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A Correlation and Regression Study for Ground Water Samples in and Around Dyeing Industry

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Abstract : Ground water samples were collected from ten locations in and around dyeing industries of Ayyampettai village of Kanchipuram Town in the month of December 2014.Water quality assessment was carried out for the physical, chemical and biological parameters such as color, odour, turbidity, Total dissolved solids(TDS), Electrical Conductivity(EC), p^H, Phenolphthalein Alkalinity, Total Alkalinity, Total Hardness, Calcium, Magnesium, Sodium, Potassium, Iron, Manganese, Free Ammonia, Nitrite, Nitrate, Chloride, Fluoride, Sulphate, Phosphate, Tidy's test Chemical Oxygen Demand(COD), Biological Oxygen Demand(BOD),and Faecal Coliform. Highly correlated and interrelated water quality parameters were determined by correlation co efficient method and related by Regression equations. Comparison of observed and estimated values of various water quality parameters exhibits that the regression equations developed in the study can be very much used for monitoring the water quality parameters by knowing the above said parameters alone. This study gives the easiest and rapid method of monitoring the quality of any system of water bodies.

Keywords: Assessment. Water quality, standards, Correlation and Regression analysis.

Introduction and Experimental

The significance of groundwater for the existence of human society cannot be ignored. Groundwater is the major source of drinking water in both urban and rural India (3,4). Apart from that it is the main source of water for the agricultural field and the industrial sectors. Being an important and integral part of the hydrological cycle, its availability depends on the rainfall and recharge conditions and it has been considered the only dependable source of unpolluted water (9,8). The demand for water has getting high over the years and this led to scarcity of water in many parts of the world. The situation is increased by the problem of water contamination. India is heading towards a freshwater crisis mainly due to improper management of water resources and environmental degradation, which has led to a lack of access to safe water supply to millions of people (10). Many parts of India are already undergoing this fresh water crisis. Though degree of suffering depending mainly on the season of the year (11). The quality of groundwater is getting severely affected because of the widespread pollution of surface water. Besides, discharge of untreated waste water through bores and leachate from unscientific disposal of solid wastes also contaminates groundwater, thereby reducing the quality of ground water (15). Drinking contaminated water from water wells can cause serious health problems, so everyone should be aware how easily groundwater can become contaminated (14). One source of contamination is from chemicals such as pesticides, dyes and fertilizers that can be carried in rainwater runoff and then mix with the groundwater (13). Once pollutants make their way down into the aquifers that store groundwater, it is very hard to remove them. From the aquifers, contamination could then be pumped from a

well and directly introduced into drinking water. The ground water quality is characterized by conducting various physico –chemical and biological analysis (16). Monitoring of water quality levels are much more important to assess the levels of pollution and to find out the potential risk to the eco system (1,2). (Joarder .M.A.M)

Study area

Kanchipuram town is located at a distance of 76Km from Chennai on the northern bank of the river Vegavathi, a tributary of the river Palar in TamilNadu, India. It is situated at 12°50' north latitude and 79°42' east longitude, (Fig.1) Kanchipuram District is made up of hard rocks and sedimentary formations overlaid by alluvium and laterite. The average rainfall of the district is 1212mm and occurs mostly due to the north – east monsoon and also not having any perennial rivers.

In Kanchipuram town, dyeing and printing of textile are considered as the traditional industries, so that a large number of textile industries along with dyeing and printing clusters have been increased in the area. The dyeing units in Kanchipuram municipality and the surrounding villages are under constant threat of ground water contamination with chemicals of dyes. The present study evaluates the groundwater quality in and around Ayyampettai, Kancheepuram town of Tamil Nadu with reference to drinking purposes by Correlation and Regression analysis. Access to safe drinking water supply is one of the basic needs of society and hence a comprehensive plan of action is sought to curb groundwater contamination in the studied region.

