Statistical Analysis of Ground Water Quality Parameters in Erode District, Taminadu, India

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Abstract: ***Water that can be used for drinking, cooking, land farming, etc should be free from physical and chemical contaminants. The major source of drinking water is ground water. The pore spaces and the fractures in rocks carries the major amount ground water which is found beneath the Earth's surface. The objective of this study is to predict the ground water quality in the Erode district of Tamil Nadu, India. A total number of 26 samples were collected from different regions of the district. The present study deals with the analysis of physical-chemical parameters, Multivariate statistical analysis for predicting the ground water quality in the Erode district. Multivariate statistical method involves determination of correlation and factor analysis. Interpretation of analytical data showed the water quality variance. Finally it was found that there is a variance of about 63.273% in ground water quality during the pre-monsoon season and about 73.624% in post monsoon season.***

Keywords: Groundwater, Physical-Chemical Parameters, Multivariate Statistical Methods, Correlation Analysis, Factor And Cluster Analysis

I. INTRODUCTION

Water is the essential thing in our day-to-day life. Ground water occurs almost everywhere below the land surface. Ground water exists in the world about 0.6%; even though its contribution is less, it is fresh source of water supply. Ground water is the one which is subjected to less pollution compared to surface water sources. Unfortunately now-a- days, the ground water is getting polluted due to increase in population, urbanization and industrialization. Also the unsafe disposal of industrial effluents and hazardous waste into natural water bodies may lead to minor to severe ill effects on human bodies those who largely depends on ground water. The impact of human activities towards ground water may also alter the quality of ground water. Therefore it becomes essential to access the quality of ground water and to monitor them periodically.

The objective of this study is to extract the parameters which influences the quality of ground water in the study area and to find whether the water is suitable for drinking. It deals with the study of physical-chemical parameters, Multivariate statistical methods for analyzing the ground water quality in the Erode district. The Multivariate statistical method involves correlation analysis and factor analysis. The correlation using sigma plot software gives the information about the relationship between the two parameters. The factor analysis using SPSS software is used to characterize the variation in ground water quality and it is also used to identify the factors which are influencing the variation in ground water quality. The ground water becomes safe for drinking when it is clear and non-saline. In addition to that it should be free from disease causing pathogenic organism, offensive taste and odour and from other compounds will cause ill effects to human beings.

II. STUDY AREA DESCRIPTION

Erode district is the western part of the Tamilnadu, India. The North latitude of Erode district lies between 10°36' and 11°58' the East latitude lies between 76°49' and 77°58' East Longitude. The total area of the Erode district is about 8162 sq km. Erode district is known for the biggest textile, power loom and handloom products.

A. Geology

Erode district is characterized by different geological conditions. The major part of the district is identified with Lime stone in abundance which is available in the form of massive beds inter banded with igneous rocks of grey and white colors. In addition to that Feldspar of fine quality are also available in large quantity.

B. Rainfall and Climate

Every year the district receives a scanty rainfall and a dry climate. During the month of February and March the climate is usually sultry along the river Cauvery. The weather during the month of April gets more and more hot and humidity is also at its maximum level. During the month June, July, August there is a flow of chillness through the palghat gap. Although the chill freeze loses its cooling effect when it reaches the Erode district. As a result hot and dusty condition prevails in the district. The Bhavani and Gobichettipalayam of Erode district is recorded with heavy rainfall compared to other taluks.

C. Temperature

The average maximum temperature in the district reaches about 96° F and a minimum of about 79° F. During the month of January the temperature will be around 85° F. It increases gradually every month and reaches the maximum of 96° F in May and again reduces gradually to a temperature 79° F in December.

III. SAMPLE COLLECTION

Selection of water sources ware done by random sampling procedure. A total number of 26 ground water sampling stations were selected from the 7 taluks of Erode district. The samples were collected separately in a sterilized bottles during pre-monsoon season (April to September) and post-monsoon season (October to March). Before collection, the container which can be used for sample collection must be well washed and thoroughly rinsed with deionised

Revised Version Manuscript Received on 25 November, 2018.

