Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Statistical predictive models of ground water quality in and around textile cluster of Chirala, Prakasam (Dist), Andhra Pradesh, India.

M. Anji Reddy[1] and K. Sri Lakshmi[2*]

[1]Director R&D, Professor, Centre for Environment, JNTUH, Kukatpally-500085, Telangana, India
[2]Research Scholar, Centre for Environment, JNTUH, Kukatpally-500085, Telangana, India

ABSTRACT

Ground water samples are collected from 11 locations in and around dyeing industries of Chirala textile cluster in the month of January 2018. Water Quality assessment is carried out for the physical, chemical, biological parameters such as colour, odour, turbidity, total dissolved solids (TDS), electrical conductivity (EC), pH, total alkalinity (TA), total hardness (TH), calcium (Ca), magnesium (Mg), sulphates (So_4), chloride (Cl), lead (Pb), copper (Cu), zinc (Zn), fluorides (F), manganese (Mn), iron (Fe), silica (Sio_2), nitrate nitrogen (No_4), sodium (Na), potassium (K), total suspended solids (TSS), phosphates (Po_4), sulphide, total coliform, E. coli, residual free chlorine. The relation between different parameters was studied by calculating correlation coefficients and then related by regression analysis. The results have been compared with water quality standards issued by World Health Organisation (WHO. From the study, it is inferred that most of the water samples are of poor-quality drinking water. The correlation coefficient has high significance to understand the relation between various water quality parameters. Further the regression technique is novel tool for monitoring and predicting the water quality of textile industrial area.

KEYWORDS: Ground water, Textile, Correlation, Regression, Water Quality.

ABBREVIATIONS: Total Dissolved Solids (TDS), Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Calcium (Ca), Magnesium (Mg), Sulphates (So_4), Chloride (Cl), Lead (Pb), Copper (Cu), Zinc (Zn), Fluorides (Fl), Manganese (Mn), Iron (Fe), Silica (Sio_2), Nitrate Nitrogen, Sodium (Na), Potassium (K), Total Suspended Solids (TSS), Phosphates (Po_4), Escherichia Coli (E.Coli).

*Corresponding Author

K. Sri Lakshmi

Research Scholar, Centre for Environment,

Institute of Science and Technology,

Jawaharlal Nehru Technological University,

Hyderabad-500085, Telangana, India

Email: [1]sri.kamatham@gmail.com, Mob No- 7702139555

1.0 INTRODUCTION

Ground water is the major source of drinking water in both urban and rural areas[1]. Due to its over exploitation and improper, unscientific waste disposal, quality of water resources is being severely affected[2,3]. The contaminants like pesticides, dyes and fertilizers through the runoff may percolate to the aquifers. They may later be pumped out for anthropogenic activities like domestic, industrial and agricultural purposes. Once contamination of aquifers takes place restoration of ground water quality as well as conservation of environment is becoming a very hard task[4]. Effect on either ground water or surface water induces environmental degradation due to contaminated effluents as well as overexploitation of existing water resources[5]. Therefore, it is highly essential to monitor ground water quality as well as derive ways and means for its protection. Ground water quality in the dyeing industrial area is determined by measuring various physical, chemical and biological parameters and comparing with the drinking water standards as given by World Health Organization or Ministry of Environment and Forestry. The predictive statistical models are developed using correlation and linear regression analysis of the various physico-chemical parameters. These models help to access and predict the overall water quality as well to measure statistical significance of various pollution indicating parameters in water[6]. This helps to provide necessary remedial measures in advance for implementation of rapid water quality management strategies.Continuous monitoring of ground water quality ensures its safety for human consumption which is highly essential to understand level of pollution as well as to find out potential risk to the ecosystem[7].

2.0 STUDY AREA

Chirala cluster is located in Prakasam District of Andhra Pradesh, India. Skilled artisans started dying and printing units and it is operating for nearly a century. The Chirala handloom cluster is situated in two mandals of Chirala and Vetapalem. There are 58 small and micro scale textile industries in this textile cluster. Currently it possesses all modern facilities like weaving, machinery, natural dying and processing units. All units are spread on both sides of 32-km long Kunderu drain which is an agricultural drain. These industries discharge huge amount of untreated or inefficiently treated effluent directly into Kunderu drain that may affect the surrounding environment. In the present study, an attempt is made to evaluate and predict the ground water quality by developing regression models based on correlation coefficient and other statistical parameters for the selected physico-chemical parameters derived from the analysis of samples collected during field survey. The map showing the sampling location for the present study in textile cluster is shown in Figure 1.