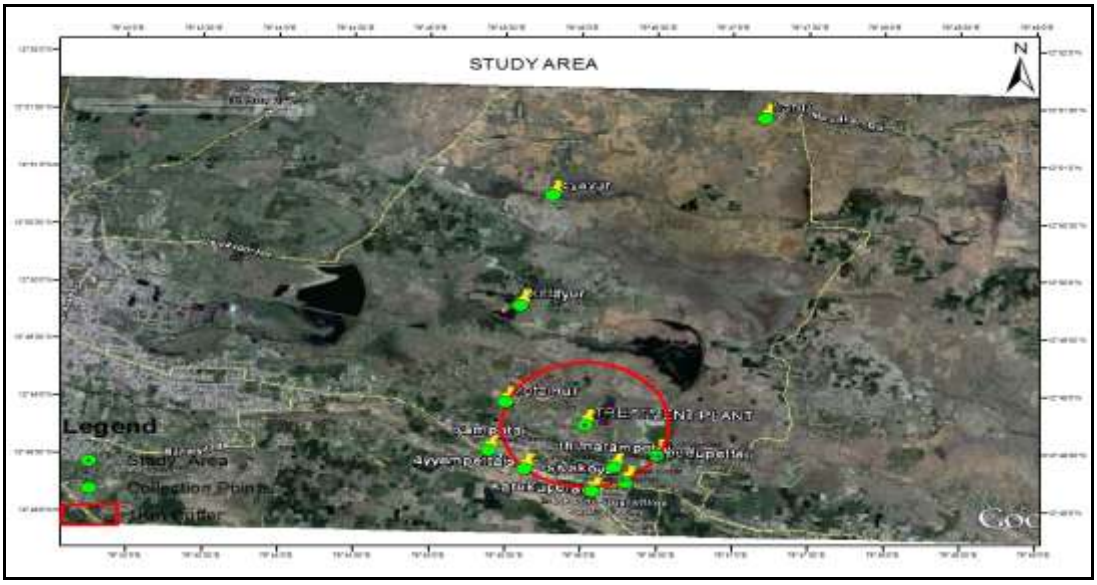

Figure 1. Location of the groundwater samples collected

Table 1. Groundwater Sample Sites

Sample	Source	Location
A	BW	Kaliyanur
B	BW	Olaiyur
C	BW	Karur
D	BW	Kuttamur
E	BW	Siva Temple (Ayyampettai)
F	BW	Thimmaiyan Pettai
G	TAP WATER	Rani Amman temple
H	BW	Kurrukkupattai
I	TAP WATER	Pudupettai
J	BW	Satya nagar, Ayyampettai

Figure 2. Location of sample A

Figure 3. Location of sample D

Ten representative groundwater samples were collected in the dyeing industrial areas of Ayyampettai village of Kancheepuram town during December 2014 and carried in pre-cleaned polyethylene bottles; after collection the samples kept in air tight boxes and analyzed within six hours of collection. . The locations of the groundwater sample sites were listed in table 1 and fig 2.

The samples were analyzed for the parameters turbidity, electrical conductivity (EC @ 25°C), total dissolved solids (TDS), pH , alkalinity, sulphate (SO_4), chloride (Cl), nitrate (NO_3), total hardness (TH), calcium (Ca), iron (Fe), magnesium (Mg), sodium (Na), faecal coliform bacteria count (F.Coli.), biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) by standard analytic methods for the examination of water and waste water APHA 1995, American Health Association. All the groundwater samples were found to be colorless and odourless. The temperature of the groundwater samples was found about 30°C.

In this present study the water quality parameters such as turbidity, electrical conductivity (EC @ 25°C), total dissolved solids (TDS), pH , alkalinity, sulphate (SO_4), chloride (Cl), nitrate (NO_3), total hardness (TH), calcium (Ca), iron (Fe), magnesium (Mg), sodium (Na), faecal coliform bacteria count (F.Coli.), biochemical oxygen demand (BOD_5) and chemical oxygen demand (COD) were considered and the correlation coefficients among all the water quality parameters were calculated. The linear regression equation was formed for the pairs which are having strong correlation and also for the parameters which are influenced by others. The correlation analysis on ground water quality parameters shows that all the parameters were correlated with others either with high or low values. The characteristics were worked out using the regression equations and then compared with observed values.