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water before sampling. From dug well the water samples were collected after 10 min of pumping and stored separately in the sterilized bottles until the analysis were done. Immediately after collecting the samples the parameters such as pH and Electrical conductivity were measured at the site itself by making use of pH meter and Conductometer. The remaining parameters were taken to the laboratory and analyzed using standard methods (Table 1).

Table 1: List of Parameters and Methods of Determination

Parameters	Methods of determination
pH	pH Meter
TH (mg/l)	EDTA Method
Ca (mg/l)	Titration Method
Mg (mg/l)	Titration Method
Na (mg/l)	Flame Photometer (Calibration Method)
K (mg/l)	Flame Photometer (Calibration Method)
TDS (mg/l)	Potentiometric Method
EC (µS/cm)	Conductometer
F (mg/l)	UV Spectrophotometric Method
SO_4 (mg/l)	Turbidimeter Method
CO_3 (mg/l)	Turbidimeter Method

Note : *Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Sodium (Na), Calcium (Ca), Magnesium (Mg), Potassium (K), Fluoride(F), Sulphate (SO_4), Carbonate (CO_3)*

IV. RESULTS AND DISCUSSION

The water samples were tested for various physical and chemical parameters and their mean values and standard deviation during the pre-monsoon and post-monsoon season were reported in table 2 and 3. From the table 2 and 3, it is clear that the pH of the groundwater in most of the study area are alkaline in nature and it ranges more than 7 in the pre monsoon as well as in the post monsoon season. The pH value of all the 26 samples were within the permissible limit of drinking water quality and it ranges from minimum of 6.5 to the maximum of 8.5. Another important parameter to be considered in assessing the ground water quality is TDS. Compared to pre monsoon and post monsoon season, the TDS in post monsoon has high level concentration which ranges from 100mg/l-2658mg/l whereas for pre monsoon season it ranges from 221mg/l to 2200mg/l. Also the Total Hardness in post monsoon season has a high concentration of 190 mg/l to 956 mg/l in comparison to pre monsoon (124 mg/l -900 mg/l). The value of other parameters was found and it is likely to vary between, the E.C (185-1789), Ca (2 mg/l -352 mg/l), Mg (2 mg/l -202 mg/l), Na (11 mg/l -142 mg/l), K (1 mg/l -114 mg/l), SO_4 (2 mg/l -188 mg/l), CO_3 (0 mg/l -88 mg/l), F (0 mg/l -1 mg/l) for pre-monsoon season (table 2) and for post-monsoon season (table 3.) it was found to vary between, E.C (123-156), Ca (2 mg/l -210 mg/l), Mg (5 mg/l -262 mg/l), Na (11 mg/l -265 mg/l), K (1 mg/l -98 mg/l), SO_4 (2 mg/l -236 mg/l), CO_3 (0 mg/l -89 mg/l), F (0 mg/l -1 mg/l).

A. Correlation Analysis

The relationship between variables were found using Correlation analysis. It is a technique which is used for investigating the relationship between the variables. It is a useful tool to determine if there is a relationship between two variables. It is used to know increasing or decreasing tendency of the physico-chemical parameters related to monsoon. It allows us to conclude how strongly the two variables relate to each other in terms of both magnitude and direction.

B. Correlation Between Variables

The correlation coefficients (r) between the variables were calculated using person's correlation method and their corresponding values (r) are tabulated in table 4 for the pre-monsoon season and in table 5 for the post-monsoon season. Out of 66 correlations (table 4), it is evident that Sulphate has a high positive correlation with carbonate. Also significant correlation was recorded between EC, Mg, F, TDS, SO_4, CO_3, Ca, and Na during pre-monsoon season.

From table 5 it is evident that TDS is highly negatively correlated with fluoride and the parameters EC, TDS, TH, CO_3, SO_4, TDS, K, Mg, Na and F have significant correlation during post-monsoon season.

pH shows a inverse relationship between most of the anions and cations during post monsoon season.

C. Factor Analysis

The software packages like Statistical Package for social sciences (SPSS) and STATISTICA 6 have been used to carry out the analysis. In this technique the large number of variable are reduced to a fewer number of factors based on the eigen values and Eigen vectors. The interpretation of data is based on rotated factors, rotated loadings and rotated Eigen values. The extraction of factor has been done with a minimum acceptable eigen value of greater than 1. A screen plot (figure 1 & 2) shows the eigen values stored from large to small as a function of factor number.

