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Statistical and multivariate analysis of ground water along the coastal aquifers in Palk Strait

Balakrishnan A.[1] and Ramu A.[2*]
[1]Department of Chemistry, Mohamed Sathak AJ College of Engineering, Siruseri, Chennai – 603 103, India
[2]School of Chemistry, Madurai Kamaraj University, Madurai – 625 021, India
ramumku@yahoo.co.in

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Abstract

The main objective of this present paper is to analyze nineteen physico, chemical and biological parameters for twenty five different ground water samples in Palk Strait sea shore area during three seasons like pre monsoon, monsoon and post monsoon. The obtained water quality parameters were used to evaluate the correlation coefficients between various water quality parameters. The regression analysis showed significant linear relationships among different pairs of water quality parameters. A multivariate analysis such as principal component analysis (PCA) was carried out by SPSS software. Results showed that EC, TDS, Total Hardness, Total alkalinity, Chloride, Magnesium and BOD were significantly damaged the ground water system at Palk Strait sea shore area.

Keywords: Ground water, Palk Strait, Correlation, Regression, Principal Component Analysis (PCA).

Introduction

In India ground water is a valuable resource that need to be exploited sustainably to meet the growing demands in various domestic, agricultural and industrial activities[1]. Ground water analysis is a vital role in environmental assessment it has a wide effect on humans health and also in the development of society and economy. For further research on ground water analysis, it is necessary to find an objective and innovative methods for ground water analysis. Since the analysis method of ground water quality is complex in nature with various parameters like pollution index also degree of correlation among the evaluated index is different, each index only can reflect one aspect of ground water quality[2]. This dealing with their relationship among their evaluated indexes gets priority. A correlation and regression coefficient of the water quality parameters helps to assess its overall quality apart from their interrelationship among its parameters[3-5].

Principal Component Analysis (PCA) is a most popular multivariate technique which enables us to describe the information on the components which contributes to the data structure and its interrelationships assumed on mathematical constraints[6-8] which enables us to describe the information with considerably fewer variables than was originally present. The main objective of the present study is to determine the nineteen physico, chemical and biological analysis of twenty five ground water samples at different locations of Palk Strait sea shore area during pre monsoon, monsoon and post monsoon seasons. The obtained results data were used for statistical analysis like correlation and regression analysis. The data were also used for multivariate analysis like Principal Component Analysis (PCA).

Materials and methods

Collection of ground water samples and analysis: Twenty five ground water samples were collected from different locations of bore well and dug well sampling points at Palk Strait sea shore area during various monsoon seasons like pre monsoon, monsoon and post monsoon. The detailed history of study area, its latitude, longitude, sampling stations and location map were presented in the previous paper[9]. The samples were collected in 1litre polythene bottles. Before filling the bottles with samples, they were thoroughly cleaned and rinsed using diluted HNO_3 acid and distilled water. Temperature, pH and EC were determined at the sampling point itself. Chemicals used for the analysis were AR grade.

In this analysis, various water quality parameters were analyzed using standard APHA method[10].

Correlation and linear regression method: Correlation and linear regression method was observed by the relationship between the two variables *viz*., water quality parameters (WQPs), x and y (x is one variable and y is another variable; any two WQPs), obtained by fitting a linear equation to observed data[11]. Direct correlations exist when there is a change in one value of the parameter which is associated with the change in other value of the parameter[12].

A linear regression equation $y = ax + b$, where, y is the dependent variable changes accordingly when x changes. a and b are the slopes of the strait line in the intercept form. To obtain the regression line y on x, Slope (a) and intercept (b) of the line are given by the following equations;

$$R = \frac{(n\sum x_i y_i - x_i y_i)}{(n\sum x_i^2 - (\sum x_i)^2)\,(n\sum y_i^2 - (\sum y_i)^2)} \quad (1)$$

Where: r = correlation coefficient; n = the number of data point

$$A = \frac{n\sum x_i y_i - \sum x_i y_i}{n\sum x_i^2 - (\sum x_i)^2} \quad (2)$$

$$B = y - Ax \quad (3)$$

Where: x is the average value among x_i and y is the average value among y_i.

