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ORIGINAL ARTICLE

A Study on the Enhancement of Fluoride Distribution with respect to Total Alkalinity using Statistical Analysis

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ABSTRACT
Groundwater is an essential source of water due to its substantial use of domestic, irrigation and industrial purpose. The present study was aimed to investigate the correlation, regression analysis of the data points of groundwater at Pennagaram block of Dharmapuri district, Tamilnadu. A few groundwater samples of the study area were analyzed for their physico-chemical parameters (APHA, 1998). Each parameter was compared with World Health Organization (WHO) standards. The correlation, regression study carried out to assess the relativity between the parameters. In this study predict strong positive correlations between the parameters EC and TDS, DO and BOD, TH and Cl, Ca, Mg, TA and F, Na & F and Na. Similarly strong negative correlations observed between Temp and DO, BOD and Temperature. In this study depict the high fluoride content of groundwater interrelated to high alkalinity and pH. It may be due to chemical weathering with the influence of various fluoride bearing minerals in the study region. The study concludes that 45% of the groundwater samples were found to be higher in fluoride levels and posing a major problem for water resources. Most of the people in this area suffer from dental and skeletal fluorosis. It also gives an understanding into the problem of fluorosis among people in the study area, where fluorosis is a public health problem of significant impact. Instructing the people and defluoridation of the groundwater before intake is important.
KEYWORDS: *Correlation, Defluoridation, Fluorosis, Groundwater, Pennagaram, Regression WHO.*

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INTRODUCTION

Water is one of the most significant natural resources and plays a vital role in all living organisms and plants to persist in this world. Groundwater is one of earth's most vital renewable and commonly distributed resources as well as an important source of water supply [1]. Safe drinking water is the primary need of every human life. Fresh water has become an unusual product due to over exploitation and pollution of water. Major impact of water is resulting from the availability of groundwater assets and in much area's groundwater is the only fresh source easily accessible and therefore protection of the groundwater quality has become a critical part in the welfare of humanity. There is huge compulsion of water for drinking, irrigation and other purposes and therefore extraction of groundwater becomes a mandate for policy planners in water budget planning.

In India most of the population is dependent on groundwater as the only source of drinking water supply where surface water is not available. The quality of water is defined in terms of its physical, chemical and biological parameters. About 80 % of the diseases in the world are due to the poor quality of drinking water [2].

Fluoride contamination of groundwater is a persistent problem in several parts of the world. The major sources of fluoride in groundwater are due to dissolution of fluoride bearing minerals such as fluorspar, cryolite, fluorapatite, and hydroxyapatite in rocks [3, 4]. Some anthropogenic activities due to agricultural usage of fertilizers, pesticides and discharge of sewage and sludge have also been indicated as a cause for the increase in fluoride concentration in groundwater [5]. Fluoride is found in almost all environs of nature, where it occurs as fluoride compounds and complexes. Fluoride originates from the weathering of fluoride containing minerals and enters into the surface water with run-off and groundwater through direct contact [6].

The presence of high fluoride in groundwater often recognized only when people exhibit symptoms of fluorosis and it is an endemic disease resulting from excess intake of fluoride through drinking water, food at a concentration of 1.5 mg/l or above [7]. Fluorosis of teeth has been reported to affect dental

enamel and more than 10 mg/l of fluoride results in pathological changes in bone leading to skeletal fluorosis [8].

In India 62.5 million people are affected by fluorosis [9]. Seventeen states of India have been identified as endemic for fluorosis. Tamil Nadu region of South India has been identified as a fluoride affected area. The highest concentration of Fluoride in groundwater is found in Dharmapuri and Salem districts. Pennagaram block of Dharmapuri district was taken for our study. Most of the people in this area suffer from dental and skeletal fluorosis. This area has phreatic aquifer in general and the groundwater is slightly alkaline in nature [10].

Groundwater pollution is an urgent issue to address. There is a globally increased interest in providing safe water for domestic purpose. The quality of water is defined in terms of its physical, chemical and biological parameters [11]. It is assessed with the help of various parameters to indicate the pollution level. A number of indices have been developed to summarize water quality data in an easily expressible and easily understood format.

