EC_GEN, SAR. But TDS has very low correlations of 0.2358, 0.3411, 0.4805, 0.4103, 0.3032, 0.4630 with K, HCO_3, F, HAR_Total, RSC, Na%. TDS has negative correlations of -0.0584, -0.0652, 0.4316, Mg, CO_3, pH_GEN. The value of TDS is independent of Mg, CO_3 and pH_GEN.

Ca has significant correlations of 0.6992, 0.7995 with Cl and HAR_Total. It has negative correlations of -0.0584, -0.1043, -0.2431, -0.3625, -0.1144, -0.2595, 0.2114 with NO_2+NO_3, Na, CO_3, PH_GEN, SAR, RSC, Na%. The value of Ca is independent of NO_2+NO_3, Na, CO_3, pH_GEN, SAR, RSC, Na%. Ca has very low correlations of 0.2461, 0.2356, 0.1534, 0.0697, 0.237, 0.0964 with TDS, Ca, K, SO_4, HCO_4, F, EC_GEN.

Na has significant correlations of 0.9124, 0.7609, 0.6731, 0.689, 0.6836, 0.5215, 0.8143, 0.9716, 0.6581, 0.88 with TDS, NO_2+NO_3, Cl, SO_4, HCO_3, F, EC_GEN, SAR, RSC, Na%. But Na has very low correlations of 0.4707, 0.3587, 0.2347 with Ca, K, HAR_Total. Na has negative correlations of -0.1043, -0.2333, 0.2896 with Mg, CO_3, and pH_GEN. The value of Na is independent of Mg, CO_3, and pH_GEN.

The K of pre monsoon groundwater samples has no significant correlations with any parameters of the water quality. Also K has low correlations of 0.4296, 0.2358, 0.2136, 0.1534, 0.3587, 0.3208, 0.1421, 0.4799, 0.0583, 0.3766, 0.2472, 0.27, 0.4559, 0.1594 with TDS, NO_2+NO_3, Ca, Mg, Na, Cl, SO_4, HCO_3, F, EC_GEN, HAR_TOTAL, SAR, RSC, Na%. It has negative correlations of 0.2702, -0.5004 with CO_3, PH_GEN. The value of K is independent of CO_3 and PH_GEN.

Cl has significant correlations of 0.8655, 0.5411, 0.5603, 0.6316, 0.6731, 0.561, 0.6353, 0.9105, 0.7675, 0.6336 with TDS, NO_2+NO_3, Ca, Mg, Na, Cl, HCO_3, EC_GEN, HAR_TOTAL, SAR. Cl has very low correlations of 0.3208, 0.3822, 0.3061 with K, F, RSC. It has negative correlations of -0.3873, 0.4369 with CO_3 and pH_GEN. The value of Cl is independent of CO_3 and pH_GEN.

SO_4 has significant correlations of 0.748, 0.7274, 0.5344, 0.689, 0.561, 0.5071, 0.7297, 0.6687, 0.6305 with TDS, NO_2+NO_3, Ca, Na, Cl, F, EC_GEN, SAR, Na%. SO_4 has very low correlations of 0.0697, 0.1421, 0.3461, 0.3765 with Mg, K, HCO_3, HAR_TOTAL. SO_4 has negative correlations of -0.2876, -0.3689, 0.0001 with CO_3, pH_GEN, and RSC. The value of SO_4 is independent of CO_3, pH_GEN, and RSC.

The CO_3 of pre monsoon groundwater samples has no significant correlations with any parameters of the water quality. But it has very low correlations of 0.4965 with PH_GEN. CO_3 has negative correlations of -0.2701, -0.0652, -0.0382, -0.2431, -0.2333, -0.2702, -0.3873, -0.2376, -0.1783, -0.1727, -0.299, -0.1849, -0.227, 0.1106, -0.1939 with TDS, NO_2+NO_3, Ca, Mg, Na, K, Cl, SO4, HCO3, F, EC_GEN, HAR_TOTAL, SAR, RSC, Na%. The value of CO_3 is independent of TDS, NO_2+NO_3, Ca, Mg, Na, K, Cl, SO_4, HCO_3, F, EC_GEN, HAR_TOTAL, SAR, RSC, Na%.