Table 2. Water Quality Parameters from Ten sampling points

W/P	EC µmhos/cm	P^H	TAL mg/l	TH mg/l	Ca^{2+} mg/l	Mg^{2+} mg/l	Fe^{2+} mg/l	NH_3 mg/l	NO_2^- mg/l	NO_3^- mg/l	Cl_2 mg/l	Fl mg/l	SO_4^{2-} mg/l	PO_4^{3-} mg/l	Tidys Test	FC	COD mg/l	BOD mg/l
A	2800	7.71	472	280	64	29	0	0	0	30	480	1	200	0	0.6	60	37.1	12.4
B	4100	7.3	736	528	116	57	2.08	0	0	40	600	1.6	550	0	0.7	0	45.8	15.2
C	1159	7.68	336	124	28	13	0.26	2	0.4	10	106	0.6	130	0.4	0.7	80	29.2	6.9
D	2700	7.63	440	272	60	29	0	0	0	28	464	0.4	180	0.4	0.6	40	56.4	17.4
E	2000	7.02	352	240	52	26	0.65	0.5	0	20	236	0.2	220	2.4	0.7	60	62.8	20.9
F	4600	7.01	720	384	84	42	2.34	0.1	0	42	744	0.8	300	0	0.7	0	9.3	3.1
G	2200	8.14	328	296	64	33	0	0	0	20	300	0.2	225	2.8	0.7	60	30.5	7.4
H	2500	7.34	408	424	92	47	0.26	0	0	20	368	0.6	250	0	0.6	0	46.4	15.5
I	4100	7.36	416	736	160	81	0	0.3	0	40	800	0.6	350	0.4	0.7	0	35.5	12.3
J	2800	7.11	424	448	99	48	2.08	0	0	24	388	0	300	2	0.8	80	27.8	9.3

The correlation coefficient referred to as the Pearson R test, is a statistical equation that measures the strength between variables and relationships (5,7). To determine how strong the relationship is between two variables, you need to find the coefficient value, which can range between -1.00 and 1.00.

Regression and correlation analysis:

Regression analysis shows that the relationship between a dependent and many independent variables(6, 12). A model of this relationship is hypothesized, and the parameter values have been estimated and are used to form an regression equation - 1.

Regression equation

$y = a x + b$ ---------- (1)

The study of correlation between various water quality parameters, the regression analysis was carried out using software SPSS 18.

Table 3. Correlation matrices for water quality parameters

W/P	TDS	EC	PH	TA	TH	Ca2+	Mg2+	Fe2+	NH3	NO2-	NO3-	Cl2	Fl	SO42_	PO43	DO	FC	COD	BOD
TDS	1																		
EC	**0.99**	1																	
PH	-0.47	-0.44	1																
TA	**0.82**	**0.81**	-0.44	1															
TH	**0.68**	**0.75**	-0.34	0.35	1														
Ca2+	0.68	**0.76**	-0.34	0.36	**1**	**1**													
Mg2+	0.67	**0.74**	-0.33	0.34	**1**	**1**	1												
Fe2+	0.56	0.54	-0.67	**0.74**	0.24	**0.24**	0.23	1											
NH3	-0.6	-0.56	0.12	-0.36	-0.47	**-0.47**	-0.46	*-0.2*	1										
NO2	-0.6	-0.57	0.24	-0.3	-0.51	**-0.51**	-0.51	-0.18	**0.96**	1									
NO3-	**0.96**	**0.98**	-0.37	**0.8**	0.7	**0.71**	0.69	0.44	-0.56	-0.58	1								
Cl2	**0.95**	**0.96**	-0.33	0.67	**0.78**	**0.79**	**0.78**	0.33	-0.54	-0.55	**0.97**	1							
Fl	0.45	0.5	-0.05	**0.74**	0.25	**0.26**	0.24	0.25	-0.07	0	0.55	0.44	1						
SO42_	0.66	**0.74**	-0.39	**0.72**	**0.74**	**0.74**	**0.73**	0.61	-0.42	-0.42	0.71	0.61	0.61	1					
PO43	-0.44	-0.43	0.14	-0.55	-0.22	**-0.23**	-0.21	-0.06	-0.05	-0.14	-0.44	-0.48	-0.73	-0.21	1				
DO	0.05	0.1	-0.35	0.04	0.22	**0.22**	0.22	0.6	0.16	0.11	0.01	-0.02	-0.3	0.32	0.52	1			
FC	-0.75	-0.77	0.33	-0.62	-0.67	**-0.67**	-0.68	-0.21	0.41	0.43	-0.72	-0.76	-0.56	-0.62	0.58	0.29	1		
COD	-0.37	-0.34	-0.01	-0.31	-0.11	**-0.12**	-0.11	-0.41	-0.1	-0.2	-0.23	-0.3	-0.04	-0.04	0.13	-0.41	0.04	1	
BOD	-0.2	-0.17	-0.18	-0.19	0.04	**0.04**	0.04	-0.31	-0.22	-0.33	-0.08	-0.14	0.02	0.08	0.06	-0.39	-0.08	**0.97**	1

