INTERPRETATION OF GROUND WATER PARAMETERS FOR SOME VILLAGES OF VILLUPURAM DISTRICT, TAMILNADU USING CORRELATION AND REGRESSION ANALYSIS

V. C. Ananthimalini[1], M. M. Senthamilselvi[2] and S. Manikandan*[3]

[1]Department of Chemistry, Siga College of Management and Computerscience, Affiliated to Tiruvalluvar University, Villupuram, Tamil Nadu, India.
[2]Regional Joint Director, Directorate of Collegiafe Education Tiruchirappalli Region, Tiruchirappalli, Tamil Nadu, India.
[3]Department of Chemistry, Surya College of Engineering and Technology, Affiliated to Anna University, Villupuram, Tamil Nadu, India.

*Corresponding Author: S. Manikandan

Department of Chemistry, Surya College of Engineering and Technology, Affiliated to Anna University, Villupuram, Tamil Nadu, India.

ABSTRACT
In the present study, a correlation and statistical analysis for Twenty data points of drinking water at some areas of Villupuram district has been done and the results were discussed here. Correlation coefficients were determined to identify the highly correlated and interrelated water quality parameters (WQPs). Regression equations relating these identified and correlated parameters were formulated for highly correlated WQPs. Comparison of observed and estimated values of the different WQPs reveal that the regression equations developed in the study can be very well used for making water quality monitoring by observing the above said parameters alone. This provides an easy and rapid method of monitoring of water quality of the water system studied.

KEYWORDS: Correlation and regression, Ground water, Statistical analysis, villupuram district.

1. INTRODUCTION
Water is our most valuable natural resource. This fact though recognized by man has not stopped him from polluting the rivers, lakes and oceans. The cause of water pollution could be municipal, agricultural and industrial. All these major causes have rampantly deteriorated the quality of water the world over. This has resulted in the decrease in the quality of drinking water available, and has also caused the decline of resources from our marine sources as the runoff water from the land is ultimately destined for the seas.[1]

Identified that the Electrical conductivity(EC) finds higher level correlation on significance with many of the water quality parameters, like total dissolved solids, chlorides, total alkalinity, sulphates, carbonates , total hardness and magnesium. S.Mahajan et al. identified that all the parameters are more or less correlated with others in the correlation and regression study of the physico - chemical parameters of ground water.[2]

S.B.Kalyanaraman et al. identified that the water quality of ground water can be predicted with sufficient accuracy just by the measurement of EC alone. This provides a mean for easier and faster monitoring of water quality in a location.[3] G.Achuthan Nair et al. concluded that the correlation study and correlation coefficient values can help in selecting treatments to minimize contaminates in ground water.[4]

Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables.[5] Once a linear relationship has been shown to have a high probability by the value of the correlation co-efficient then the best straight line through the data points has to be estimated. A systematic study of correlation and regression coefficients of the water quality parameters helps to quantify relative concentration of various pollutants in water and provide necessary cue for implementation of rapid water quality management programmes.[6]

The quality of the groundwater varies from place to place with the depth of water. The classification, modeling and interpretations of monitoring data are the most important steps in the assessment of water quality. To define the resource water quality many researchers treated water quality parameters individually by describing the seasonal variability and their causes. It is a very difficult and laborious task to regularly monitor all the parameters

even if adequate manpower and laboratory facilities are available. For this reason, in recent years an easier and simpler approach based on statistical correlation, has been developed using mathematical relationship for comparison of physicochemical parameters.[7],[8]

A few number of studies are available regarding the analysis of groundwater quality data using regression techniques in different parts of India and Bangladesh.[9]