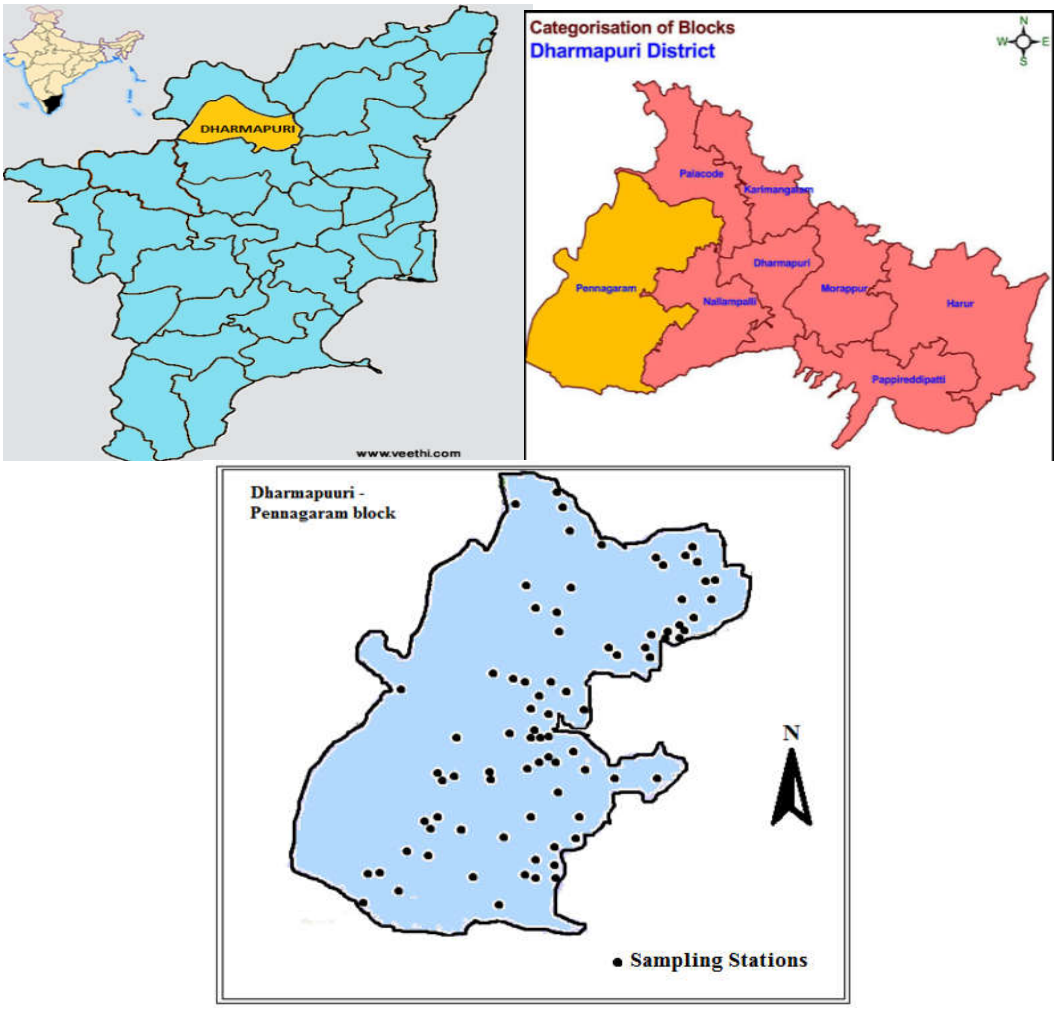
Correlation and regression analysis was carried out to determine the influence of total alkalinity and pH on the fluoride content of the water and the dependence of these parameters on fluoride toxicity [12].

EXPERIMENTAL TECHNIQUES

Profile of the Study Area

The study area, lies between the longitude of 77^0 46' to 78°4' and North latitude of 11°53' to 12°19'. In these, Plain area covers an area of 604.48 Km2 (Fig.1). The study area falls in Pennagaram block, Dharmapuri district of Northern Tamil Nadu. The major source of recharge of water in this area is rainfall, during monsoon season. The average annual rainfall is 902 mm. During the year 2013 - 2014 the actual rainfall of the district is 757.4mm. As the study area is underlain by the Archean crystalline rock, groundwater may occur in the fractured rocks. The study area goes through a hot climate during the summer with a temperature up to 36° C and in winter it varies between 16° C - 12° C.

