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DEPLETION OF GROUNDWATER QUALITY - A STATISTICAL ANALYSIS ON THE GROUNDWATER QUALITY OF EDAMALAIPATTIPUDUR AREAS OF TIRUCHIRAPPALLI DISTRICT, TAMILNADU, INDIA

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ABSTRACT

A systematic study has been carried out to explore the physico-chemical characteristics of groundwater in Edamalaipatti pudur areas of Tiruchirappalli District. Groundwater samples from Open Well (OW), Bore Well (BW) and Hand Pump (HP) in Edamalaipatti pudur areas during January-March 2014 and they were analysed for pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Calcium Hardness (CH), Magnesium Hardness (MH), Total Dissolved Solids (TDS) and Fluoride (F). The calculated Langelier Saturation Index (LSI) revealed the scale forming nature of the groundwater samples. The relationship between the parameters using the Pearson correlation matrix has also been determined.

KEY WORDS: Groundwater quality in Edamalaipatti pudur, Langelier Saturation index (LSI), Factor Analysis (FA).

1 INTRODUCTION

Water is one of the most important and abundant compounds of the eco system[1]. Water is essential for survival of all living organisms[2]. Groundwater contains various types of

pollutants and several other substances dissolved or suspended in it. The groundwater is getting polluted because of disposal of industrial effluents, hazardous wastes, sewage disposal and deep percolation of pesticides and fertilizers from activated fields[3-6]. The availability of water through surface and groundwater resources has become critical day to day. In India, most of the population depends on groundwater as the main source of drinking water supply[7-9]. Fluoride is an essential trace element for human metabolism. Its concentration in drinking water is the prime factor to decide whether fluoride is beneficial or harmful. In India, research on the assessment of groundwater quality especially with reference to fluoride has been carried out by various workers[10-15]. Hardness of water is mainly due to calcium and magnesium ions. Inadequate intakes of calcium have been associated with increased risks of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, hypertension and stroke, coronary artery disease, insulin resistance and obesity[16]. Statistical investigation offers more attractive options in environmental science and the correlation study provides an excellent tool for the prediction of parametric values within a reasonable degree of accuracy[17].

In the present study, the study was made on the physico-chemical parameters of the groundwater samples collected from Edamalaipatti pudur taluk, Tiruchirappalli, Tamil Nadu, India.

Fig. 1 Satellite map of the study area

2 ABOUT THE STUDY AREA

The study area Edamalaipatti pudur is located in Tiruchirappalli District, South India with the latitude 10° and longitude 78° covering an area about 20 sq. km (Fig.1). Edamalaipatti pudur

is a fast developing area in Tiruchirappalli, Tamil Nadu, India. Most of the cultivation and barren land in the study area are being converted to residential and commercial category, resulting in the increasing in depth of the groundwater table and depletion of groundwater quality.

3 MATERIALS AND METHODS

67 Groundwater samples were collected from various sources viz., Open Well (OW), Bore Well (BW) and Hand Pump (HP) of Edamalaipatti puthur (EP Puthur) areas of Tiruchirappalli District during January-March 2014. Groundwater samples were collected in precleaned and dried 500 ml containers with necessary precautions[18] and the temperature of the water samples was measured on the spot. The collected groundwater samples were tightly corked without any entry of foreign particles and brought to the laboratory for further investigation of other water quality parameters.

The parametric studies carried out were pH, Electrical Conductivity (EC), Total alkalinity (TA), Calcium hardness (CH), Magnesium hardness (MH), Total hardness (TH), Total Dissolved Solids (TDS) and Fluoride (F) using the standard procedures[19] (Table 1).
All the parameters are expressed in milligram per litre (mg/l) except pH (units) and EC. EC is measured in millisiemens (mS).

Table 1. Methods of analysis and instrumental details.