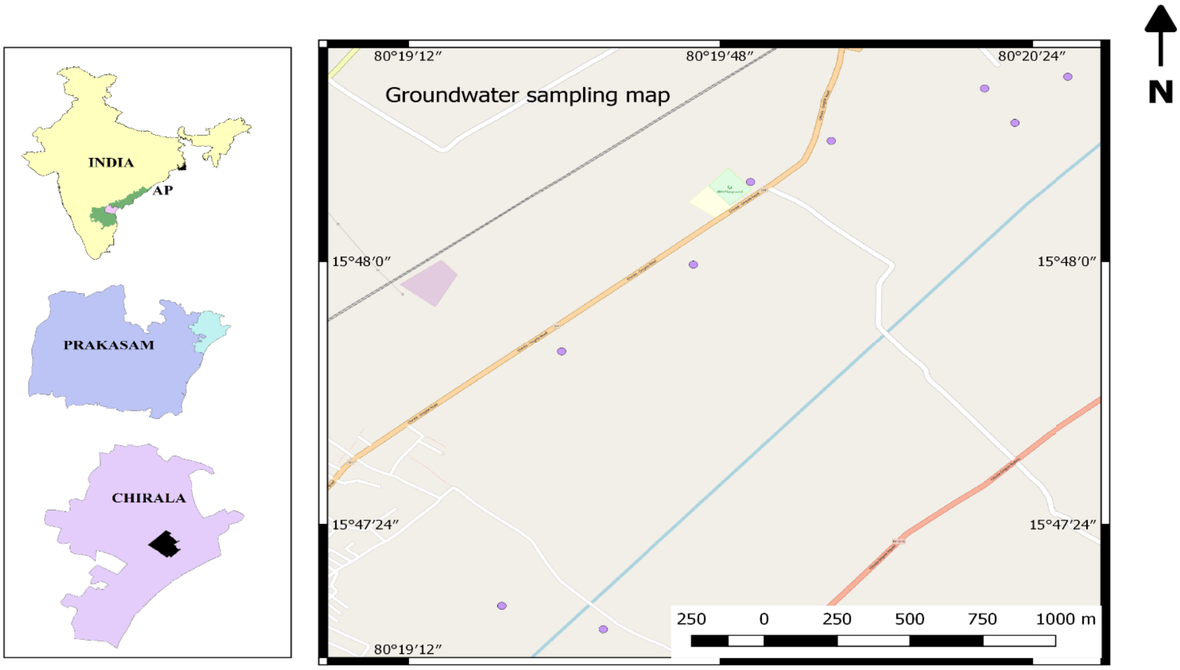


Figure 1: Map showing ground water locations

3.0 MATERIALS AND METHODS

In the present study, a total of 11 samples are collected in the dyeing industrial areas of Chirala town of Andhra Pradesh during January 2018. They are collected in clean polythene bottles and immediately brought to the environmental laboratory of Centre for Environment, Jawaharlal Nehru Technological University Hyderabad and analysed within 24 hours of collection as per normal standards.

The samples are analysed for the mandatory parameters such as pH, colour, odour, turbidity, total dissolved solids (TDS), electrical conductivity (EC), total alkalinity (TA), total hardness (TH), calcium (Ca), magnesium (Mg), Sulphates (So_4), chloride (Cl), lead (Pb), copper (Cu), zinc (Zn), fluorides (F), manganese (Mn), iron (Fe), silica (Sio_2), nitrate nitrogen, sodium (Na), potassium (K), total suspended solids (TSS), phosphates (Po_4), sulphide, total coliform, E. coli, residual free chlorine was done using standard methods for chemical analysis of water and waste water[8].

Statistical techniques have been applied for major pollution indicating parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), calcium (Ca), magnesium (Mg), sulphates (So_4), chloride (Cl), nitrate nitrogen, sodium (Na) and potassium (K) and are compared with Bureau of Indian Standards and World Health Organisation standards. All other parameters analysed are in compliance with WHO and BIS standards. Further, the above-mentioned parameters are also used for calculating Correlation Coefficient. The pairs of parameters that have strong correlation are used for developing regression models for prediction of ground water quality.