Table 4. Least square of the relation (y=ax+b) among significantly correlated parameters.

(Dependent)	X(Independent)	Correlation	a	b	Y=aX+b	R^2
EC	TDS	0.987	2.417	-258.982	EC=2.417TDS-258.982	0.974
EC	TH	0.754	4.65	1160.544	EC=4.65TH+1160.544	0.563
EC	Cl^-	0.964	4.723	777.251	EC=4.723Cl^-+777.251	0.929
EC	SO_4^{2-}	0.736	6.713	1079.976	EC=6.713SO_4^{2-}+1079.976	0.542
EC	Mg^{2+}	0.744	41.598	1211.999	EC=41.598Mg^{2+}+1211.999	0.553
EC	NO_3^-	0.977	98.498	197.054	EC=98.498NO4+197.054	0.955
TDS	TH	0.679	1.719	663.752	TDS=1.719TH+663.752	0.461
TDS	Cl^-	0.947	1.895	455.36	TDS=1.895Cl^-+455.36	0.896
TDS	SO_4^{2-}	0.655	2.438	645.771	TDS=2.438SO_4^{2-}+645.771	0.429
TDS	Ca^{2+}	0.684	7.998	650.256	TDS=7.998Ca^{2+}+650.256	0.463
TDS	Mg^{2+}	0.673	15.36	683.234	TDS=15.36Mg^{2+}+683.234	0.452
TH	SO_4^{2-}	0.737	1.084	79.923	TH=1.084SO_4^{2-}+79.923	0.543
TH	Ca^{2+}	1.000	4.619	-5.083	TH=4.619 Ca^{2+}-5.083	0.999
TH	Mg^{2+}	0.999	9.015	8.093	TH=9.015Mg^{2+}+8.093	0.999
Ca^{2+}	Mg^{2+}	0.998	1.948	2.992	Ca^{2+}=1.948Mg^{2+}+2.992	0.996
Ca^{2+}	SO_4^{2-}	0.740	0.236	18.176	Ca^{2+}=0.236SO_4^{2-}+18.176	0.548
Mg^{2+}	SO_4^{2-}	0.729	0.119	8.35	Mg^{2+}=0.119SO_4^{2-}+8.35	0.531
Mg^{2+}	Cl^-	0.777	0.068	9.938	Mg^{2+}=0.068Cl-+9.938	0.64
NH_3	NO_2^-	0.962	4.75	0.100	NH4=4.75NO3- +0.100	0.926
Cl	NO_3^-	0.965	19.85	-95.292	Cl=19.85NO4+-95.292	0.932