HCO_3 has significant correlations of 0.7536, 0.6836, 0.6353, 0.7344, 0.7116, 0.6753, 0.6088 with TDS, Na, Cl, EC_GEN, SAR, RSC, Na% . HCO_3 has very low correlations of 0.3411, 0.4573, 0.237, 0.4799, 0.3461, 0.2239, 0.4454 with NO_2+NO_3, Ca, Mg, K, SO_4, F, HAR_TOTAL. HCO_3 has negative correlations of -0.1783, -0.0256 with CO_3 and pH_GEN. The value of HCO_3 is independent of CO_3 and pH_GEN.

F has significant correlations of 0.5075, 0.5215, 0.5071, 0.5892 with TDS, Na, SO_4, EC_GEN. F has very low correlations of 0.4805, 0.3362, 0.0964, 0.0583, 0.3822, 0.2239, 0.2706, 0.485, 0.0385, 0.4744 with NO_2+NO_3, Ca, Mg, K, Cl, HCO_3, HAR_TOTAL, SAR, RSC, Na%. F has negative correlations of -0.1727, 0.6322 with CO_3 and pH_GEN. The value of F is independent of CO_3 and pH_GEN.

The pH of pre monsoon groundwater samples has none significant correlations with any constraints of the water quality. But it has very low correlations of 0.4965 with CO_3. pH has negative correlations of -0.4188, -0.4316, -0.3672, -0.3625, 0.2896, -0.5004, -0.4369, -0.3689, -0.0256, -0.6322, -0.4982, -0.4705, -0.156, 0.0017 with TDS, NO_2+NO_3, Ca, Mg, Na, K, Cl, SO_4, HCO_3, F, EC_GEN, HAR_TOTAL, SAR, Na%. The value of pH is independent of TDS, NO_2+NO_3, Ca, Mg, Na, K, Cl, SO_4, HCO_3, F, EC_GEN, HAR_TOTAL, SAR, Na% .

EC_GEN has significant correlations of 0.9685, 0.7125, 0.7304, 0.8143, 0.9105, 0.7297, 0.7344, 0.5832, 0.7343, 0.7607, 0.6147 with TDS, NO_2+NO_3, Ca, Na, Cl, SO_4, HCO_3, F, HAR_TOTAL, SAR, Na%. EC_GEN has very low correlations of 0.4225, 0.3766, 0.374 with Mg, K, and RSC. EC_GEN has negative correlations of -0.299. -0.4972 with CO_3 and pH_GEN. The value of EC_GEN is independent of CO_3 and pH_GEN.

HAR_TOTAL has significant correlations of 0.603, 0.7716, 0.7995, 0.7679, 0.7343 with TDS, Ca, Mg, Cl, and EC_GEN. HAR_TOTAL has very low correlations of 0.4103, 0.2347, 0.2472, 0.3765, 0.4454, 0.2706, 0.139 with NO_2+NO_3, Na, K, SO_4, HCO_3, F, SAR. HAR_TOTAL has negative correlations of -0.1849, -0.4705, -0.0384, -0.0524 with CO_3, pH_GEN, RSC and Na%. The value of HAR_TOTAL is independent of CO_3, pH_GEN, RSC and Na%.

SAR has significant correlations of 0.8521, 0.6359, 0.9716, 0.6336, 0.6687, 0.7116, 0.7607, 0.6583, 0.9581 with TDS, NO_2+NO_3, Na, Cl, SO_4, HCO_3, EC_GEN, RSC, Na%. SAR has very low correlations of 0.3294, 0.27, 0.485, 0.139 with Ca, K, F, HAR_TOTAL. SAR has negative correlations of -0.1144, -0.227, 0.156 with Mg, CO_3, pH_GEN. The value of SAR is independent of Mg, CO_3, and pH_GEN.

RSC has significant correlations of 0.5048, 0.6581, 0.6753, 0.6533, 0.56 with TDS, Na, HCO_3, SAR, and Na%. RSC has very low correlations of 0.3032, 0.189, 0.4559, 0.3061, 0.0385, 0.0322, 0.374 with NO_2+NO_3, Ca, K, Cl, F, pH_GEN, and EC_GEN. RSC has negative correlations of -0.2595, -0.001, -0.1106, -0.0384 with Mg, SO_4, CO_3, HAR_TOTAL. The value of RSC is independent of Mg, SO_4, CO_3, and HAR_TOTAL.

Na% has significant correlations of 0.699, 0.88, 0.6305, 0.6088, 0.6147, 0.9581, 0.56 with TDS, Na, SO_4, HCO_3, EC_GEN, SAR, RSC. Na% has very low correlations of 0.463, 0.1268, 0.1594, 0.4762, 0.4744 with NO_2+NO_3, Ca, K,, Cl, and F. Na% has negative correlations of -0.2114, -0.1939, -0.0617, -0.0524 with Mg, CO_3, pH_GEN, and HAR_TOTAL. The value of Na% is independent of Mg, CO_3, pH_GEN, and HAR_TOTAL.