Study area Location map



Geomorphology

Dharmapuri district forms division of the upland level region of Tamil Nadu with lots of hill ranges. The western division of the district connecting Pennagaram has hill ranges of the Mysore Plateau connect with of undulating hills. The south border of the district is bounded by the Shervaroy hill ranges. The plains occupying the middle, eastern and southern part of the district include an average increase of 488 m above Mean Sea Level. The Plateau region beside the western edge and the northwestern part of the district has a usual increase of 914 m above Mean Sea Level.

Hydrogeology

The district is underlain by Archaean Crystalline formations with recent alluvial deposits of limited areal and vertical extents along major rivers. The main aquifer systems in the district are constituted by

(i) unconsolidated and semi-consolidated formations,

(ii) Weathered and broken crystalline rocks.

In the areas underlain by crystalline rocks, occurrence of groundwater is basically limited to zone of weathering and fracturing. Generally the rigid rock aquifers are heterogeneous in surroundings, which are indicated by the variations in lithology, composition and texture. Groundwater occurs under phreatic circumstance in the weathered mantle and semi confined to confined state in the fracture and fissured zones of these rocks. Thickness of weathered substance varied widely less than 1m bgl to more than 20m bgl.

MATERIALS AND METHODS

Sample Collection

A total of eighty groundwater samples was collected from hand pumps and Bore well at different locations on the entire Pennagaram Block during the pre-monsoon season of May 2015. The water samples were taken in pre-cleaned, sterilized polyethylene bottles of 2 Liter capacity without air bubbles. The temperature of the samples was measured at the time of sample collection.

Methodology

The samples were analyzed to assess the various physico–chemical parameters such as pH, Temperature, Electrical Conductivity(EC), Total Dissolved Solids(TDS), Total Hardness(TH), Total Alkalinity(TA), Calcium, Magnesium, Chloride, Biological Oxygen Demand(BOD), Chemical Oxygen Demand(COD), Dissolved Oxygen(DO), Nitrate, Sulfate, Phosphate, Fluoride as per standard procedure recommended by APHA(1995) method. The water quality parameter values are in mg/l except pH and EC (EC in µS/cm).

Coefficient of Correlation (R)

In statistics, correlation is a wide class of statistical connection between two or more variables. The correlation study is helpful to find a conventional relationship which can be exploited in practice. It is used for the measurement of the potency and statistical significance of the relation among two or more water quality parameters [13, 14, 15].

Let x and y are any variables (Water quality Parameters) and (Xi, Yi) (I = 1, 2, 3……..n) be n pairs of experimental values of these variables. Then the correlation coefficient R between the variables x and y is specified by the well-familiar relation

$$R = \frac{n\sum xy - \sum x \sum y}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y^2)]}} \quad \text{---------- (1)}$$

Where, the summations have taken over 1 to n (n = number of observations). The values of experimental parameters (a & b) were work out with the help of equations 2 and 3.

$$a = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2} \quad \text{---------- (2)}$$

Keeping the above explanation in mind a linear relationship (Regression line) is proposed.

$$y = ax + b \quad \text{---------- (3)}$$

To study the correlation coefficient and the regression analysis of various water quality parameters was carried out utilizing SPSS software version 16.0.

RESULTS AND DISCUSSION

The physico-chemical parameters of the present study values in the groundwater of Pennagaram block are shown in table 1.

Correlation is the mutual connection between the two variables. A straight correlation exists when the decrease or increase in the value of one parameter is related with a subsequent decrease or increase in the value of another parameter. The results of the correlation analysis, which are shown in table 2. The correlation coefficients between various water quality parameters of groundwater of the study area during pre-monsoon season were calculated and the values of correlation coefficients are given.

