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A STATISTICAL APPROACH FOR DETERMINING GROUND WATER QUALITY IN DINDIGUL DISTRICT, TAMIL NADU

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Abstract

Water is the most important resource all over the world. These resources are in the form of Surface and groundwater. The surface water is very limited in most part of the areas, where groundwater play's a major role. This resource cannot be used effectively if the quality of the water is not good. This valuable resource is getting depleted both by human and anthropogenic activities. In order to access the groundwater quality, the study area chooses for this is Dindigul district of Tamil Nadu. This study is purely based on the secondary data for the year 2016.Statistical techniques such as cluster analysis, correlation and one way ANNOVA test were applied to findout the quality of groundwater in the study area. The chemical parameters such as EC, pH, TDS, Cl, Mg, Na, K, etc., are used to assess the quality of the groundwater in the study area.

Keywords:
Groundwater;
Cluster analysis;
Correlation;
ANNOVA;
pH.

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1. Introduction

Water is one of the most important natural resource of the earth. It occurs on the earth surface in the form of groundwater and surface water. Groundwater is an essential resource for human health, socio-economic development and functioning of ecosystems where groundwater is absent (Zektser, 2000; Humphreys, 2009; Steube et al., 2009). The demand for drinking and irrigation water and shortage of surface water brings much demand on groundwater. Due to the expansion of urban activities, industrial activities, use of high fertilizers in the agriculture field leads and other anthropogenic activities affects the quality of the water. Based on the physical, chemical and biological aspects the quality of water has been defined. It is very much important to know the quality of water before its use for various purposes such as drinking, agriculture, etc, (Nagarajan 2010; Bozdag and Gocmez 2013). The quality and quantity of groundwater should be assessed properly for their opimal use (Kharad et al., 1999). Any region of the world, a groundwater quality map is much needed to evaluate the safeness of water for drinking and irrigation purposes. Based on the common methods, it is difficult to assess the relationship, so some statistical techniques are required to validate between sample points. It is necessary to understand the hydrogeo chemical characteristics of groundwater to protect and utilize these resources effectively. To assess the groundwater in statistical manner, the study area taken for this is Dindigul district of Tamil Nadu. Dindigul district lies in between Tiruchirappalli and Madurai districts. The district lies between 10°05’ and 10° 09’ North Latitude and 77°30’ to 78°20’ East Longitude. Under the revenue administration, there are 4 Revenue Divisions, 8 taluks and 362 Revenue villages in the district (fig.1).