The correlation coefficient is a helpful tool for the promotion of research in water pollution problems. Groundwater quality is analyzed for its physical,

chemical and biological parameters which are closely interlinked

2. Description of the study area
Study Area
The study area lies between Latitude N $11^0 56^'$ and Longitude E $79°29^1$ and is located in Northeast of Tamil Nadu in India, which is in the far southeast part of India , situated 160 km south of Chennai, 160 km north of Trichy, 177 km east of Salem, 40 km west of Pondicherry. It shares the seashore of the Bay of Bengal covering about 7217 Km^2 area (Fig.1). The area includes Villupuram, Vikkravandi, Tindivanam.
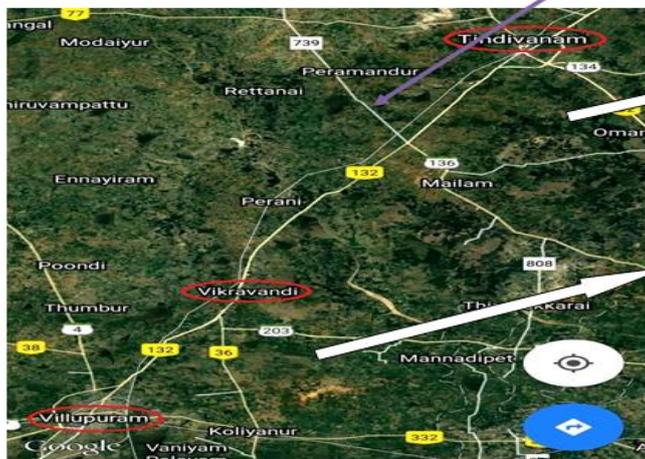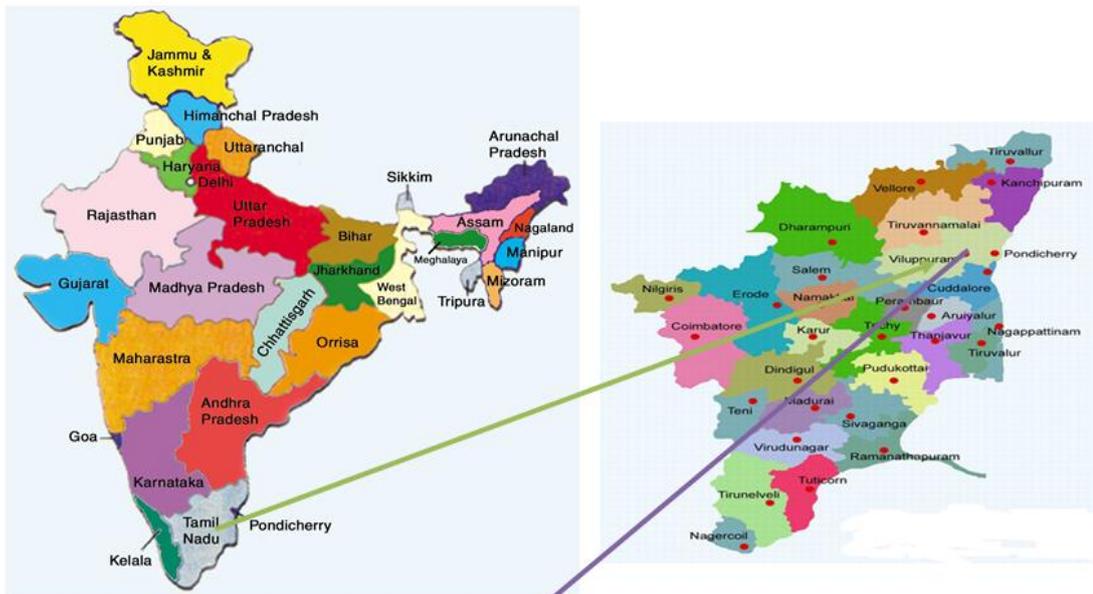
S1-Janakipuram, S2-Villupuram bus stand,
S3-Villupuram railway station, S4-E.S.Eng college, S5-Papankulam, S6-Nannadu,
S7-Cinthamani, S8-Villupuram medical college, S9-Sugar factory, S10-Panayapuram.

Rainfall
Villupuram district receives rainfall from both southwest and northeast monsoons. The annual normal rainfall for the district is 1046.8 mm (41.2in). The driest month is march with 6 mm (0.24in) with an average of 222 mm

(8.7in) per annum, the most precipitation falls in October.

Climate
The district enjoys a tropical climate. The highest temperatures are recorded during May and June. The mean daily minimum and maximum temperature are 24.6 to 32.0° C. The average annual temperature 28.4.^{0}c.