The acid base reactions and pH in most ground water samples are conquered by the collaboration between the $CO_2$and aqueous carbonate mixtures. In our water quality parameters, low correlation standards existing between CO3 and pH. Hence, it might be proved that the pH of the ground water can be modified by the aqueous carbonate complexes yielding less impact and CO_3 in unsaturated zone of subsurface takes more impact in carbonate, bicarbonate, and CO_2 equilibrium. From the results there are no considerable changes between the parameters of pre monsoon season. It shows the dissolution of the toxic synthetic chemicals into the groundwater due to after the effects of atmospheric precipitations in the pre monsoon season increasing permeation rate.

Table-2
Correlation matrix for pre monsoon samples

Parameters	TDS	NO_2+ NO_3	Ca	Mg	Na	K	Cl	SO_4	CO_3	HCO_3	F	pH_GEN	EC_GEN	HAR	SAR	RSC	Na%
TDS	1																
NO_2+ NO_3	0.79	1															
Ca	0.6992	0.7106	1														
Mg	0.2461	-0.058	0.2356	1													
Na	0.9124	0.7609	0.4707	-0.104	1												
K	0.4296	0.2358	0.2136	0.1534	0.3587	1											
Cl	0.8655	0.5411	0.5603	0.6316	0.6731	0.3208	1										
SO_4	0.748	0.7274	0.5344	0.0697	0.689	0.1421	0.561	1									
CO_3	-0.27	-0.065	-0.038	-0.241	-0.233	-0.270	-0.38	-0.237	1								
HCO_3	0.7536	0.3411	0.4573	0.237	0.6836	0.4799	0.635	0.3461	-0.18	1							
F	0.5075	0.4805	0.3362	0.0964	0.5215	0.0583	0.382	0.5071	-0.17	0.2239	1						
pH_GEN	-0.41	-0.431	-0.367	-0.362	-0.289	0.500	-0.43	-0.368	0.496	-0.025	-0.632	1					
EC_GEN	0.9685	0.7125	0.7304	0.4225	0.8143	0.3766	0.910	0.729	-0.29	0.7344	0.5832	-0.4972	1				
HAR_ TOT	0.603	0.4103	0.7716	0.7995	0.2347	0.2472	0.767	0.3765	-0.18	0.4454	0.2706	-0.4705	0.7343	1			
SAR	0.8521	0.6359	0.3294	-0.114	0.9716	0.27	0.633	0.6687	-0.22	0.7116	0.485	-0.156	0.7607	0.139	1		
RSC	0.5048	0.3032	0.189	-0.259	0.6581	0.4559	0.306	-0.001	-0.11	0.6753	0.0385	0.0322	0.374	-0.038	0.6533	1	
Na%	0.699	0.463	0.1268	-0.211	0.88	0.1594	0.476	0.6305	-0.19	0.6088	0.4744	-0.0617	0.6147	-0.052	0.9581	0.56	1

Factor Analysis: Factor Analysis was achieved using PSPP software on a data of pre monsoon samples. Extraction method surveyed in this work is principal component analysis and the rotation method is Varimax[14]. To carry out the factor analysis the important parameters are chosen from the correlation analysis whose correlations values are significantly high with another. The dissimilarity here has been transformed into 3 iterations. Small values in the rotated component matrix showing the variables that do not acceptable well for factor elucidation and can be conceivably dropped for further analysis[15]. The Eigen values, percentage of inconsistency and their accumulative measurement of variance are presented in Table. The Eigen values of first three factors explaining about

71.819% of the total variance and variance values are higher than one.