3.1 Correlation Analysis

The Pearson R test or correlation coefficient (r) is a statistical equation which measures the strength between variables and relationships[9]. The value may range between -1.00 to 1.00, which determines the relation between any two variables. 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[10].

3.2 Linear Regression Analysis

The parameters having fairly high correlation can be considered for linear regression analysis which is in the form:

$$Y=ax+b \text{----------------------------} (1)$$

Where, y and x are the dependent and independent variables respectively. 'a' is the slope of line, b is intercept on y axis. The regression equation is developed and R^2 square is calculated using SPSS software package**.** The regression analysis helps to understand the statistical significance between any two dependent variables and many independent variables, which can be used for prediction from the known data products.

4.0 RESULTS AND DISCUSSION

The ground water samples collected from the 11 pre-determined locations selected for the present study are colourless, odourless, tasteless, free from excess salts and temperature was around 27°c. The results of the statistical analysis of water quality parameters are presented in Table 1. The results of chemical analysis are compared with Bureau of Indian standards for drinking water[11] and World Health Organisation standards[12] presented in table 2. The results show that the variation among the parameters measured at each location is very narrow among pH, total alkalinity, calcium, magnesium, nitrates. While the variation is high among the parameters TDS, total hardness, chlorine and sodium. The correlation matrix is given in Table 3. Correlation coefficient (r) is the value obtained by performing correlation analysis and it shows the percent variance of dependent variable explained in terms of independent variables. A value nearer to either +1 or -1, indicates a good relation, while a value nearer to 0 means no relation. Positive value indicates direct relation among the variable while negative value indicates the variables have inverse relation. The results of correlation analysis indicated that all parameters were correlated either positively or negatively and strongly or poorly.

The results of the chemical analysis of major pollution indicating parameters pH, Sulphates (So_4), Nitrate Nitrogen, Sodium (Na) are within the standards of BIS and WHO standards. While the parameters Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Calcium (Ca), Magnesium (Mg), Chloride (Cl), and Potassium (K) showed significant deviation from standards.

Table 1: Statistical analysis of ground water samples

Parameter	Min	Max	Mean	Median	Standard Deviation	Permissible Limits	Excessive Limits
pH	7.25	7.93	7.57272727	7.52	0.204943	6.5-8.5	No Relaxation
EC(μmho/cm)	725	5200	2329.09091	1925	1322.289	--	--
TDS	510	3320	1455.63636	1245	806.4053	500	2000
TotalAlkalinity	120	285	222.272727	220	54.92557	200	600
TotalHardness	85	865	352.272727	345	214.4221	200	600
Calcium	17.68	166.93	68.2281818	43.79	50.02469	75	200
Magnesium	9.53	107.16	45.3136364	42.87	28.3689	30	100
Sulphate	30.1	272.5	111.530909	111.6	73.95314	200	400
Chloride	163.9	1512.9	580.307273	463.1	414.2474	250	1000
Nitrate	2.1	10.3	5.22727273	5.6	2.67884	45	No Relaxation
Sodium	105.9	979.6	353.909091	299.5	258.5265	--	--
Potassium	5.1	10.6	6.55454545	6.2	1.593338	--	--

Table 2: Comparison of ground water samples with drinking water standards

Parameter	Indian standard	% compliance	WHO Standard	% compliance
pH	6.5-8.5	100	7.0-8.0	100
EC	-	-	-	-
TDS	500	0	1000	27
TA	200	36	-	-
TH	200	18	100	18
Calcium	75		75	
Magnesium	30	36	30	36
Sulphate	200	90	250	90
Chloride	250	18	250	18
Nitrate	45	100	50	100
Sodium	-	-	200	45
Potassium	-	-	-	-

All parameters have units in mg/l except for pH and EC.