Results and discussion

Twenty five ground water samples were analyzed for nineteen physico chemical parameters and the experimental results were compared with Bureau of Indian standard (BIS) and World Health Organization (WHO). The results showed that, some of ground water samples have high hardness, EC, TDS, Sodium, Calcium, Chloride, DO, BOD, COD content. From this study, it was observed some of water samples unfit for drinking purposes due to high salt concentration. These high dissolved solids may be due to salt water intrusion. The effect of seasonal changes in various monsoons (Pre monsoon, monsoon and post monsoon) on the physico chemical properties of the water in Palk Strait Sea shore area were also investigated. This study showed that the salt concentration is found to be very high during pre monsoon compared to other seasons; it may be due to water evaporation during pre monsoon season.

Correlation and regression analysis: Correlation coefficients were estimated to identify the highly correlated and interrelated WQPs. The equation of regression can be used for making water quality monitoring. This systematic study on correlation and regression showed significant relationships among the various water quality parameters. This study provided simple and fast method of monitoring water quality for the ground water samples. Higher level correlation significance with various water quality parameters were found by Electrical Conductivity (EC). The water quality parameters include total dissolved solids, total hardness, total alkalinity, chloride, sulphate, calcium, magnesium, sodium and potassium[13]. During pre monsoon in Palk Strait, EC has positive correlation with TDS, TH, THA, PHA, Cl^-, SO_4^{2-} and Ca^{2+} and weak correlation with K^+. During post monsoon in Palk Strait, EC has positive correlation with TDS, TH, THA, PHA, Cl^-, SO_4^{2-}, Ca^{2+}, $Mg^{2+}$and Na^+.

The linear regression analysis has also been carried out (a and b, respectively intercept and slope of the strait line, obeying the linear regression (LR) model equation y=a+bx, where y and x are two different water quality parameters) and linear relationship between any two water quality parameters in Palk Strait sea shore area are given in Table-1.

A typical straight line plot of the linear relationship between two different WQPs *viz.* Electrical Conductivity (EC) and Total Dissolved Solids (TDS) in Palk Strait during pre monsoon is presented in Figure-1.

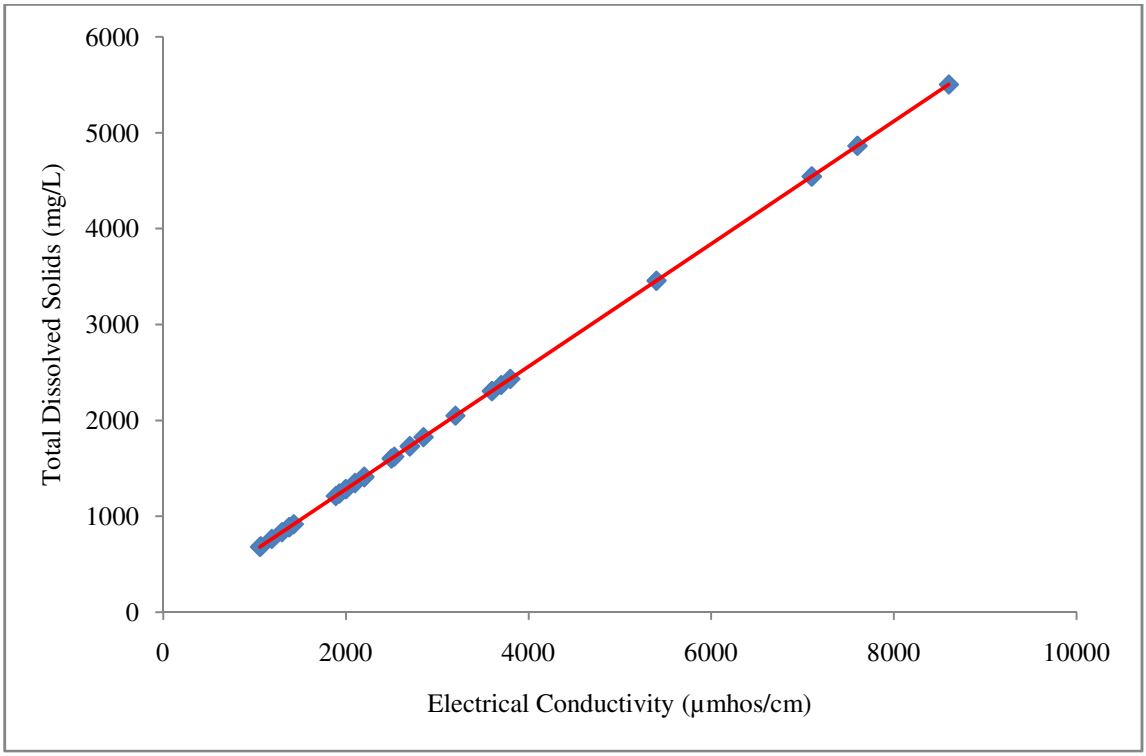

Figure-1: Linear Plot between EC and TDS at Palk Strait during pre monsoon.