Table-3
Initial Eigen values, Variance percentage and cumulative percentage of variance of FA for pre monsoon samples

Factors	Eigen values		
	Total	Variance Percentage	Cumulative %
1	4.526	45.255	45.255
2	1.576	15.762	61.017
3	1.080	10.802	71.819
4	.961	9.607	81.426
5	.610	6.100	87.525
6	.544	5.436	92.961
7	.369	3.687	96.648
8	.256	2.558	99.206
9	.075	.754	99.960
10	.004	.040	100.000

Table-4
Rotated factor loading matrix for pre monsoon samples

	FACTOR		
Chemical parameters	1	2	3
NO_2	.892	.201	-.092
Ca	.715	.152	.216
Mg	-.001	-.010	.958
Na	.773	.535	-.068
K	.011	.863	.100
Cl	.582	.361	.658
SO_4	.843	.120	.089
CO_3	-.052	-.343	-.469
HCO_3	.363	.720	.230
F	.704	-.071	.125

Factor 1 has higher loadings of NO_2, Ca, Na, Cl, SO_4 and F. Factor 1 involves in 45.255 % of the total variations. It is realized that major cation and anion can be derived from Factor 1. Hence the hydrogeology of the groundwater samples can be influenced by these six parameters may be deliberated as the important chemical constraints.

Factor 2 has higher loadings of Na, K, and HCO_3. The total variations of the factor 2 comprises in 15.762 %. The higher loadings of Factor 3 are Mg and Cl. The total variations of the factor 2 comprises in 10.802 %. The Eigen value of factor 3 and factor 2 are slightly above 1.

The major water quality parameters of pre monsoon groundwater samples are found to be NO_2, Ca, Na, Cl, SO_4 and F. Hence factor 1 can be considered as the important water quality parameters, because it is having higher loading component, in like manner factors 2 and 3 having small loading component are considered as less important water quality parameters in groundwater chemistry. Since, Factor 1 is selecting significant variables, so considered as important factor and it is subsidizing 45.255 % of the total variations in pre monsoon groundwater samples. The categorization of factor loading is altered by the impact of suspension due to percolation of heavy metal is measured here as the origin for the difference in the concentrations of water quality parameters.

Regression Analysis: The chemical parameters which have robust correlation with TDS and factor 1 having higher loading parameters are engaged for doing regression analysis. The regression model is developed in NCSS software and the summary of regression model is presented in table.

Table-5
Summary of regression model for pre monsoon samples

Predictors (Independent variables)	Dependent variable	Adjusted R Square
Constant, NO_2+NO_3, Ca, Na, Cl, SO_4 and F	TDS	0.9782

Six chemical parameters are here considered as independent variables to develop model with TDS. Two parameters are having significance with TDS at 1% level. One parameter having significance with TDS at 10% level. Four parameters are having significance with TDS at more than 10% level. The higher significance parameters with TDS have lower influence on dependent variable TDS, however these parameters are highly correlated with TDS.

The regression model is derived between high influencing water quality parameters has adjusted R² value of 0.9782 and TDS.

The relationship between those two factors are expressed in the following equation.

$$TDS = -0.26 * NO_2 + NO_3 + 2.19 * Ca + 1.62 * Na + 1.22 * Cl + 0.75 * SO_4 - 6.90 * F + 101.99 + \varepsilon$$

Relationship between the actual Versus Predicted TDS are developed from the above equation.

The regression equation between the parameters whose values are highly correlated with the TDS and TDS are also developed. Here TDS were taken as independent variable and other parameters previously considered as predictors, considering here as dependent variables. This may be help to predict the other influencing water quality parameters if the concentration of TDS is known. The regression equation of water quality parameters, Adjusted R² value and significance value are tabulated.

Table-6
Coefficients regression model and significance level for Pre monsoon samples

MODEL	Dependent Variable	Predictors	Coefficients	Significance
I	TDS	Constant	101.93	0.111***
		NO_2+NO_3	-0.264	0.936***
		Ca	2.186	0.021**
		Na	1.620	0.001*
		Cl	1.218	0.002*
		SO_4	6.753	0.291***
		F	-6.902	0.795***

Note: *1% Significance, **10% Significance, ***More than 10% Significance.