Topography
The general geological formation of the district appears to be simple. The greater part of it is covered by the Metamorphic rocks belonging to Genesis family. There are also three great groups of sedimentary rocks belonging to different geological periods. The Kalrayan Hills in the north represents a continuous range of hills covered with some thorny forests and vegetation. Among the hills, the most beautiful part of the district lies, round about the Gingee Hills.[11]

3. MATERIALS AND METHODS
Collection of water samples
Groundwater samples were collected from 20 locations within the study area during the month of Jan 2017,

Sampling is done at each station in polythene bottles of two-litre capacity. The samples were analyzed for various water quality parameters such as pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Alkalinity, Total Hardness (TH), Chloride, Sulphate, Nitrate, Iron, Calcium, Magnesium, Fluoride and Ammonia were determined using standard methods.[12] The method used for estimation of various Physico-chemical parameters are shown in Table-1. Reagents used for the present investigation were A.R. Grade and double distilled water was used for preparing various solutions. Methods used for estimation of various Physico-chemical parameters are shown in Table-1. To study the correlation between various water quality parameters, the regression analysis was carried out using SPSS 22 software.

Methods used for estimation of Physico - Chemical parameters, Table-1.

S.No	Parameter	Methods
1	P^{H}	P^{H} Meter
2	Electrical Conductivity	Conductivitymeter
3	Total Hardness	EDTA Titration
4	TDS	Filtration method
5	Alkalinity	Indicator method
6	Chloride	Argentometric method
7	Nitrate	Phenol disulphonic acid method
8	Sulphate	Nephelometry Method
9	Fluoride	SPADN spectrophotometric method
10	Calcium	EDTA titration
11	Magnesium	EDTA Titration
12	Iron	PHENANTHROLINE Spectrometry
13	Ammonia	Calorimetric method

4. RESULTS AND DISCUSSION

Physico – chemical Characteristics of groundwater samples in Villupuram district during the month of January-2017 Table-2.

Sample	P^H	EC	TH	TDS	Alkalinity	Cl	NO_3	SO_4	F	PO4	Ca	Mg	Mn	Fe	NH_3	DO	BOD	COD
S1	7.4	2480	580	1732	482	378	34	215	0.3	1.2	131	66	0	0	0.82	8.5	1.2	3.6
S2	7.3	2520	570	1780	503	382	36	221	0.4	1.4	128	74	0	0.1	0.79	8.2	1.6	4
S3	7.5	2510	540	1750	498	376	41	216	0.4	1.3	132	73	0	0.1	0.86	8.1	2.4	4.4
S4	7.6	2670	521	1696	465	381	26	226	0.8	0.9	122	64	0	0	0.68	8.3	2.7	3.6
S5	7.2	2690	512	1696	476	386	24	231	0.7	1	125	68	0	0	0.84	8.2	1.4	4.2
S6	7.2	2680	521	1694	435	367	22	223	0.8	1.4	122	83	0	0	0.6	8	1.5	3.2
S7	7.2	1645	315	1124	324	198	36	122	0.6	1.6	76	64	0	0	0.5	8.6	1.2	3.6
S8	7.1	1375	312	1160	336	222	42	132	0.5	1.7	83	53	0	0	0.45	9	1.4	2.8
S9	6.8	1196	289	1276	427	234	37	123	0.2	1.4	76	49	0	0	0.6	9.2	1.8	3.5
S10	6.9	1159	285	1297	413	231	43	124	0.3	1.1	81	45	0	0	0.54	9.4	1.1	2.3
S11	7	4100	1145	2963	602	602	91	256	0.4	1.7	254	129	0.2	0.5	2.2	7.8	5.2	7.5
S12	7.1	3930	1112	2830	587	611	86	234	0.3	1.8	256	124	0.1	0.4	2.4	7.6	5.6	8.2
S13	7.3	4150	1078	2939	607	587	84	232	0.2	1.9	258	113	0.1	0.5	2.3	7.4	5.4	8.7
S14	7.5	3840	1034	2796	543	387	75	242	0.9	1.8	249	125	0	0.1	0.1	7.2	5.8	9.1
S15	7.4	4050	1124	2882	546	375	72	243	1.1	1.6	248	95	0	0.1	0.2	7.1	5.3	9.4
S16	7.2	3860	1167	2794	524	379	73	236	0.8	1.1	225	116	0	0.2	0.1	8.5	2.2	4.3
S17	7.3	2780	856	1990	598	487	121	235	0.3	0.9	170	94	0	0	0.45	9	2.1	5.7
S18	7.2	2790	734	1997	579	495	124	231	0.2	1.2	163	93	0	0	0.51	9.3	1.8	4.5
S19	7.4	2796	879	1990	534	562	113	246	0.1	0.8	169	96	0	0	0.52	9.1	2.1	5.4
S20	7.5	2789	823	1982	512	567	116	237	0.2	0.7	156	88	0	0	0.56	9.2	2.3	6.3