The number factors generated during the pre-monsoon season was four factors and it was found that there is a total variance of about 63.273%. The explained variance 17.819% for factor 1; 17.389% for factor 2; 14.284% for factor 3; 13.781 for factor 4. The variables Mg, TDS, EC for factor 1; TH, SO_4, CO_3 for factor 2; K, TDS, F for factor 3 and pH, Ca, Na for factor 4 are having high loadings for corresponding four factors in the pre monsoon season. The number of factors indicate how many different contributions are involved in determining the quality of ground water in the study area. In post-monsoon season, the number of factors contributing to the variation remains the same but the cumulative variance explained by those factors has increased to 73.624% (table 7).

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Blue Eyes Intelligence Engineering
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The increase in percentage is due to the several environmental factors like nature of aquifer, surface penetration by rainfall, characteristics of flood water and carbon dioxide in the atmosphere which are released by human activities.

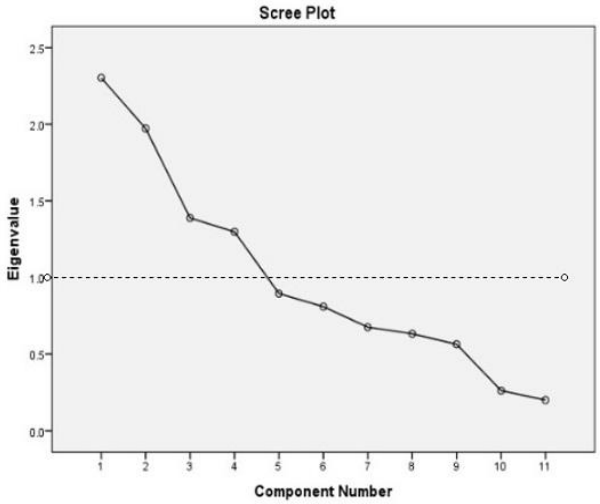

Figure 1. Screen Plot Diagram for Pre Monsoon Season

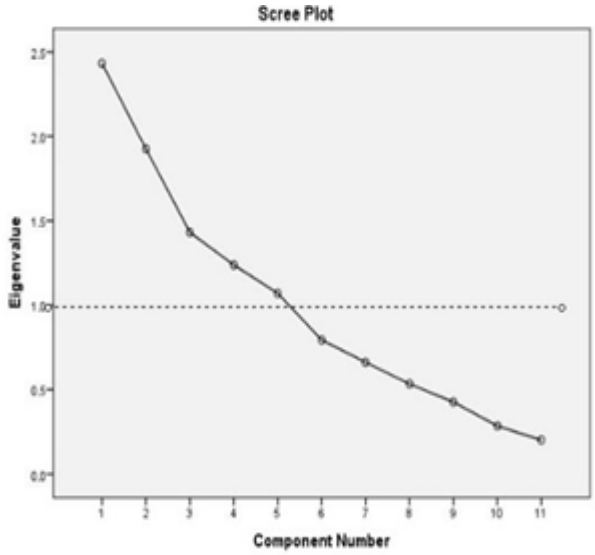

Figure 2 Screen Plot Diagram for Post Monsoon Season

The variance in the post monsoon season were 19.417%, 17.304%, 13.720%, 12.676%, 10.507% with loadings TH, K, EC, SO_4; Mg, TDS, F; pH, TDS, EC; Na, F; Ca for factor 1, 2, 3, 4, and 5 respectively. The variance in factor 1 of pre-monsoon is as high as in post monsoon season, and for factors two to five the variance in post monsoon season was decreased compared to pre-monsoon season. All major high factor loadings explained in pre-monsoon and post-monsoon are having positive values except for Mg, TDS in factor 1; TH in factor 2; K, TDS in factor 3 and Na in factor 4 of pre-monsoon season (figure 2) and so4 in factor 1; TDS in factor 2 of the post-monsoon season is having a negative value (figure 3).