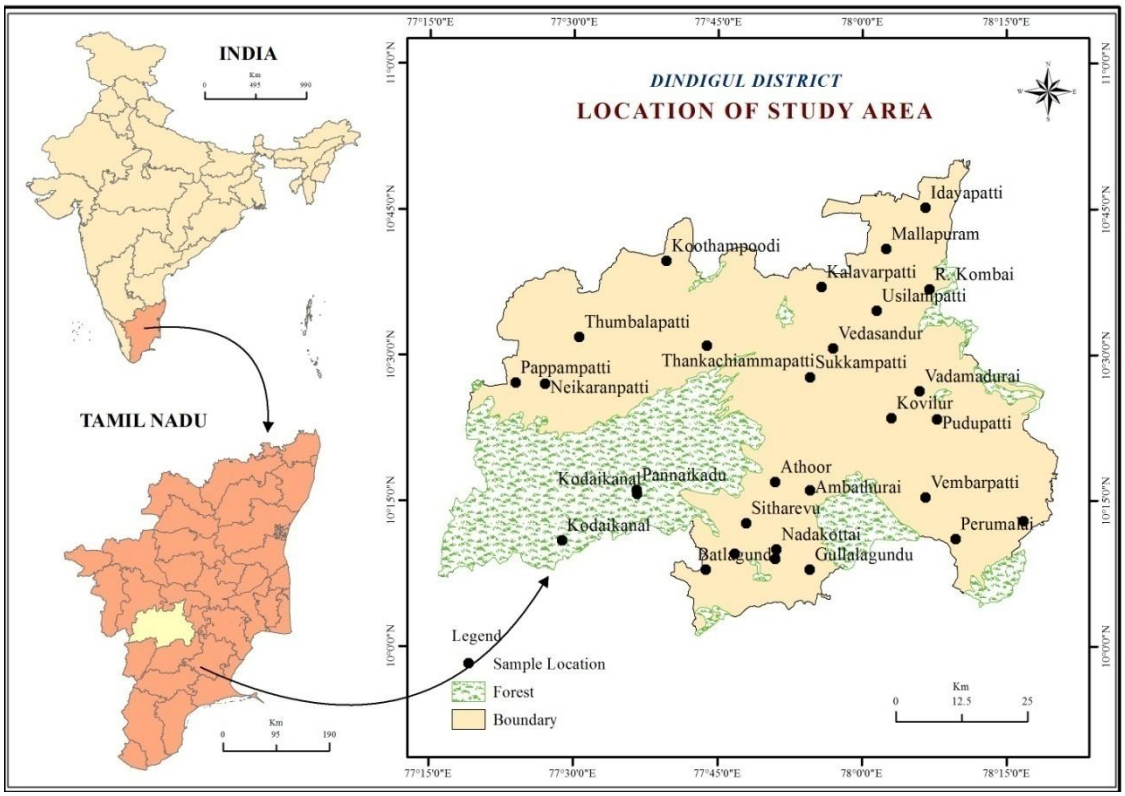


Figure 1. Location of Study area

2. Aim and Objective

The main aim of the study is to assess the groundwater quality for Dindigul district using statistical methods and it comprises of following objectives,

1. To study the hydrogeo chemical parameters using statistical techniques.

3. Research Method

To reach the goal of the study, the secondary data obtained from the state ground and surface water resources data centre, Tharamani, Chennai were used. The data are gathered for pre monsoon (July) and post monsoon (January) season to identify the seasonal behavior of chemical parameters in the groundwater. The samples were taken both monsoon and premonsoon season in the same well (Table 1). A set of 30 wells were identified as a common well and are spatially located using GIS software. To validate the chemical parameters between post and pre monsoon season, statistical techniques such as, Pearson's Correlation, Cluster analysis (CA) and one-way ANOVA test were used to identify the similarities between chemical parameters and their location samples. The formula for Pearson's Correlation was easily identified in so many

literatures. Cluster Analysis (CA) were performed using Statistical Packages for Social Science (SPSS) 14. A One-way analysis of variance (ANOVA) test and Pearson's Correlation was worked out using EXCEL software at 5% level of significance to test the significance level of seasonal chemical change of the parameters.

Table1. Descriptive statistics of chemical parameters in Dindigul district

Monsoon	**Parameters**	**Total Samples**	**Minimum**	**Maximum**	**Mean**	**SD**	**Skewness**	**Kurtosis**
Post	**TDS**	**29**	130	1551	770.59	425.82	0.24	1.92
Pre		**29**	151	1396	684.90	394.50	0.49	2.02
Post	**Ca^{2+}**	**29**	14	152	52.07	37.95	1.42	3.92
Pre		**29**	16	88	43.72	20.89	0.41	2.06
Post	**Mg^{2+}**	**29**	6.08	116.64	52.71	27.94	0.19	2.43
Pre		**29**	8.51	153.09	54.47	35.11	0.83	3.47
Post	**Na^{+}**	**29**	10	359	143.62	101.12	0.58	2.31
Pre		**29**	8	290	120.34	81.39	0.54	2.13
Post	**K^{+}**	**29**	2	94	13.52	18.73	3.18	13.39
Pre		**29**	1	43	12.45	10.30	1.32	3.91
Post	**Cl^{-}**	**29**	4	716	210.90	177.56	1.07	3.74
Pre		**29**	4	560	187.86	151.05	0.91	3.09
Post	**$SO4^{2-}$**	**29**	4	350	86.62	66.47	2.07	9.51
Pre		**29**	12	201	75.66	56.29	0.66	2.13
Post	**HCO3**	**29**	74.25	536.8	264.74	121.88	0.58	2.70
Pre		**29**	54.44	524.60	249.47	116.14	0.34	2.73
Post	**F^{-}**	**29**	0.09	1.78	0.70	0.46	0.50	2.34
Pre		**29**	0.05	1.43	0.64	0.36	-0.21	2.37

Post	**pH**	**29**	7.9	8.6	8.18	0.14	0.89	5.46
Pre		**29**	7.9	8.6	8.12	0.14	1.22	6.24
Post	**EC**	**29**	250	2760	1323.10	712.91	0.23	1.97
Pre		**29**	240	2550	1196.21	682.51	0.51	2.19
Post	**Total**	**29**	100	670	347.07	171.69	0.28	1.98
Pre	**Hardness**	**29**	80	750	333.45	178.82	0.50	2.45