Statistical evaluation for the ground water samples in Villupuram District, Table-3.

	P^H	EC	TH	TDS	Alkalinity	Cl	NO_3	SO_4	F	PO4	Ca	Mg	Mn	Fe	NH_3	DO	BOD	COD
Min	6.8	1159	285	1124	324	198	22	122	0.1	0.7	76	45	0	0	0.1	7.1	1.1	2.3
Max	7.6	4150	1167	2963	607	611	124	256	1.1	1.9	258	129	0.2	0.5	2.4	9.4	5.8	9.4
Average	7.3	2801	719.9	2018	499.6	410.4	64.8	211.3	0.475	1.325	161.2	85.6	0.02	0.1	0.801	8.385	2.705	5.215
Median	7.3	2735	657	1881	507.5	381.5	57.5	231	0.4	1.35	144	85.5	0	0	0.58	8.4	2.1	4.35
Std.dev	0.2	935.3	306.7	611.8	80.07	126.8	34.12	44.08	0.277	0.353	63.55	25.39	0.051	0.164	0.665	0.701	1.647	2.168
Std.Error	0	209.1	68.58	136.8	17.91	28.36	7.629	9.857	0.062	0.079	14.21	5.677	0.011	0.037	0.149	0.157	0.368	0.485

Correlation coefficient and Linear Regression
In statistics, correlation is a broad class of statistical relationship between two or more variables. The correlation study is useful to find a predictable relationship which can be exploited in practice. In water quality it is used for the measurement of the strength and statistical significance of the relation between two or more parameters.[13]

Correlation analysis measures the closeness of the relationship between chosen independent and dependent variables. If the correlation coefficient is nearer to +1 or −1, it shows the probability of linear relationship between the variables x and y. The correlation between the parameters is characterized as strong, when it is in the range of +0.8 to 1.0 and -0.8 to -1.0, moderate when it is having value in the range of +0.5 to 0.8 and -0.5 to -0.8, weak when it is in the range of +0.0 to 0.5 and-0.0 to -0.5.[14]

Correlation Matrix for different parameters of groundwater samples in Villupuram district, Table-4.

	PH	EC	TH	TDS	Alkalinity	Cl	NO3	SO4	F	PO4	Ca	Mg	Mn	Fe	NH3	DO	BOD	COD
PH	1																	
EC	.358	1																
TH	.264	**.949****	**1**															
TDS	.208	**.968****	**.971****	1														
Alkalinity	.240	**.813****	**.844****	**.828****	1													
Cl	.275	.733**	.760**	.701**	**.864****	1												
NO3	.129	.463*	.657**	.521*	.702**	.721**	1											
SO4	.568**	.847**	.787**	.749**	**.828****	**.806****	.487*	1										
F	.272	.280	.131	.203	-.176	-.351	-.406	.147	1									
PO4	-.276	.291	.209	.355	.029	-.053	-.156	-.136	.205	1								
Ca	.226	**.963****	**.975****	**.993****	**.834****	.725**	.569**	.745**	.170	.375	1							
Mg	.195	**.919****	**.944****	**.927****	.797**	.760**	.629**	.749**	.099	.324	**.942****	1						
Mn	-.299	.532*	.512*	.580**	.490*	.588**	.267	.296	-.212	.499*	.582**	.589**	1					
Fe	-.164	.703**	.672**	.759**	.585**	.590**	.261	.376	-.099	.603**	.750**	.711**	.895**	1				
NH3	-.228	.407	.336	.419	.434	.595**	.126	.229	-.389	.455*	.431	.407	.870**	.835**	1			
DO	-.306	-.736**	-.556*	-.686**	-.383	-.262	.135	-.487*	-.568**	-.644**	-.679**	-.569**	-.411	-.595**	-.381	1		
BOD	.163	.810**	.782**	.863**	.644**	.550*	.366	.506*	.221	.596**	.881**	.778**	.630**	.754**	.512*	-.783**	1	
COD	.280	.834**	.844**	.868**	.723**	.639**	.547*	.605**	.150	.441	.898**	.805**	.499*	.632**	.391	**-.703****	**.931****	1