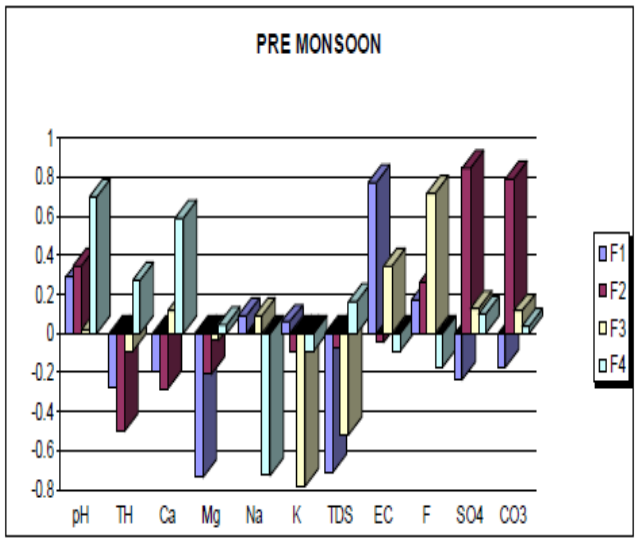

Figure 3. Factor Loadings in Pre Monsoon Season

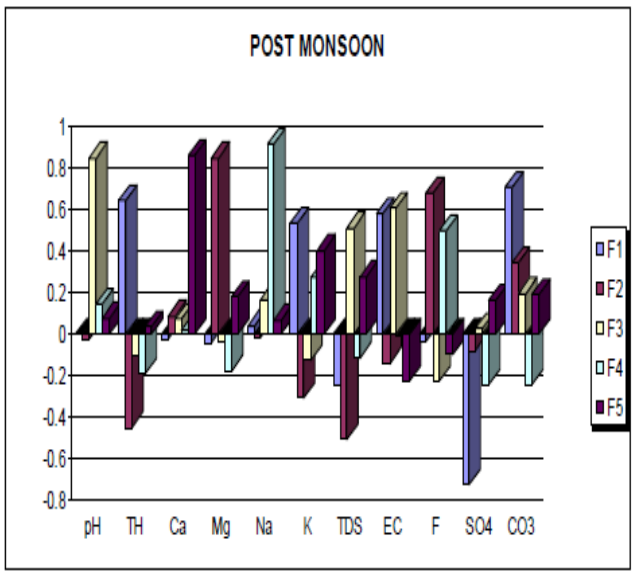

Figure 4. Factor Loadings in Pre Monsoon Season

Table 2: Basic Statistics of Groundwater in Pre-Monsoon Season (Expressed in mg/l, except for pH and EC (µS/cm))

Symbols	Parameters	Min	Max	Mean	Standard Deviation
pH	pH	7.6	8.4	8.085	0.229
EC	Electrical Conductivity	185	1789	580.192	390.467
TDS	Total Dissolved Solids	221	2200	797.346	545.594
TH	Total Hardness	124	900	419.192	212.139

Ca	Calcium	2	352	80.538	80.231
Mg	Magnesium	2	202	49.615	54.060
Na	Sodium	11	142	51.692	36.989
K	Potassium	1	114	27.731	37.735
SO_4	Sulphate	2	188	51.000	48.793
CO_3	Carbonate	0	88	6.885	17.310
F	Fluoride	0	1	0.500	0.510

Table 3: Basic statistics of Groundwater in Post-Monsoon Season (Expressed in mg/l, Except for pH and EC (µS/cm))

Symbols	Parameters	Min	Max	Mean	Standard Deviation
pH	pH	7.1	8.4	7.900	0.291
EC	Electrical Conductivity	123	1569	485.308	349.705
TDS	Total Dissolved Solids	100	2658	657.385	613.942
TH	Total Hardness	190	956	422.192	206.110
Ca	Calcium	2	210	60.731	47.581
Mg	Magnesium	5	262	70.885	61.258
Na	Sodium	11	265	74.231	63.451
K	Potassium	1	98	29.577	31.036
SO_4	Sulphate	2	236	60.962	65.254
CO_3	Carbonate	0	89	14.654	20.165
F	Fluoride	0	1	0.462	0.508