Table 1: Comparison of drinking water quality with WHO standards

WQPs	WHO limits	Present study value		Total number of samples within the permissible limit	% of samples within the permissible limit
		Min	Max		
pH	6.9–8.5	6.89	8.1	79	98.75%
EC	2000	1601	3421	16	20%
TDS	2000	1111	2374	67	83.75%
TH	500	280	1200	31	38.75%
TA	600	140	800	59	73.75%
Ca^{2+}	200	47.1	249	73	91.25%
Mg^{2+}	150	20.7	195	78	97.5%
Cl^-	600	93.2	702	77	96.25%
SO_4^{2-}	250	26	222	80	100%
NO_3^-	45	18.9	60.1	48	60%
PO_4^{3-}	5	0.64	3.15	80	100%
F^-	1.5	0.27	3.23	36	45%
K^+	12	2	45	44	55%
Na^+	200	61	320	65	81.25%

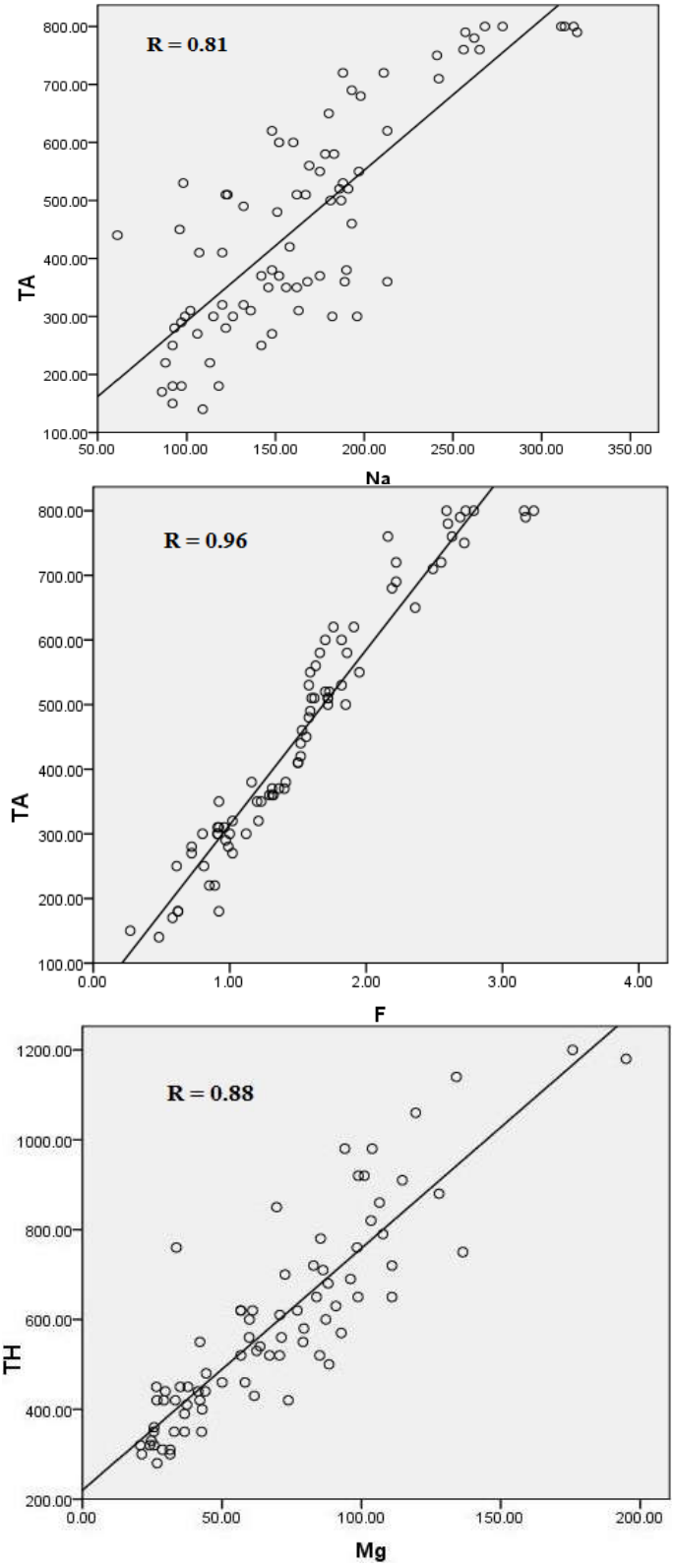
Except **pH – no unit; **EC** (EC in µS/cm) remaining all Parameters are inmg/L*
*****WHO*** *– World Health Organization.*