In this study, the numerical values of correlation coefficient, R for the 18 water quality parameters were tabulated in Table-3. It is shown that a single parameter analyzed has relationship with other parameters. Total hardness has highly positive correlation with EC(R=0.949) and weak correlation with P^H. Total dissolved solids has highly positive correlation with EC(R=0.968), TH(R=0.971) and weak correlation with P^H.

Alkalinity has highly positive correlation with EC(R=0.813), TH(R=0.844), TDS(R=0.828) and weak correlation with P^H. Chloride has highly positive correlation with alkalinity(R=0.864) and significant positive correlation with EC,TH,TDS and weak correlation with P^H. Nitrate has significant positive correlation with alkalinity, TH, TD, Cl and weak correlation with P^H.

Sulphate has highly positive correlation with EC(R=0.847), Alkalinity(R=0.828), Cl (R=0.806) and significant positive correlation with TH, TDS, P^H and weak correlation with NO_3. Fluoride has weak correlation with EC, P^H, TH, TDS, SO_4, and negative correlation with alkalinity, Cl,NO_3. Phosphate has weak correlation with EC, alkalinity, TH, TDS, F, and negative correlation with alkalinity, Cl, P^H. NO_3,SO_4.

Calcium has highly positive correlation with EC(R=0.963), TH(R=0.975), TDS(R=0.993), alkalinity (R=0.834) and significant positive correlation with Cl, NO_3, SO_4 and weak correlation with P^H, F, PO_4. Magnesium has highly positive correlation with EC(R=0.919), TH(R=0.944), TDS (R=0.927), Calcium (R=0.942) and significant positive correlation with Cl, NO_3, SO_4, Alkalinity and weak correlation with P^H, F, PO_4.

Manganese has significant positive correlation with EC,TH, TDS, Cl ,Ca, Mg and weak correlation with alkalinity, NO_3, SO_4, PO_4, and negative correlation with P^H,F. Iron has highly positive correlation with Mn(R=0.895) and significant positive correlation with EC, TDS, TH, Alkalinity, Cl, PO4, Ca, Mg, and weak correlation with SO_4,NO3 and negative correlation with PH, F. Ammonia has highly positive correlation with Mn(R=0.870), Fe (R=0.835) and significant positive correlation with Cl and weak correlation with SO_4,NO3, EC, TDS, TH, Alkalinity, PO4,Ca, Mg and negative correlation with PH, F.

DO negative correlation with Cl, pH, F SO_4, EC, TDS, TH, Alkalinity, PO4, Ca, Mg, Mn, Fe, NH3 and weak correlation with NO3. but BOD has highly positive correlation with EC(R=0.810), TDS (R=0.863), calcium (R=0.881) and significant positive correlation with Cl,PO4,SO4, Alkalinity, Mg, Mn, Fe, NH3, TH and weak correlation with P^H, F, NO3. and negative correlation with DO.

COD has highly positive correlation with EC(R=0.834), TH (R=0.844),TDS (R=0.868), calcium (R=0.898), Mg (R= 0.805) BOD (R=0.931), significant positive correlation with Cl,SO4, Alkalinity, Fe, NO3 and weak correlation with P^H, F, PO4, Mn, NH3 and negative correlation with DO.