Table-1: Least square of the relation (y = ax+b) among significantly correlated parameters in Palk Strait sea shore area.

Pre monsoon					
Y (Dependent)	X (Independent)	Correlation	b	a	Regression equation
TDS	THA	0.660	8.25	631.9	TDS = 631.9 (THA) + 8.25
TDS	TA	0.033	0.374	1039.5	TDS = 1039.5 (TA) + 0.374
TH	Mg^{2+}	0.929	1.82	177.4	TH = 177.4 (Mg^{2+}) + 1.82
Na^+	K^+	0.035	0.502	22.8	Na^+ =22.8 (K^+) + 0.502
Na^+	SO_4^{2-}	0.316	1.25	140.2	Na^+ = 140.2 (SO_4^{2-}) +1.25
Monsoon					
TDS	THA	0.846	10.14	207.8	TDS = 207.8 (THA) + 10.14
TDS	TA	0.222	2.44	965.8	TDS = 965.8 (TA) + 2.44
TH	Mg^{2+}	0.128	1.97	102.6	TH = 102.6 (Mg^{2+}) + 1.97
Na^+	K^+	0.736	0.55	26.0	Na^+ = 26.0 (K^+) + 0.55
Na^+	SO_4^{2-}	-0.080	-0.318	198.4	Na^+ = 198.4 (SO_4^{2-}) - 0.318
Post Monsoon					
TDS	THA	0.851	10.45	198.5	TDS = 198.5 (THA) + 10.45
TDS	TA	0.229	2.60	938.3	TDS = 938.3 (TA) + 2.60
TH	Mg^{2+}	0.954	1.94	60.8	TH = 60.8 (Mg^{2+}) + 1.94
Na^+	K^+	0.044	0.64	30.2	Na^+ = 30.2 (K^+) + 0.64
Na^+	SO_4^{2-}	0.351	1.95	80.01	Na^+ = 80.01 (SO_4^{2-}) + 1.95

The series of LR model is tested by verifying the linear correlation and linear plot the simulated (y) values. The linear relationship between the two different WQPs for the water samples collected during three seasons.

$$y_{cal} = my_{obs} + C \quad (4)$$

Where: y_{cal} and y_{obs} are the calculated and observed WQPs, m and C are the values of slope and intercept.

Principal component analysis (PCA): It is possible to reduce the dimension of variables by providing the correlation between the analyzed chemical variables by a technique is known as Principal component analysis (PCA). It gives the relationship between measured hydrochemical variables by providing multivariate pattern which helps in the classification of original data. It reduces large number of hydrochemical data into a few major factors whose Eigen values in correlation matrix is greater than one[14]. Factor analysis[15-17] was applied to distinguish the partial contributions.

Principal Component Analysis study was also carried out for Palk Strait sea shore area during pre monsoon, monsoon and post monsoon seasons. These results showed that six components such as EC, TDS, TA, bicarbonate, Magnesium and BOD are significantly affected to the ground water system during pre monsoon. During monsoon and post monsoon seasons, five components like EC, TDS, TH, TA and Mg^{2+} were contribute to the ground water pollution. Same type of principle component analysis study was carried out in the area of Sadras, Tamilnadu, India, by Mondal et al[18].