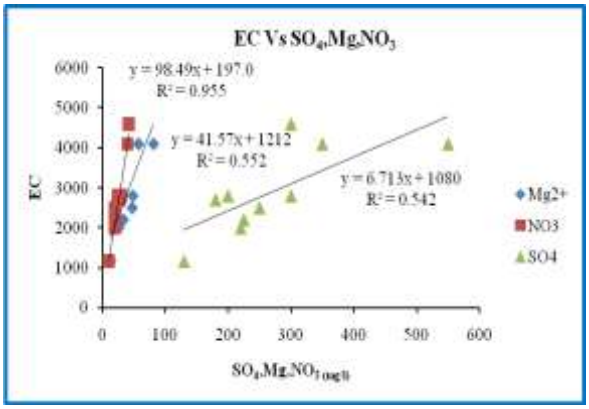

Figure : 4 EC Vs SO_4, Mg, NO_3

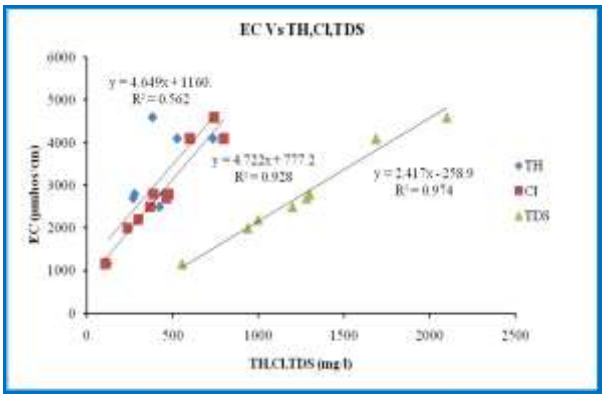

Figure : 5 EC Vs TH, Cl, TDS

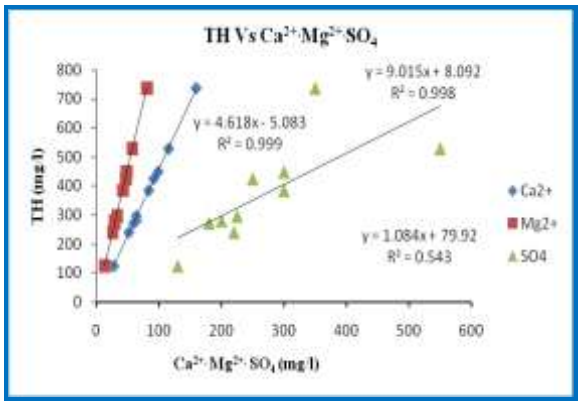

Figure : 6 TH Vs Ca, Mg, SO_4,

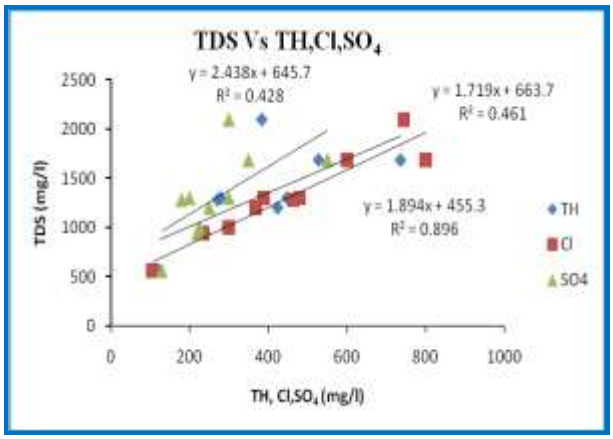

Figure : 7 TDS Vs TH, Cl, SO_4

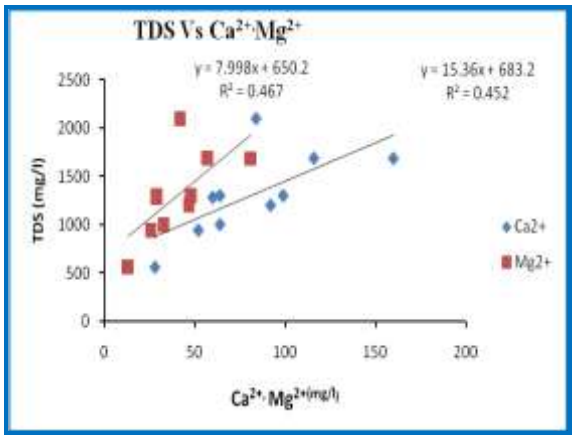

Figure : 8 TDS Vs Ca, Mg

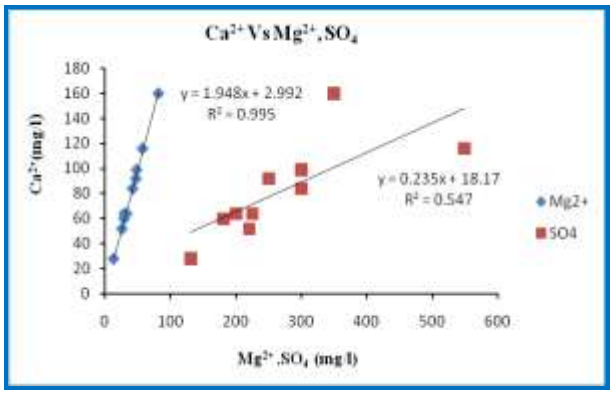

Figure : 9 Ca Vs Mg, SO_4

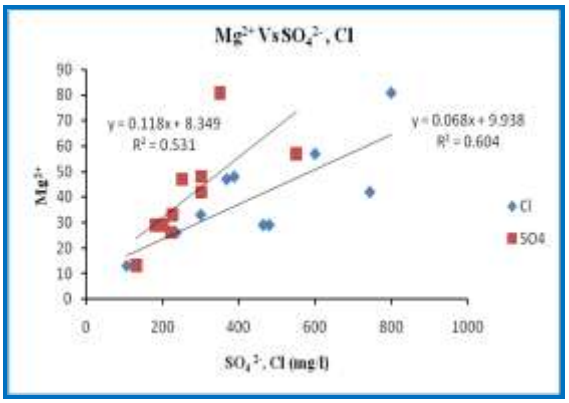

Figure : 10 Mg Vs SO_4 , Cl

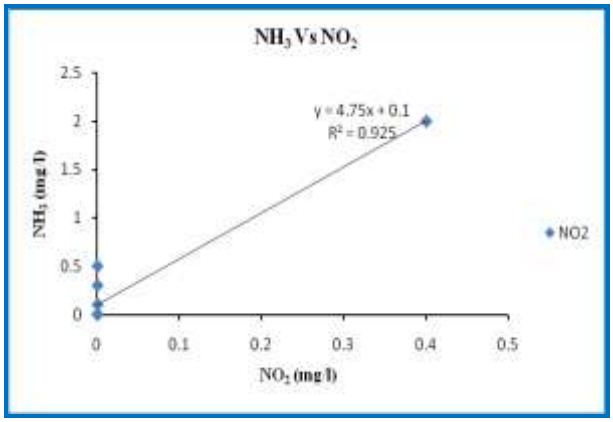

Figure : 11 NH_3 Vs NO_2

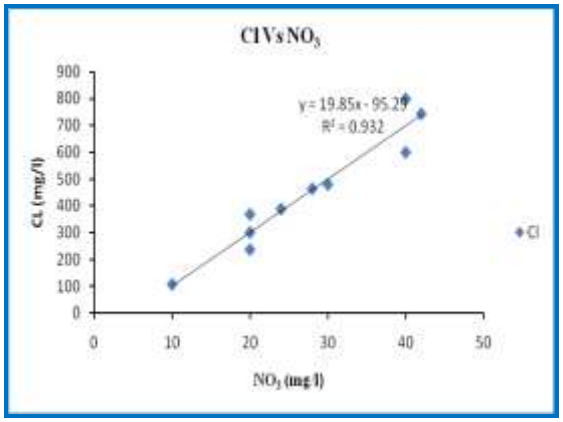

Figure : 12 Mg Vs SO_4, Cl

Results and Discussion

Water Quality analysis carried on ground water collected from 10 locations of the study area divulge that there were some locations in the water quality parameters for the water quality standards. The relationship between two variables is the correlation co-efficient which proclaims the speculation of one variable on other. Associated with correlation co-efficient is r, which is the percentage of variance in the dependent variable, explained by the independent variable. The outcome of the correlation analysis is considered in the subsequent interpretation. A high correlation co-efficient (nearly 1 or -1) means a fine relationship between the variables and a correlation co-efficient around zero means no relationship. Positive and negative values of r clearly conclude the positive and an inverse relationship respectively. The correlation co-efficient (r) among various water quality parameters of the ground water of the study area are given in Table 3 respectively.