4. Results and Analysis

There is a strong positive correlation between TDS, Na+, Cl- and EC in both the seasons and Hardness has positive relation with TDS during Pre monsoon season. The Ca2+ with fluoride and pH of water showed strong negative correlation (r=0.04, 0.3, respectively) in post monsoon but there is positive relation with all parameters during pre monsoon season. A strong positive correlation is found between Na+ with Cl- and EC in both the monsoon period (Table 2 and 3). The geochemical and biochemical process contributing to the water chemistry leads to positive correlations among the chemical variables (Subba Rao et al. 2012). The Mg2+ has fairly strong positive correlation with Ec and Hardness in both monsoon seasons. A strong negative correlation exists between K+ and f (r=0.3, 0.2, for post and pre monsoon season respectively). EC has strong positive relation with Cl- in both monsoon periods and hardness with pre monsoon season. SO42- in the groundwater has strong negative correlation with pH in post monsoon but it has positive relation with all parameters in pre monsoon season. There is a strong positive correlation exhibit between EC and Hardness in both the monsoon periods. The correlation matrix between various cations and anions for two seasons bears statistically significant correlation with each parameter associated with it.

Table 2. Correlation matrix for post monsoon season – Dindigul District - 2016

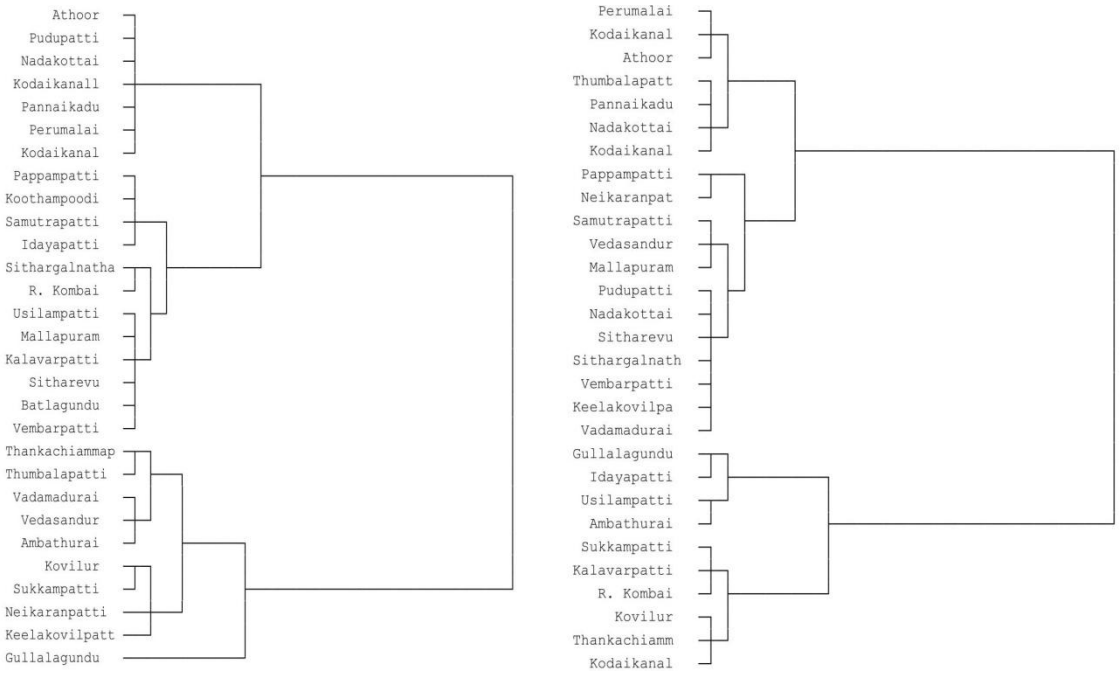
Parameters	*TDS*	*Ca^{2+}*	*Mg^{2+}*	*Na^{+}*	*K^{+}*	*Cl^{-}*	*$SO4^{2-}$*	*HCO3*	*F^{-}*	*pH*	*EC*	*HAR*
TDS	1											
Ca^{2+}	0.603	1										
Mg^{2+}	0.806	0.332	1									
Na^{+}	0.940	0.370	0.703	1								