Table 3: Correlation coefficients among various water quality parameters

	pH@27.2oC	Conductivity	TDS	TA	TH	Ca	Mg	SO4	Cl	NO3	Na	K
pH@27.2oC	1											
Conductivity	-0.1618198	1										
TDS	-0.1827396	0.97933797	1								Positively correlation	
TA	-0.1329721	0.31726652	0.310865	1							Weak	
TH	-0.449909	0.76942186	0.802982	0.209279	1						Worse	
Ca2+	-0.4920439	0.42802491	0.502791	0.077296	0.891873	1					Negative correlation	
Mg^{+2}	-0.2542236	0.95582881	0.948415	0.433754	0.86731	0.570677	1					
So_{4-}^{2}	-0.0537755	0.95340611	0.927678	0.242611	0.703189	0.355089	0.890582	1				
cl^-	-0.1217171	0.98138577	0.954515	0.172581	0.708559	0.343082	0.902516	0.950908	1			
No_3^-	-0.4265524	0.15725456	0.255158	-0.24174	0.627959	0.78943	0.28871	0.018973	0.129415	1		
Na^{2+}	-0.1766429	0.9645535	0.974802	0.147861	0.777021	0.463689	0.899385	0.928401	0.976766	0.267885	1	
K	-0.2513094	0.89572139	0.935687	0.086427	0.797103	0.532401	0.846184	0.880083	0.912721	0.35573	0.975008	1

The results of correlation analysis shown in Table 3 gives an indication that EC has a positive and significant correlation with TDS, Mg^{2+}, So_4^{2-}, cl^-, Na^{2+}, K, weak correlation with TH, worse correlation with TA, Ca^{2+}, No_3^- , TDS has a positive and significant correlation with TH, Mg+2, So_4^{2-}, cl^-, Na^{2+}, K, weak correlation with Ca^{+2} and worse correlation with K. TA has a weak correlation with Mg^{2+}, worse correlation with TH, Ca^{+2} , So_4^{2-}, cl^-, Na^{2+}, K and strong and negative correlation with No_3^-. TH has strong and positive correlation with Ca^{2+}, Mg^{2+} and weak correlation with So_4^{2-}, cl^-, No_3^- , Na^{2+}, K. Ca^{+2} has weak correlation with Mg^{2+}, No_3^-, K and worse correlation with So_4^{2-}, cl^-, Na^{2+}. Mg^{2+} has strong and positive correlation with So_4^{2-}, cl^-, Na^{2+}, K and worse correlation with No_3^-. So_4^{2-} has strong and positive correlation with cl^-, Na^{2+}, K and worse correlation with No_3^-. Cl^- has strong and positive correlation with Na^{2+}, K and worse correlation with No_3^-. Na^{2+} has strong and positive correlation with K. No_3^- has worse correlation with Na^{2+}, K. While pH has strong and negative correlation with EC, TDS, TA, Mg^{2+}, So_4^{-2}, cl^-, Na^{2+}, K and has weak and negative correlation with TH, Ca^{2+}, No^{3-}.

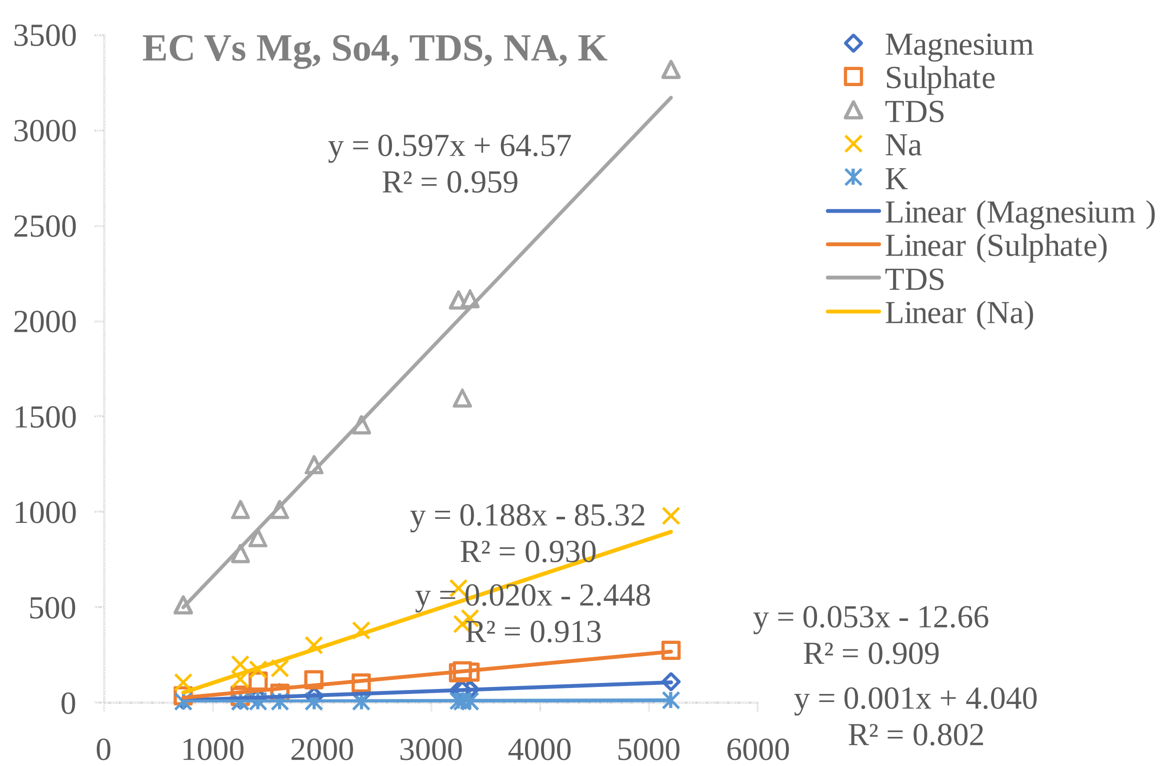
Taking into consideration the strong and positively or negatively correlated parameters, linear regression analysis was carried. The values of different independent variables and depended variables were substituted in equation 1 to develop regression equation and R^2 is calculated for all correlated parameters which are given in Table 4 and the graphs are shown in Figure 2. Statistically significant correlation among most of the parameters was observed in samples collected with p Value <0.05 (Table 4). However, some of the parameters have correlation coefficients with p value >0.05.