Table 4: Correlation Matrix Indicating Pre-Monsoon Season

Parameters	pH	EC	TDS	TH	Ca	Mg	Na	K	SO4	CO3	F
pH	1										
EC	0.386*	1									
TDS	0.281*	0.137	1								
TH	-0.038	0.39*	0.015	1							
Ca	0.107	-0.062	0.096	0.03	1						
Mg	-0.09	-0.227	-0.274	-0.289	0.143	1					
Na	0.185	0.106	0.064	-0.108	0.085	-0.111	1				
K	0.07	0.135	0.063	0.318*	0.08	-0.217	0.172	1			
SO4	0.028	-0.342	0.238*	-0.28	0.054	-0.012	-0.245	-0.223	1		
CO3	0.067	0.367*	-0.058	0.223*	0.066	0.241*	-0.12	0.315*	-0.35	1	
F	-0.135	-0.18	-0.496	-0.309	-0.054	0.418*	0.341*	-0.063	0.002	0.055	1

Table 5: Correlation Matrix indicating Post-Monsoon Season

Parameter	pH	EC	TDS	TH	Ca	Mg	Na	K	SO_4	CO_3	F
Ph	1										
EC	0.093	1									
TDS	-0.062	-0.401	1								
TH	-0.025	-0.106	0.178	1							
Ca	0.14	-0.082	0.274*	0.084	1						
Mg	0.078	0.386*	-0.36	-0.075	-0.071	1					

Na	-0.25	0.189	-0.092	-0.183	-0.231	0.204*	1				
K	-0.116	-0.158	-0.319	0.049	-0.017	0.112	-0.023	1			
SO_4	0.303*	-0.145	0.243*	-0.248	-0.066	-0.269	0.03	-0.129	1		
CO_3	0.082	-0.052	0.071	-0.18	-0.111	-0.235	-0.1	-0.197	0.63*	1	
F	-6.079	0.305*	0.221*	-0.27	-0.155	0.036	0.045	-0.284	0.219*	0.206*	1

Table 6: Rotation PCA Loading Matrix (Pre Monsoon Season)

Parameters	F1	F2	F3	F4
pH	0.286	0.348	0.018	**0.699**
TH	-0.277	**-0.498**	-0.093	0.269
Ca	-0.19	-0.281	0.119	**0.589**
Mg	**-0.736**	-0.212	-0.04	0.049
Na	0.09	-0.002	0.094	**-0.723**
K	0.059	-0.092	**-0.778**	-0.089
TDS	**-0.707**	-0.074	**-0.519**	0.16
EC	**0.772**	-0.049	0.347	-0.09
F	0.171	0.262	**0.716**	-0.173
SO_4	-0.237	**0.844**	0.127	0.103
CO_3	-0.175	**0.792**	0.114	0.035
Eigen values	1.96	1.913	1.571	1.516
% of variance	17.819	17.389	14.284	13.781
Cumulative %	17.819	35.208	49.492	63.273

Table 7: Rotation PCA loading matrix (post monsoon season)

Parameters	F1	F2	F3	F4	F5
pH	-0.001	-0.026	**0.851**	0.146	0.076
TH	**0.644**	-0.45	-0.105	-0.194	0.039
Ca	-0.022	0.086	0.074	0.019	**0.864**
Mg	-0.042	**0.851**	-0.039	-0.178	0.183
Na	0.04	-0.015	0.167	**0.919**	0.067
K	**0.537**	-0.308	-0.126	0.272	0.404
TDS	-0.24	**-0.51**	**0.515**	-0.113	0.277
EC	**0.585**	-0.14	**0.607**	-0.008	-0.229
F	-	**0.684**	-	**0.502**	-0.1
	0.037		0.225		
SO_4	**-0.726**	-0.078	0.026	-0.244	0.162
CO_3	0.707	0.345	0.197	-0.248	0.188
Eigen values	2.136	1.903	1.509	1.394	1.156
% of variance	19.417	17.304	13.72	12.676	10.507
Cumulative %	19.417	36.721	50.44	63.117	73.624

V. CONCLUSION

The Statistical analysis like correlation and factor analysis were applied successfully to the ground water sample data from dug wells during pre-monsoon and post monsoon seasons and the information regarding influence of environmental parameters towards the ground water quality contamination were assessed. Also helped to identify the natural groupings Interpretation of these analytical data showed the ground water quality variance. As a result, there is a total variance of about 63.273% during pre-monsoon season and about 73.624%

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