K^+	0.436	0.113	0.166	0.439	1							
Cl^-	0.908	0.389	0.764	0.945	0.29	1						
$SO4^{2-}$	0.666	0.648	0.623	0.478	0.15	0.469	1					
HCO3	0.704	0.627	0.582	0.568	0.34	0.458	0.42	1				
F^-	0.071	-0.049	0.192	0.114	-0.38	0.087	0.18	0.12	1			
pH	0.228	-0.308	0.256	0.290	0.571	0.146	-0.03	0.16	0.06	1		
EC	0.996	0.592	0.832	0.940	0.386	0.926	0.65	0.70	0.10	0.203	1	
HAR	0.873	0.775	0.853	0.675	0.174	0.727	0.77	0.73	0.10	0.001	0.884	1

Table 3. Correlation matrix for pre monsoon season – Dindigul District- 2016

Parameters	*TDS*	*Ca^{2+}*	*Mg^{2+}*	*Na^+*	*K^+*	*Cl^-*	*$SO4^{2-}$*	*HCO3*	*F^-*	*pH*	*EC*	*HAR*
TDS	1											
Ca^{2+}	0.754	1										
Mg^{2+}	0.891	0.555	1									
Na^+	0.963	0.643	0.790	1								
K^+	0.651	0.561	0.372	0.687	1							
Cl^-	0.946	0.705	0.888	0.900	0.564	1						
$SO4^{2-}$	0.787	0.727	0.692	0.708	0.440	0.689	1					
HCO3	0.846	0.473	0.813	0.856	0.516	0.718	0.573	1				
F	0.301	0.136	0.520	0.202	-0.20	0.276	0.490	0.36	1			
pH	0.263	0.230	0.198	0.267	0.187	0.213	0.009	0.27	-0.02	1		
EC	0.997	0.724	0.917	0.958	0.622	0.954	0.774	0.86	0.33	0.25	1	
HAR	0.940	0.741	0.970	0.826	0.464	0.923	0.772	0.79	0.46	0.22	0.952	1

Cluster analysis was performed to identify the similarity groups between the sampling sites. The water quality assessment used factor analysis for data reduction and decision (Helena et al 2000). Cluster analysis (CA) provides meaning full aggregations of samples based on a large number of inter-dependent variables (Hulya Boyacioglu, 2008). The large numbers of items are divided into smaller number of homogenous groups based on the correlation structure in CA. Subjective to



criteria group similarity is mazimized or minimized (Rasmussen 2005). The graphical representation of dendrogram (fig.2) indicates that there are three clusters in post and pre monsoon season respectively but the similarity in the sampling locations are varied in nature.

Figure 2. Dendrogram for post monsoon (A) and pre monsoon (B) season

The monsoonal variation of groundwater chemical parameters in Dindigul district was analyzed using one-way variance analysis (one-way ANOVA). In post monsoon season, the concentration of chemical parameters seems to be little higher than the values obtained in the pre monsoon season. The results indicate that at 5% significant level there is no significant change of the hydro-chemical parameters of groundwater in Dindigul district from post monsoon to pre monsoon season. The slight variation in the chemical parameters due to suspension and high evapo-transpiration related to corresponding geology of the area.

Table. 4 Results of One way ANOVA test.

Parameters	**Mean Post Monsoon**	**Mean Pre Monsoon**	***F- Values***	***P-value***
TDS	770.586	684.897	3.59	1
Ca^{2+}	52.069	43.724	1.075	0.304
Mg^{2+}	52.706	54.466	0.044	0.833
Na^{+}	143.621	120.345	0.932	0.338
K^{+}	13.517	12.448	0.072	0.789
Cl^{-}	210.897	187.862	0.283	0.597
SO_4^{2-}	86.621	75.655	0.459	0.501
HCO3	264.738	249.473	0.238	0.627
F^{-}	0.703	0.642	0.327	0.570
pH	8.179	8.124	2.375	0.129
EC	1323.103	1196.207	0.479	0.492
Total Hardness	347.069	333.448	0.087	0.768

5% significance level

5. Conclusion

The groundwater qualities of the study area are highly influenced by local rocks and anthropogenic activities. A multivariate statistical technique was applied to understand the characteristics of the groundwater. Correlation technique resulted that there is a strong positive correlation between TDS, Na+, Cl- and EC in both the seasons. Cluster analysis indicates that even though there is a similar cluster in post and pre monsoon season but the villages are varied in nature may be due to geological settings and variation of rainfall. One way ANOVA test shows there is a no significant change in chemical parameters both in post and pre monsoon season.

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