Table 4: Linear correlation coefficient and linear regression equation for some pairs of parameters which have significant value of correlation.

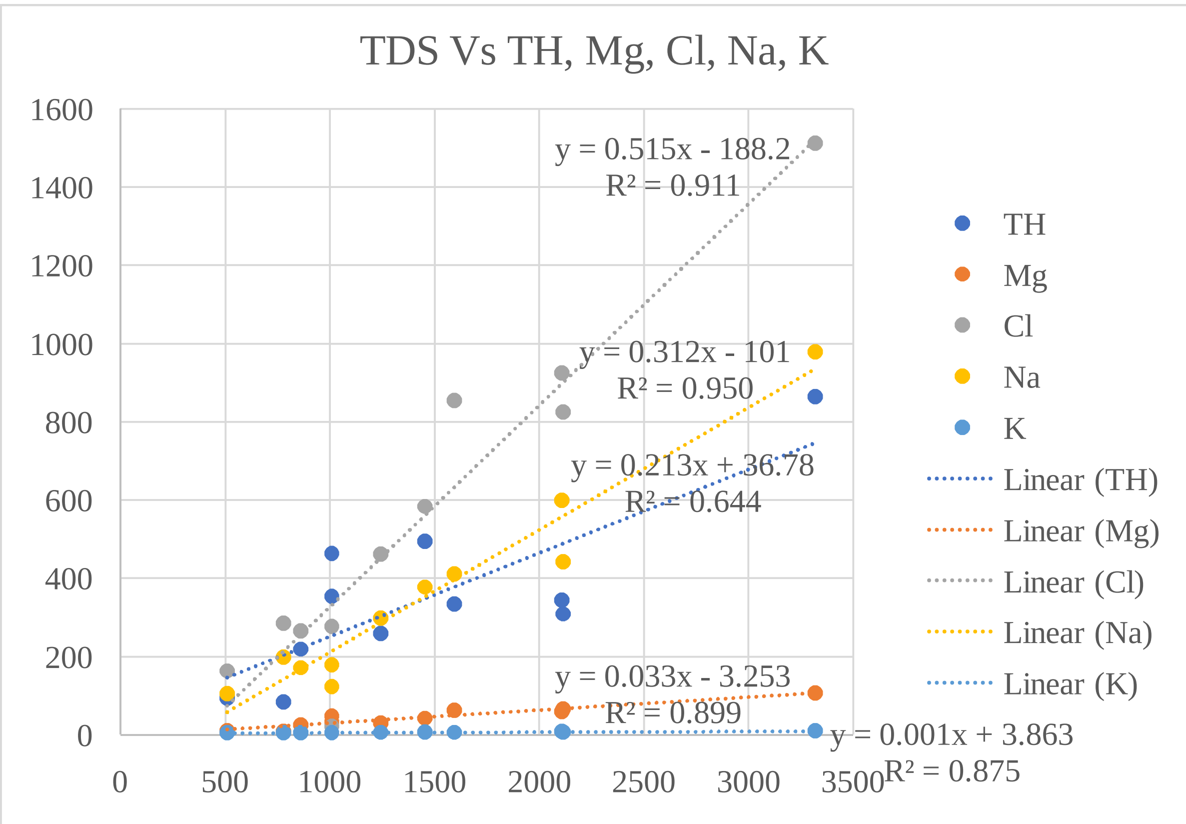
Pairs of parameters		Correlation	Regression Coefficient		Regression Equation	R^2	P Value
Dependent	**X(Independent)**		**A**	**b**	**Y= aX+b**		
EC (F Value= 3.70E-06)	Mg2+	0.95	0.0205	2.4484	Y=0.0205x+2.4484	0.91	0.039
	So4	0.95	0.0533	-12.661	Y=0.0533x-12.661	0.9	0.064
	TDS	0.97	0.5973	64.576	Y=0.5973x+64.576	0.95	0.039
	Na	0.96	0.1886	-85.32	Y= 0.1886x-85.32	0.93	0.005
	K	0.89	0.0011	4.0407	Y=0.0011x+4.0407	0.8	0.005
TDS (F Value= 7.97E-05)	TH	0.8	0.2139	36.78	Y=0.2139x+36.78	0.64	0.21
	Mg	0.94	0.0334	-3.2533	Y=0.0334x-3.2533	0.89	0.029
	Cl	0.95	0.5054	-188.28	Y=0.5054x-188.28	0.91	0.096
	Na	0.97	0.3125	-101	Y=0.3125x-101	0.95	0.05
	K	0.93	0.0018	3.8463	Y=0.0018x+3.8634	0.87	0.266
TH (F value= 0.0002)	Ca	0.89	0.2076	-4.063	Y=0.2076x-4.063	0.79	0.0002
TH (F value= 0.0005)	Mg	0.8	0.1145	5.438	Y=0.1145x+5.438	0.75	0.0005
Mg (F value= 0.012)	SO4	0.89	2.3216	6.3306	Y=2.3216x+6.3306	0.79	0.409
	Cl	0.9.	13.854	65.74	Y=13.854x-65.74	0.81	0.614
	Na	0.89	8.1969	17.489	Y=8.1969x-17.487	0.8	0.404
	K	0.84	0.0475	4.401	Y=0.0475x+4.401	0.71	0.465
So4 (F value=0.00035)	K	0.88	0.019	4.4397	Y=0.019x+4.4397	0.77	0.0003