Parameters	Method
Physical parameters	
1. pH	pH meter (Systronics Model 335)
2. EC	Water Quality Analyser (Systronics Model 371)
3. TDS	
Chemical parameters	
1. Calcium Hardness	Volumetric - EDTA method
2. Total Hardness	Volumetric - EDTA method
3. Total Alkalinity	Volumetric - HCl method
4. Fluoride	Spectrophotometry–SPADNS [Sodium-2- (p-sulphophenylazo)-1,8 –dihydroxy-3,6-naphthalene disulphonate), $C_{16}H_9N_2Na_3O_{11}S_3$] method

3.1 LANGELIER SATURATION INDEX

The prediction of calcium carbonate stability is important to find out whether water will precipitate, dissolve or whether it is in equilibrium with calcium carbonate. This is possible by using the Langelier Saturation Index[20] (LSI, also called Langelier Stability Index). Usually, the LSI value ranges from -3 to +3. The LSI is expressed as the difference between the actual system pH and the saturation pH.

LSI = pH - pHs

Where **pH** = -log $[H^+]$,

a = $(\log_{10}[TDS] - 1) / 10$

b = $-13.12 \times \log_{10}(T + 273) + 34.55$

c = $\log_{10}[Ca^{+2}$ as $CaCO_3] - 0.4$

d = $\log_{10}$ [alkalinity as $CaCO_3$]

pHs = pH for a saturated solution of $CaCO_3$,

T = Temperature in ˚C

If the actual pH of the water is below the calculated saturation pH, the LSI is negative, which makes the $CaCO_3$ dissolve in water and the water has a very limited scaling potential. If the actual pH exceeds pHs, the LSI is positive and it is being supersaturated with $CaCO_3$ and the water has a tendency to form a scale. At increasing positive index values, the scaling potential increases. According to Langelier, the corrosive action of water is mainly due to the presence of excess of free CO_2 and carbonates of calcium and magnesium. The interaction of free CO_2 with calcium and magnesium carbonates affects the carbonate equilibrium that leads to corrosion. The lower the pH with high free carbon dioxide, the higher the potential level of corrosion compared with the higher pH with low free CO_2.

4 RESULTS AND DISCUSSION

The Descriptive statistics of the physico-chemical parameters for the groundwater samples in the study area was given in Table 2. The pH values ranges from 6.01 to 7.74. Though maximum number of samples lies under the desirable limit of WHO[21], some of the groundwater samples with lower pH value prove to be corrosive nature. The mean conductivity value lies from 0.10 to 7.05 mS. the higher electrical conductivity value indicates the total ionic composition of water. Some of the groundwater samples in the study area show very high EC values that may be attributed to the presence of large number of dissolved salts.

Table 2. Descriptive statistics of the physico-chemical Parameters for the groundwater samples.

Parameters	Minimum	Maximum	Mean	Std. Deviation
pH	6.01	7.74	6.8491	0.43103
EC	0.10	7.05	2.7452	1.44991
TA	47.60	857.00	481.3821	143.68246
TH	81.60	2036.00	816.0313	364.78914
CH	122.40	1126.10	537.4406	235.36060
MH	8.16	1215.80	287.1872	234.25086
TDS	153.30	3864.00	1384.7209	689.35288
F	0.18	4.86	1.7027	1.17508

The minimum and maximum values of total alkalinity values are 47.60 mg/l and 857.00 mg/l. The high hardness of the groundwater samples was proved by the mean values (816.03 mg/l). The mean value of calcium hardness was high (537.44 mg/l) compared to magnesium hardness (287.18 mg/l) which proves the utmost contribution of calcium ions to the total hardness. The study area was proved to be fluoristic area by the analysed mean value (1.70 mg/l).The dependent nature among the individual parameters was proved by the correlation coefficient values analyzed by Karl Pearson correlation matrix[22] (Table 3).

Table 3. Karl Pearson Correlation matrix for the physico-chemical parameters.