Linear Regression Model depicting the existence of strong correlation between Total Hardness and Magnesium
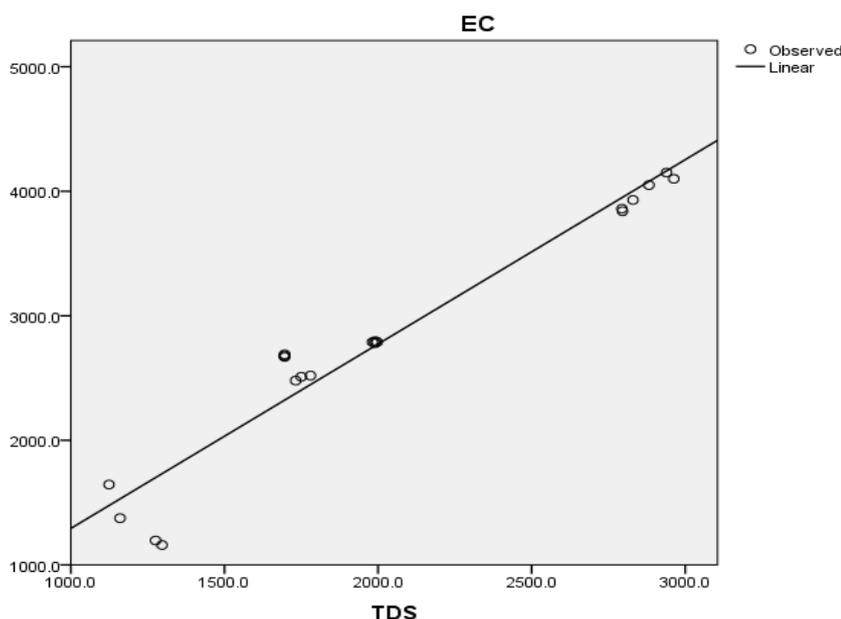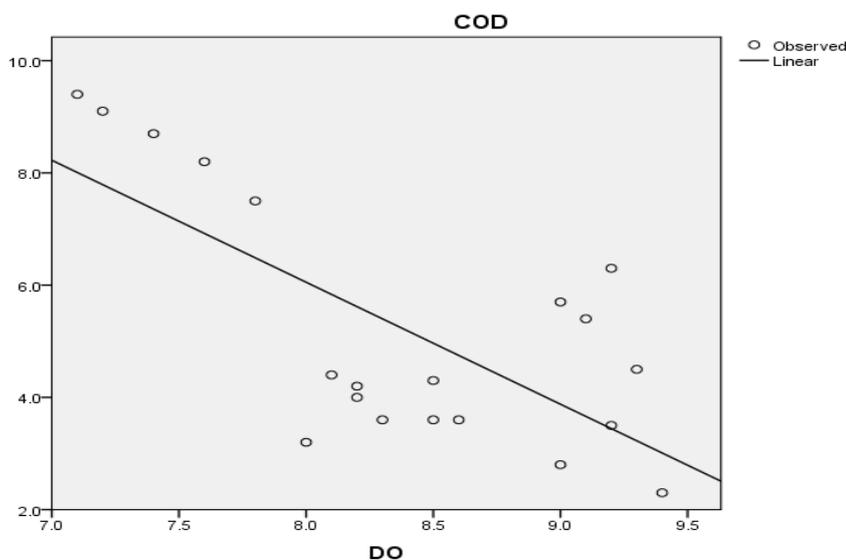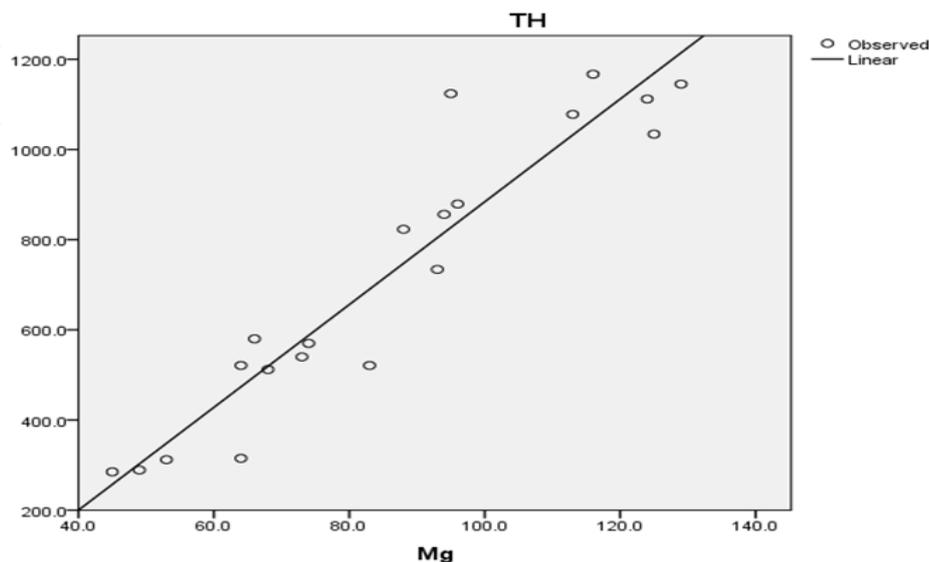
5. CONCLUSION