The results of the statistical analysis which are shown in Table 3 gives an indication that TDS has a positive and significance correlation with EC, TA, TH, Ca^{2+}, Mg^{2+}, NO_3^-, Cl_2, and SO_4^{2-}, weak correlation with Fe^{2+}, Fl and very worse correlation with DO, and negative correlation with pH, NH_3, NO_2^-, PO_4^{3-}, Fcoli, COD and BOD. EC has a positive and significance correlation with TA, TH, Ca^{2+}, Mg^{2+}, NO_3^-, Cl_2, and SO42-, weak correlation with Fe^{2+},Fl and very worse correlation with DO, and negative correlation with pH, NH_3, NO_2^-, PO_4^{3-}, Fcoli, COD and BOD. pH has a positive correlation with NH_3, NO_2^-, PO_4^{3-},FColi and negative correlation with TA, TH, Ca^{2+}, Mg^{2+}, Fe^{2+}, NO_3^-, Cl_2, Fl, SO_4^{2-}, DO, COD and BOD. TA has a positive and significance correlation with Fe^{2+}, NO_3^-, Cl_2, Fl, SO_4^{2-} weak correlation with TH, Ca^{2+}, Mg^{2+}, and very worse correlation with DO and negative correlation with NH_3, NO_2^-, PO_4^{3-}, Fcoli, COD and BOD. TH has a positive and significance correlation with Ca^{2+}, Mg^{2+}, Cl_2, NO_3^-, SO_4^{2-} and weak correlation with Fe^{2+}, Fl , DO and very worse correlation with BOD, and negative correlation with NH_3, NO_2^-, PO_4^{3-}, Fcoli and COD. Ca^{2+} has a positive and significance correlation with Mg^{2+}, Cl_2, $NO_3^-$and SO_4^{2-} and weak correlation with Fe^{2+}, Fl , DO and very worse correlation with BOD and negative correlation with NH_3, NO_2^-, PO_4^{3-}, Fcoli and COD. Mg^{2+} has a positive and significance correlation with NO_3^-,Cl_2, and SO_4^{2-} and weak correlation with Fe^{2+}, Fl , DO and very worse correlation with BOD and negative correlation with NH_3, NO_2^-, PO_4^{3-}, Fcoli and COD. Fe^{2+} has a positive correlation with SO_4^{2-} and DO and weak correlation with NO_3^-, Cl_2, Fl and negative correlation with NH_3, NO_2^-, PO_4^{3-}, Fcoli ,COD and BOD. NH_3, has a positive and significance correlation with NO_2^- and weak correlation with DO and Fcoli and negative correlation with NO_3^-, Cl_2, Fl, SO_4^2, PO_4^{3-}, COD and BOD. NO_2^- has a weak correlation with DO and Fcoli and negative correlation with NO_3^-, Cl_2, Fl, SO_4^2, PO_4^{3-}, COD and BOD.

NO_3^- has a positive and significance correlation with Cl_2 and SO_4^{2-} and weak correlation with Fl and very worse correlation with DO and negative correlation with PO_4^{3-}, Fcoli, COD and BOD. Cl_2 has a positive correlation with Fl, SO_4^{2-}, and negative correlation with PO_4^{3-}, Fcoli, DO, COD and BOD. Fl has a positive correlation with SO_4^{2-} and very worse correlation with BOD and negative correlation with PO_4^{3-}, Fcoli, DO and COD. SO_4^{2-} has a weak correlation with DO and very worse correlation with BOD and negative correlation with PO_4^{3-}, Fcoli, and COD. PO_4^{3-} has a positive correlation with Fcoli, DO and COD and very worse correlation with BOD. DO have a weak correlation with Fcoli and negative correlation with COD and BOD. Faecal Coliform has a very worse correlation with COD and negative correlation with BOD. COD has a positive and significance correlation with BOD.

Conclusion

The results find out from correlation analysis shows that TDS and EC are having significance correlation with most of the parameters. Since, the EC finds high correlation with the TDS, TH, chlorides and sulphate, magnesium and nitrate. Regression equations relating the EC and these parameters were formulated and are given in Table 4 and Fig 4 to 9. Since the TDS find high correlation with the TH, chlorides, sulphates, calcium and magnesium. Regression equations relating these parameters were formulated. Likely the regression equation between TH and calcium, Magnesium and sulphate. On the basis of the findings of present study, it is recommended that ground water in the study area should be treated before it is used for drinking purpose.

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