Parameters	pH	EC	TA	TH	CH	MH	TDS	F
pH	1.000	-0.239	-0.030	-0.338**	-0.513**	-0.123	-0.147	-0.018
EC	-0.239	1.000	0.059	0.440**	0.390**	0.320**	0.535**	0.047
TA	-0.030	0.059	1.000	0.077	-0.169	0.075	0.006	0.060
TH	-0.338**	0.440**	0.077	1.000	0.586**	0.606**	0.536**	0.162
CH	-0.513**	0.390**	-0.169	0.586**	1.000	-0.048	0.518**	-0.048
MH	-0.123	0.320**	0.075	0.606**	-0.048	1.000	0.200	0.132
TDS	-0.147	0.535**	0.006	0.536**	0.518**	0.200	1.000	0.131
F	-0.018	0.047	0.060	0.162	-0.048	0.132	0.131	1.000
**. Correlation is significant at the 0.01 level (2-tailed).								

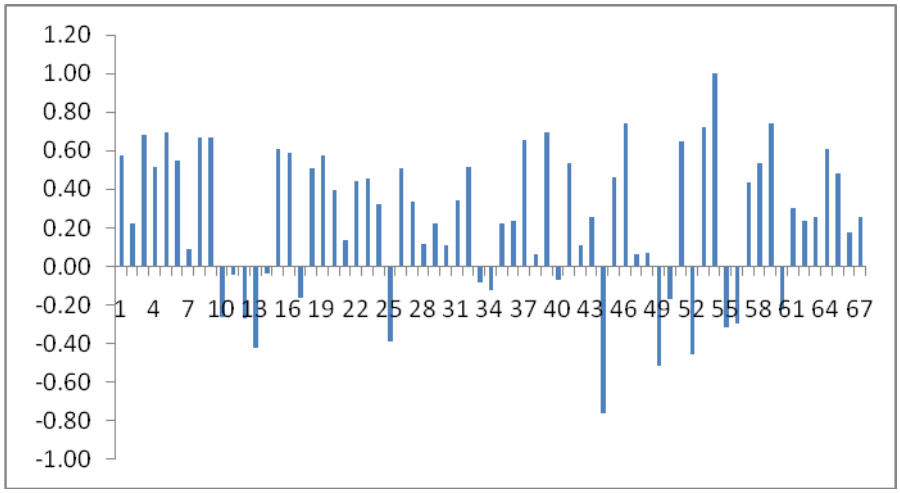


Fig 2 represents the distribution of LSI in the study area. The diagram clearly indicates that the maximum number of groundwater samples seems to be corrosive which must be taken in to consideration.

The Box plots (Fig 3- Fig 6) represent the distribution of TA, TH, TDS and F in the study area.

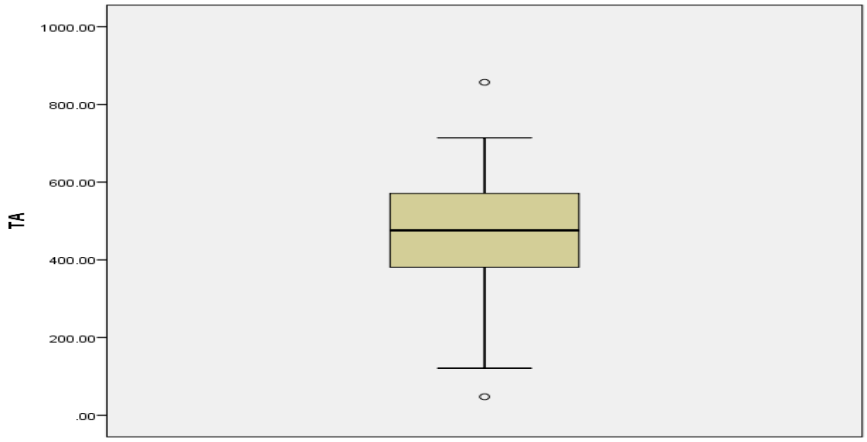
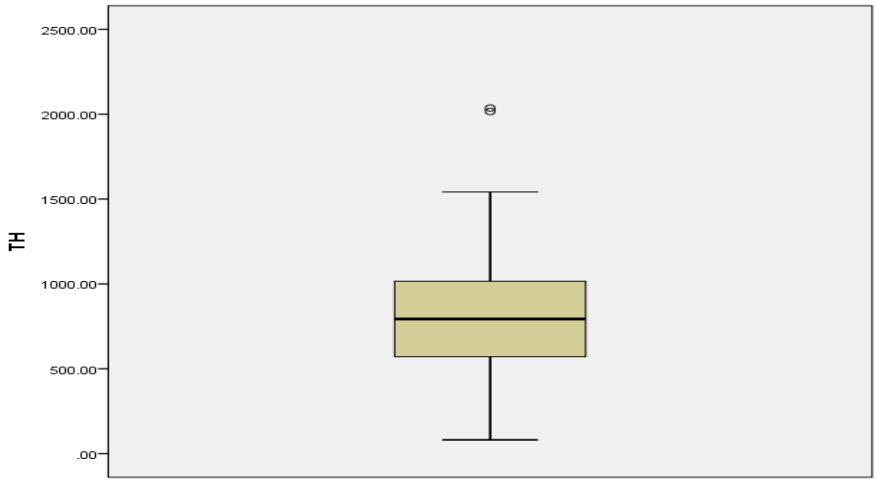