Rapid and reliable monitoring measures are essential for keeping a close watch on water quality and health environment. Based on the correlation regression study, it can be concluded that all the parameters are more or less correlated with each other, The linear correlation is very useful to get fairly accurate idea of quality of the groundwater by determining a few parameters experimentally and then predicting the remaining from correlation equation. it is recommended that ground water in the study area should be treated before it is used for drinking purpose.

6. REFERENCE

1. Mehta, B.H. & AMIN, C.S., A study of water pollution levels in Vasai region, India. J. of Ind. Poll. Cont., 2008; 24(1): 63-68.
2. Mahajan, S. V., Savita Khare & Shrivastava, V.S., A correlation and Regression Study, Indian J. Env. Prot., 2005; 25(3): 254-259.
3. Kalyanaraman, S.B. & Geetha, G., Correlation analysis and prediction of characteristics parameters and water quality index of ground water, Poll. Res., 2005; 24(1): 197-200.
4. Achuthan Naiar, G., Abdullah, I. Mohamad & Mahamoud Mahdy Fadiel., Physio-chemical parameters and correlation coefficients of ground water of North East Libya, Poll Res., 2005; 24(1): 1-6.
5. Sharma.s & Chhipa RC, Statisticalregresssion analysis of underground water and quality of south west area of jaipur city and its agglomerates, In J pure and and APPL Chem., 2012; 347-35.
6. Jothivenkatachalam kNithya A & Mohan SC, correlation analysis of drinking water quality around perur block of Coimbatore district. Tamil nadu India E-J Chem J., 2010; 649-654.
7. Iyer, Padmanabha C.S., Sindhu, M., Kulkarni, S., Tambe, S., Kulkarni, D., (2003), Journal of Environmental Monitoring, 5: 324-327.

8. Sarkar, Mitali., Banerjee, A., Pramanik, P.P., Chakraborty, S., (2006), Appraisal of elevated fluoride concentration in ground water using statistical correlation and regression study, J. Indian Chem. Soc., 83: 1023-1027.

9. Kumar, A., Garg, S. N., Gopal, K., (1994), Relationship between electrical conductivity and Cationic and anionic contents in groundwater", Indian Journal of Environmental Protection, 14(7): 595-603.

10. Bajpayee. S1, Das. R1, Ruj. B1, Adhikari. K2, Chatterjee. P.K1 Assessment by multivariate statistical analysis of ground water geochemical data of Bankura, India, INTERNATIONAL JOURNAL OF ENVIRONMENTAL SCIENCES, 2012; 3(2): ISSN 0976 – 4402.

11. Tamilnadu water supply and Drainage board.

12. APHA, Standard Methods for the Examination of Water and Wastewater. APHA- AWWA-WPCF 2005. Washington D.C.

13. Mehta, K.V, (2010), Physicochemical characteristics and statistical study of groundwater of some places of Vadgam taluka in Banaskantha district of Gujarat state (India), *Journal of Chemical Pharmaceutical Research,* 2(4): 663670.

14. Nair A J, Abdullan G, Mohamad I and Fadiel M M, 2005, *Poll Res*., 24(1): 1-6.