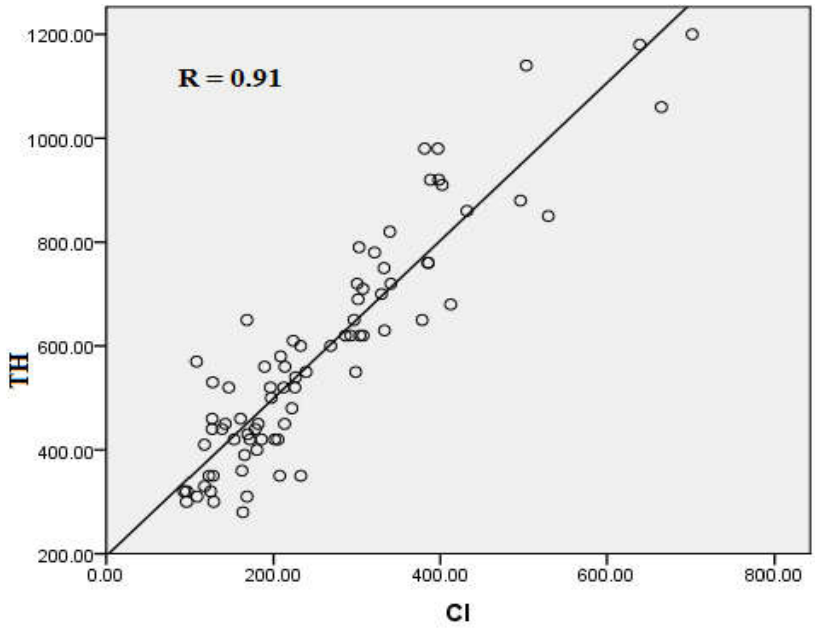
Table 2: Correlations Matrix for the groundwater parameters around Pennagaram Block of Dharmapuri district

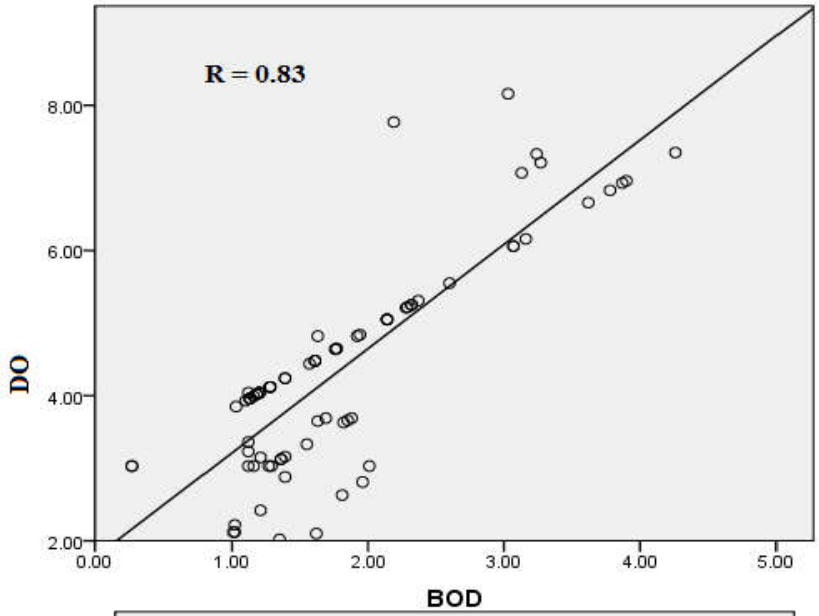
WQPs	pH	EC	TDS	Temp	DO	COD	BOD	TH	TA	Cl^-	SO_4^{2-}	Ca^{2+}	Mg^{2+}	NO_3^-	PO_4^{3-}	F^-	K^+	Na^+
pH	1	.14	.14	-.06	.11	-.01	.12	-.14	**.61****	-.05	-.09	-.19	-.06	-.08	.00	.59**	.35**	.55**
EC		1	**1.0****	-.07	.01	.00	-.05	.55**	.14	.55**	.39**	.43**	.49**	**.67****	.22*	.12	.40**	.33**
TDS			1	-.07	.01	.00	-.05	.55**	.14	.55**	.39**	.43**	.49**	**.67****	.22*	.12	.40**	.33**
temp				1	**-.90****	-.32**	**-.71****	.16	-.24*	.17	.17	.29**	.02	.07	.17	-.26*	-.16	-.19
DO					1	.33**	**.83****	-.08	.23*	-.11	-.09	-.16	-.00	-.09	-.16	.24*	.11	.16
COD						1	.24*	-.06	-.04	-.04	-.02	-.12	-.00	-.02	.08	-.05	.00	.00
BOD							1	-.02	.22*	-.03	-.09	-.05	.00	-.04	-.15	.23*	.06	.14
TH								1	-.22*	**.91****	**.67****	**.79****	**.88****	**.60****	.19	-.21	-.02	-.13
TA									1	-.16	-.15	-.20	-.17	-.08	-.21	**.96****	**.64****	**.81****
Cl^-										1	**.65****	**.73****	**.79****	.48**	.24*	-.11	.11	.08
SO_4^{2-}											1	**.69****	.48**	.37**	.05	-.11	.14	.06
Ca^{2+}												1	.40**	.50**	.05	-.19	-.01	-.06
Mg^{2+}													1	.50**	.24*	-.16	-.02	-.14
NO_3^-														1	.17	-.09	.11	.04
PO_4^{3-}															1	-.22*	-.10	-.09
F^-																1	**.66****	**.82****
K^+																	1	**.68****
Na^+																		1