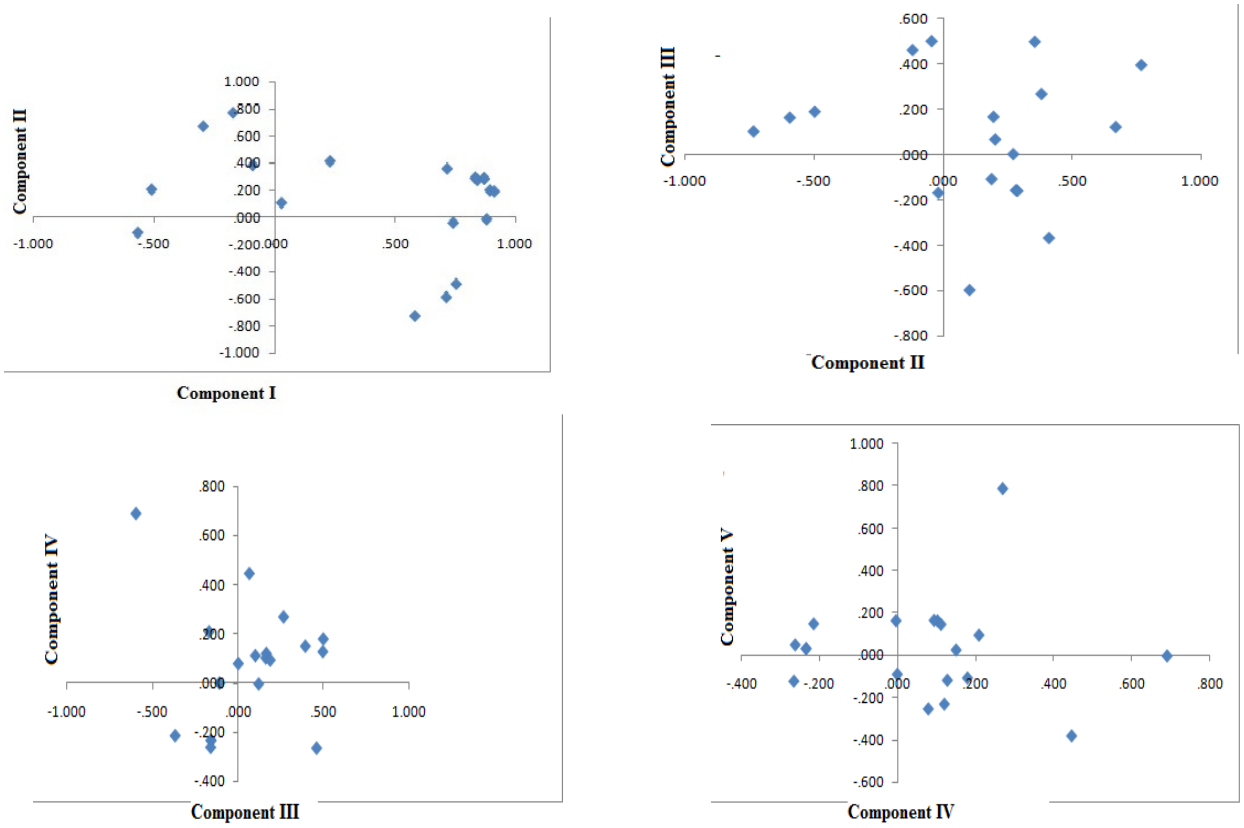

Figure-2: Variation of one component versus other component.

Conclusion

Twenty five ground water samples were collected from different locations of bore well and dug well in Palk Strait sea shore area during the various monsoon periods such as pre monsoon, monsoon and post monsoon seasons. The collected ground water samples were analyzed for nineteen physico chemical parameters and the obtained experimental results were compared with Bureau of Indian standard (BIS) and World Health Organization (WHO). The results showed that, some of ground water samples have high hardness, EC, TDS, Sodium, Calcium, Chloride, DO, BOD, COD content. From this study, it was observed some of water samples unfit for drinking purposes due to high salt concentration. These high dissolved solids may be due to salt water intrusion. The effect of seasonal changes in various monsoons (Pre monsoon, monsoon and post monsoon) on the physico chemical properties of the water in Palk Strait Sea shore area were also investigated. This study showed that the salt concentration is found to be very high during pre monsoon compared to other seasons; it may be due to water evaporation during pre monsoon season.

The statistical analysis was carried out for the experimentally estimated water quality parameters. Correlation coefficients were determined to identify the highly correlated and inter related WQPs. Results of correlation analysis showed that EC and TDS having high correlation with most of the parameters. Electrical conductivity finds higher level correlation significance with many of the water quality parameters, *viz* total dissolved solids, total hardness, total alkalinity, chloride, sulphate, calcium, magnesium, sodium and potassium. Regression equations can be used for making water quality monitoring. A systematic correlation and regression study showed significant linear relationship among different pairs of water quality parameters. Principal Component Analysis (PCA) showed that, EC, TDS, TH, TA and Mg^{2+} were contribute to the ground water pollution.

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