Fig. 3 Box plot for



TA **Fig.**

4 Box plot for TH

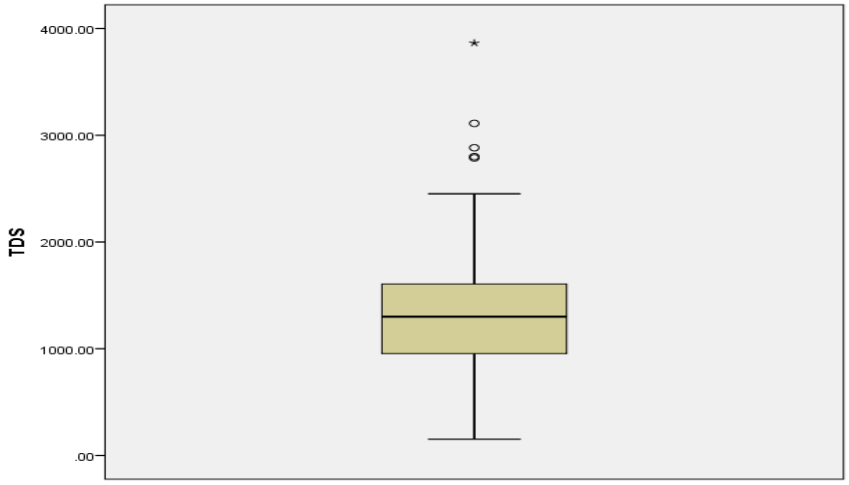


Fig. 5 Box plot for TDS

4.1 FACTOR ANALYSIS

FA was used to understand the correlation structure of collected data and identified most important factors contributing the data structure[23]. FA was also applied to find association between parameters so that the number of measured variable can be reduced. After obtaining correlation matrix and Eigen values, factor loading was used to measure correlation between variables and factors. Table 4 shows the principal component values for the physico-chemical parameters of the present study area. The high loading values proves that the study area contain high values of EC, TH, CH and TDS. Also the positive loading of fluoride proves that the present area is Fluoristic area.

Table 4. Component Matrix

Para meters	Component		
	1	2	3
pH	-.543	.317	-.302
EC	.712	.116	-.061
TA	.033	.582	.572
TH	.853	.212	-.163
CH	.743	-.549	-.001
MH	.483	.686	-.297
TDS	.744	-.049	-.075
F	.277	.005	.723

CONCLUSION

Physico-chemical analysis of groundwater samples were studied and analysed for the groundwater samples collected from the different sources in EP Puthur, Tiruchirappalli district. The study revealed that the study area was predominant in hardness producing ions and fluoride ions. The same was proved by Principal component loadings of Factor Analysis. Hence proper management plan to be executed to avoid serious problems in future. The people in the study area must boil the groundwater and to be consumed. Since Boiling removes the temporary hardness. Also, in the study area the techniques viz., Water Softening, Defluoridation can be implemented in order to avoid adverse health effect on human beings.

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