The value of correlation, regression coefficient, R for the water quality parameters are tabulated in table2. The correlation coefficient measures the degree of association or correlation between two variables. Its shows R more than 0.80, i.e. there is more than 80% association of the data. As we can see the calculated values point up some strong positive correlations between EC and TDS (R = 1), DO and BOD (R = 0.83), TH and Cl^- (R = 0.91), TH and Ca (R = 0.79), TH and Mg (R = 0.88), TH and F (R = 0.96), TA and Na (R = 0.81), Ca and Cl^- (R = 0.73), Mg and Cl^- (R = 0.79) & F and Na (R = 0.82). Similarly strong negative correlations observed between Temp and DO (R = -0.90) & BOD and Temp (R = -0.71). However, some weak correlations observed between EC-TDS and NO_3^- (R = 0.67), TH and SO_4^{2-} (R = 0.67), pH and TA (R = 0.61), TA and K^+ (R = 0.64), Cl and SO_4^{2-} (R = 0.69), F and K (R = 0.66) & K and Na (R = 0.68).
In our study the correlation is thought to be perfect variation in one variable is followed by a subsequent and comparative deviation in the order. The value of correlation coefficient lies between -1 to +1.

Fig.1 positive correlations between the parameters







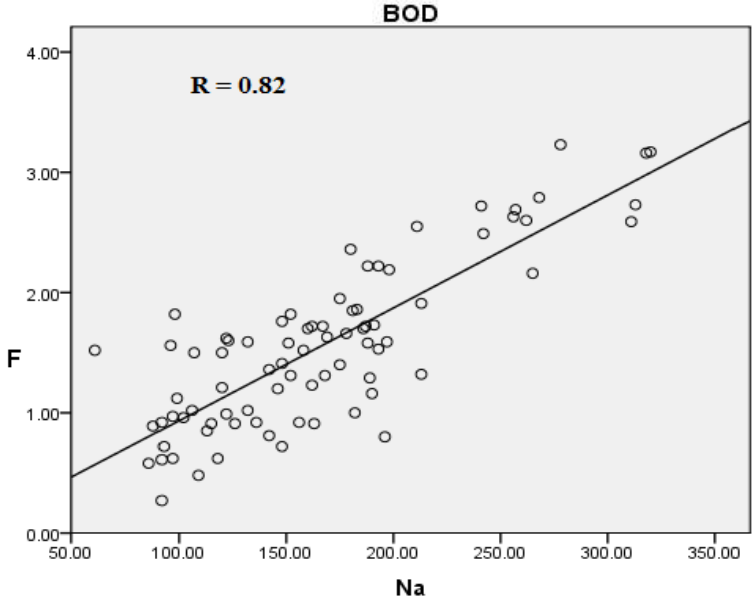
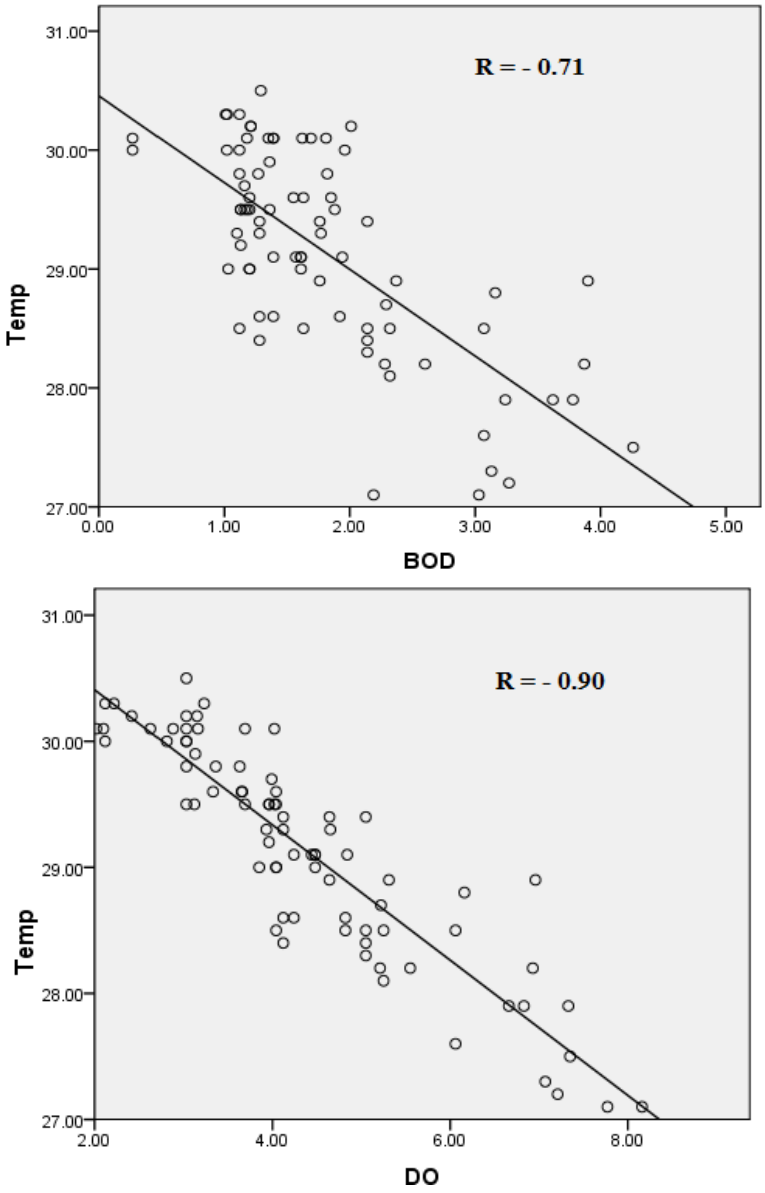


Fig.2 Negative correlations between the parameters



CONCLUSION

Most of the physico-chemical parameters measured in groundwater samples were within the limits set by the World Health Organization. This study realizes that 45% of the groundwater samples were found to be higher (≤ 1.5 mg/L) in fluoride levels and posing a major problem for water resources. The correlation of 16 Physico-chemical parameters of groundwater revealed that all the parameters were more or less correlated with one another. In the correlation, regression study EC, TDS, TH, Calcium, magnesium has a high correlation with most of the other parameters. Since, F^- gives a negative important correlation with Total alkalinity and pH. It may be due to chemical weathering with the influence of various fluoride bearing minerals in the study region. Most of the people in this zone suffer from dental and skeletal fluorosis. It provides an understanding into the problem of fluorosis among people in the study area, where fluorosis is a public health problem of significant impact. Inculcating the people, whereas affected by fluorosis in the Pennagaram block of Dharmapuri district there is compulsory need for defluoridation of the groundwater before consumption.

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