Graphs 1 to 6 showing linear regression equation and value of R^2.

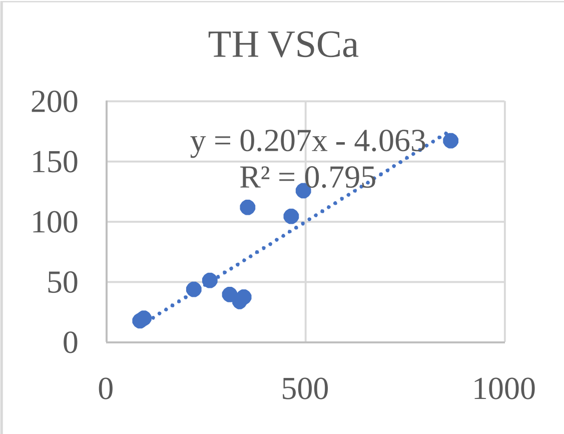
Graph 1



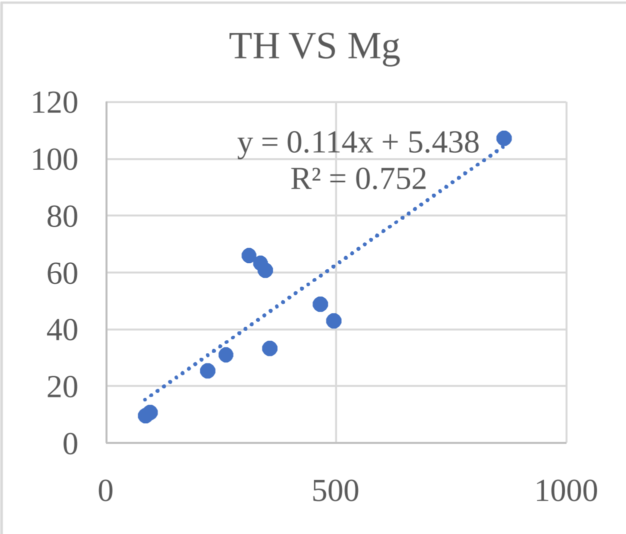
Graph 2



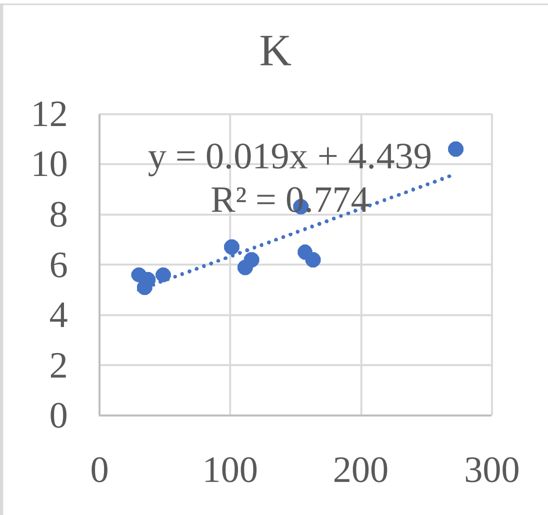
Graph 3



Graph 4



Graph 5



Graph 6

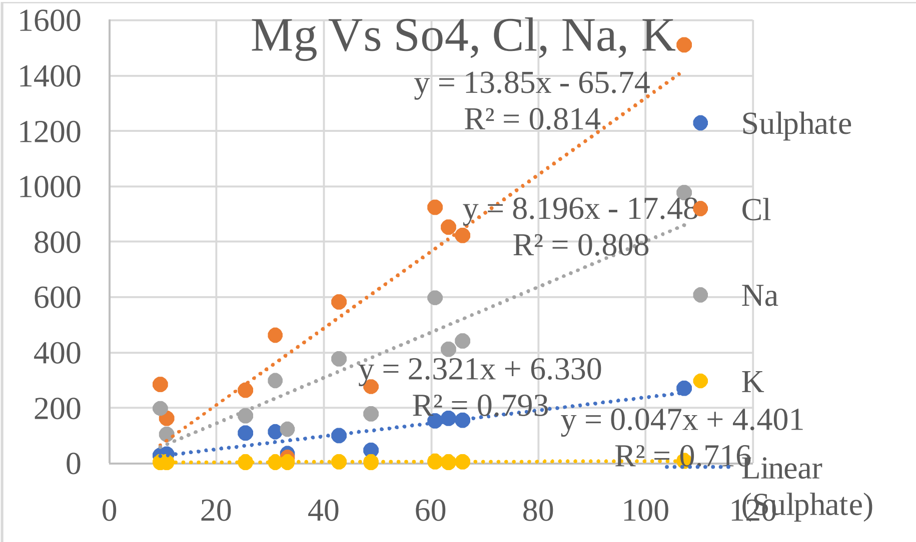


Figure 2: Graphs 1 to 6 showing linear regression equation and value of R^2.

Table 5: Prediction of estimated parameters using regression models

Parameter/location		1	2	3	4	5	6	7	8	9	10	11
EC	**Observed**	1410	3250	3355	3285	1925	725	1610	1250	2360	5200	1250
	Predicted	1345.065	3217.727	3390.292	3216.355	2006.187	884.1158	1644.988	1203.822	2316.409	5237.12	1157.919
TDS	**Observed**	862	2110	2115	1595	1245	510	1010	1010	1455	3320	780
	Predicted	761.5351	2174.229	1944.393	1723.075	1203.899	577.3223	1069.414	1028.565	1383.143	3334.9	811.5251
TH Vs Ca	**Observed**	220	345	310	335	260	95	465	355	495	865	85
	Predicted	254.5376	229.7144	237.759	214.6979	282.3871	162.0252	485.5313	514.3002	568.2753	726.2551	154.5169
TH Vs Mg	**Observed**	220	345	310	335	260	95	465	355	495	865	85
	Predicted	217.319	449.4399	482.8721	465.7291	253.904	120.9632	371.2781	268.8138	332.1315	754.4024	113.147
Magnesium	**Observed**	25.39	60.73	65.82	63.21	30.96	10.72	48.83	33.23	42.87	107.16	9.53
	Predicted	27.87165	62.46035	62.77869	60.22934	44.60891	17.5369	23.08265	24.84913	45.62848	105.0835	24.32035
Sulphate	**Observed**	111.6	154.1	157.2	163.4	116.5	34.59	48.66	36.99	101.2	272.5	30.1
	Predicted	84.79396	182.8295	109.3028	97.04839	97.04839	52.11546	72.53952	64.36989	117.4725	276.7801	72.53952

Using the above regression models, the predicted values of the parameters are estimated and are given in Table 5 along with experimentally calculated values. Thus, it can be concluded that correlation analysis and linear regression models are good tools for forecasting the quality of ground water and have great significance for understanding water quality in the areas of textile development[13,14].