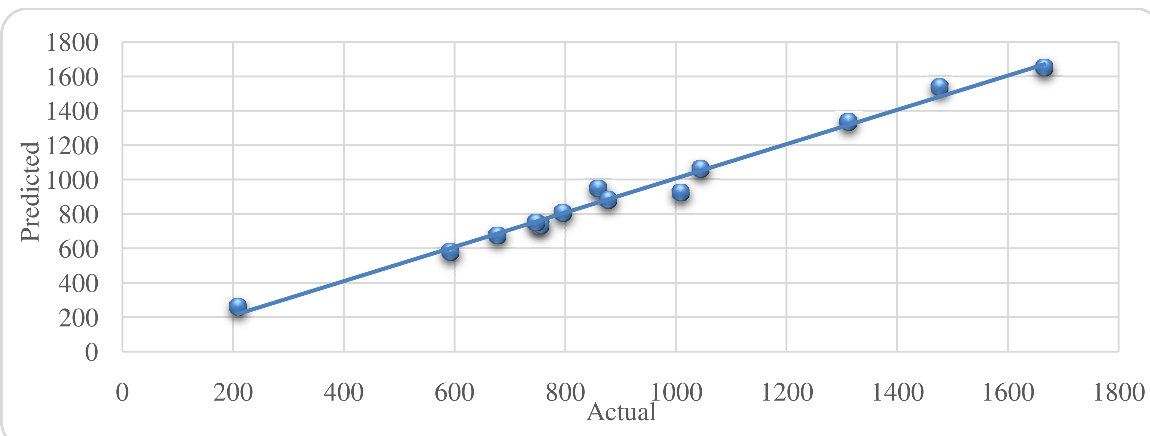

Figure-4
Regression line between Actual Vs Predicted TDS

Table-7
Regression equations for pre monsoon samples

S.No	Regression equations	Adjusted R Square value	Significance
1	$NO_2 + NO_3$ = 0.025 TDS - 7.464	0.924	0
2	Ca = 0.071 TDS + 18.144	0.888	0
3	Na = 0.299 TDS – 122.259	0.817	0
4	Cl = 0.247 TDS - 55.724	0.726	0
5	SO_4 = 0.081 TDS – 1.091	0.950	0

6	F = 0.01 TDS + 0.275	0.990	0

The significance value of all parameters is 0. This shows that the results are apt to variables. To validate this equation, the observed TDS from samples are included in that equation to find out the concentration of NO_2+NO_3, Ca, Na, Cl, SO_4, F.

The regression equation has been developed to predict the influencing parameters from TDS. The regression equation is developed to show the relationship between the influencing water quality parameters and TDS. It can give the precise value in the water quality parameters.

Table-8
Validation of the TWAD board results with regression model

S.NO	Water quality parameters	Well No	Date of Collection	Water quality Test Results (Mg/ltr)	LRE Results (Mg/ltr)
1	Ca	22001D	20/01/2005	36	50.22
			04/01/2006	72	60.288
			08/01/2007	28	34.932
			14/01/2008	40	48.987
			22/01/2009	12	31.879
			04/01/2011	16	33.015
2	NO_2+NO_3	22001D	20/01/2005	36	42.54
			04/01/2006	15	7.85
			08/01/2007	7	5.185
			14/01/2008	6	6.986
			22/01/2009	4	3.761
			04/01/2011	4	4.161
3	Na	22001D	20/01/2005	92	84.65
			04/01/2006	71	50.001
			08/01/2007	55	36.849
			14/01/2008	99	87.563
			22/01/2009	115	95.387
			04/01/2011	108	86.035
4	SO_4	22001D	20/01/2005	19	25.675
			04/01/2006	59	47.023
			08/01/2007	23	31.82
			14/01/2008	58	48.039
			22/01/2009	33	37.071
			04/01/2011	21	38.431
5	Cl	22001D	20/01/2005	35	54.303
			04/01/2006	71	90.994
			08/01/2007	39	49.564
			14/01/2008	18	31.091
			22/01/2009	46	32.234
			04/01/2011	50	38.945
6	F	22001D	20/01/2005	0.44	5.685
			04/01/2006	0	0.275
			08/01/2007	0.23	5.195
			14/01/2008	0.40	6.055
			22/01/2009	0.41	4.765
			04/01/2011	0.92	4.925

Conclusion

The present work reveals that the variation in the quality of ground water in the study area based on the physico-chemical parameters and monitoring of groundwater parameters by using statistical analysis including correlation analysis, factor analysis and regression analysis. With attention to correlation analysis, the significant relationship between the various parameters are found out. Many parameters are having good significant relationship with others except pH. The results of correlation analysis shown the important chemical parameters on the groundwater chemistry. Factor analysis results shows that the fruition of groundwater chemistry is generally owing to rock supremacy. The prediction model was derived from regression analysis and the validation of the regression analysis was proved. The validation results are compared with the collected samples parameters value. Hence, the variation between the parameters are varying from -25.45 % to 37 %. This reveals that the developed model is respectable and all cations and anions in the groundwater are of mixed type and there is domination of particular ion. From this study it is clearly understood that Dindigul city is under threat due to water scarcity problems and water pollution problems. Hence it is recommended that the monitoring the quality of groundwater by statistical analysis occasionally in the study area to prevent further contamination.

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