5. CONCLUSION

The present study is carried out to understand the ground water quality at 11 different locations around the textile cluster of Chirala, Andhra Pradesh. The general observation is that ground water samples collected at locations 3,4,5,7,8,9,10 are of inferior quality. The reason for the deteriorating quality of water could be due to establishment of more industrial units in the study area without proper planning. However, water quality should be continually analysed and proper rapid, cost effective treatment for treating ground water before consumption is highly essential. This also helps in preventing the deterioration of water quality and helps in conservation of water resources as well as the Environment. Further, it can also be stated that correlation and regression studies are better tools in order to get a fair idea of the ground water quality by determining some important pollution indicating parameters.

6. ACKNOWLEDGEMENT

The author would like to thank the Directorate of Science and Technology for financial assistance. The author is extremely thankful to Professor M. Anji Reddy, Centre for Environment, Jawaharlal Nehru Technological University Hyderabad, for his encouragement, valuable suggestions and support.

7. REFERENCES

1. Agyenim J. B. and Nimba-Bumah G. B., Correlation Analysis of Groundwater Coloration from Mountainous Areas, Environmental Research, Engineering and Management 2014;1: 16–24.
2. Tiwari AK, Singh PK, Mahato MK., Chemistry of Groundwater and Their Adverse Effects on Human Health: A Review. Indian Journal of Health and Wellbeing 2013; 4(4): 923-92.
3. Singh P., Tiwari A. K. and Singh P. K., Hydrochemical characteristic and Quality Assessment of Groundwater of Ranchi Township Area, Jharkhand, India, Current World Environment, 2014, 9(3): 804-813.
   doi: http://dx.doi.org/10.12944/CWE.9.3.30.
4. Kadongola W. K., Environmental Impacts of landfills, MSc. Thesis, University of Botswana, Botswana, 1997.
5. Carneiro PA, Umbuzeiro GA, Oliveira DP, Zanoni MV., Assessment of water contamination caused by a mutagenic textile effluent/dyehouse effluent bearing disperse dyes. Hazard Mater 2010, 174(1–3):694–699.
   doi: http://dx.org/10.1016/j.jhazmat.2009.09.106.
6. Mehta, K.V., 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, 2010; 2(4): 663-670.
7. AchuthanNaiar G. Abdullah I. Mohamad &MahamoudMahdyFadiel., Physio-chemical parameters and correlation coefficients of ground water of North East Libya, Poll Res 2005; 24(1): 1-6.

8. American Public Health Association (APHA), Standard Methods for the Examination of Water and Waste water 2005, 21st Edition.
9. Heydari M M, AbasiA, Correlation Study and Regression Analysis of Drinking Water Quality in Kashan City, Iran Seyed Mohammad Rohani and Seyed Mohammad Ali Hosseini Middle-East, J. Sci. Res., 2013; 13(9): 1238-1244.
10. Heydari M M, Abasi A., Correlation Study and Regression Analysis of Drinking Water Quality in Kashan City, Iran Seyed Mohammad Rohani and Seyed Mohammad Ali Hosseini Middle-East, J. Sci. Res., 2013; 13 (9): 1238-1244.
11. Bureau of Indian Standard (BIS) Indian standard Drinking water Specification (Second Revision), Indian Standard (10500:2012).
12. WHO (World Health Organization) Guidelines for drinking water quality, 2nd Ed., 1993; 1: 188.
13. Saxena Swati. and Umesh Saxena., Correlation and Regression Analysis of Ground Water of Bassi Tehsil, District Jaipur, Rajasthan, India, 2016; 6 (1): 43-57.
14. Prasoon Kumar Singh, Binay Prakash Panigrahy*, Ashwani Kumar Tiwari, Bijendra Kumar, Poornima Verma, A statistical evaluation for the groundwater quality of Jharia coalfield, India, Int J Chem Tech Res 2015; 7(4): 1880-1888.