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Correlation between Electrical Conductivity and Total Dissolved Solids in Natural Waters

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ABSTRACT The study aims at establishing the correlation ratio between Total Dissolved Solids (TDS)and Electrical Conductivity (EC) for natural waters such as fresh water , sea water and tender coconut .The EC value can be obtained from in situ conductivity measurements since it is quick reliable and relatively of low cost . Twenty four fresh water , fifteen sea water and twenty eight (eight from pollution free area and twenty from textile industrial belt) tender coconut samples were considered for the analysis various water quality parameters. In sea water, the result indicates 96 % of the variability in TDS could be ascertained to the variable EC. The regression equation for sea water is in the form of y = bx + c where b is the correlation ratio due to ionic species and the intercept c values are assigned to unionic species. In the case of tender coconut, the correlation ratio was found to be 0.63 for samples taken from pollution free residential areas where as the ratio found to be varied between 0.59 to 0.93 in textile industrial belt.

(Electrical Conductivity , Total Dissolved Solids , Sea Water , Fresh Water , Tender Coconut , Correlation ratio , coefficient of correlation (r) Coefficient of Determination (R^2).)

INTRODUCTION

Matter present in the dissolved form consists of inorganic salts and organic matter which is represented in the form of Total Dissolved Solids (TDS) .The inorganic TDS is contributed predominantly by six major ions such as calcium, magnesium, sodium, bicarbonates, chlorides and sulfates and measured gravimetrically. The organic matter contributing to TDS is determined in terms of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

Electrical Conductivity (EC) is a surrogate measure of Total Dissolved Solids (TDS). Electrical conductivity methods are more advantageous as the measurement is faster than gravimetric measurement of TDS and will be highly useful. It is also effective as compared to the laboratory measurements. [1]

The relationship between TDS and EC is a function of the type and nature of the dissolved cations and anions in the water [2]. The relationship between EC and TDS is not directly linear, since the conductive mobility of ionic species is variable. [3]

In general, the TDS – EC relationship is given by equation 1 [4]

$$TDS = (0.55 \text{ to } 0.7)\, EC \qquad (1)$$

This correlation is approximate because nonionic species do not contribute to EC and the individual ionic species have different weights. The actual multiplier depends on the activity of the specific dissolved ions present and the average activity of all ions in the sample which are in turn influenced by the sample temperature, the relative amount of the each ion and the total concentration of dissolved solids in the sample. Measuring the TDS of the preliminary samples gravimetrically and regressing those results against the measured specific conductance of the samples would determine the correlation [5].

METHODS AND MATERIALS

This study has been made to establish the correlation of TDS and EC for natural water as well as to evaluate their individual ion contribution to TDS. In this study 24 fresh water samples , 28 tender coconut samples and 15 sea water samples were analysed .The samples were analysed according to APHA standards and it is listed in Table 1

Table 1: Instrumental / chemical techniques used for chemical analysis of samples.

S.No	Parameters	Techniques used
1.	EC	Conductivity meter with selective electrode and sensor
2.	TDS	Gravimetric (evaporation) method
3.	Na , K	Flame photometer
4.	Ca , Mg	EDTA Titrometric method
5.	SO_4	Spectrophotometer
6.	HCO_3	Acidimetric neutralization
7.	Cl^-	Mohr titrametric & chloride metric

Simple correlation analysis will be used to assess how well the parameters are associated with TDS [8]. Linear regression attempts to model the relationship between TDS and conductivity by fitting a linear equation to the observed data. Conductivity will be considered as an independent variable, and the TDS is considered to be a dependent variable. A linear regression line, (R^2) has an equation of the form $y = bx + c$ where b is slope of the line and c is the intercept.

RESULTS AND DISSCUSSION

Correlation between Electrical Conductivity (EC) and Total Dissolved Solids (TDS) for Fresh Water.

The study area covers the Tiruvallur district located on the northern border of Tamil Nadu, India. The major locations are Avadi, Ambattur , Manavalanagar, Periyapalayam, Redhills, Thiruninravur , Gummidipoodi, etc . The major part of this area is having flat topography with every gentle slope towards east .The altitude of the land surface varies from 10 meters above Mean Sea Level (MSL). In the west to sea level in the east. The area is under lined by various geological formations. Quaternary sediments covers most part of the area and the Archacan crystalline rocks exposed in the southern part of the area (Figure 1). The tertiary shales and clays are exposed in the north western part.

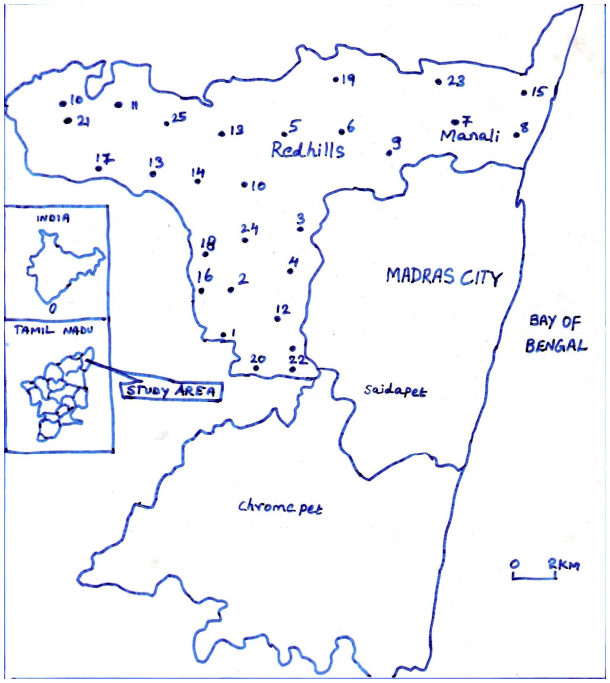

Figure 1: Geology of the area

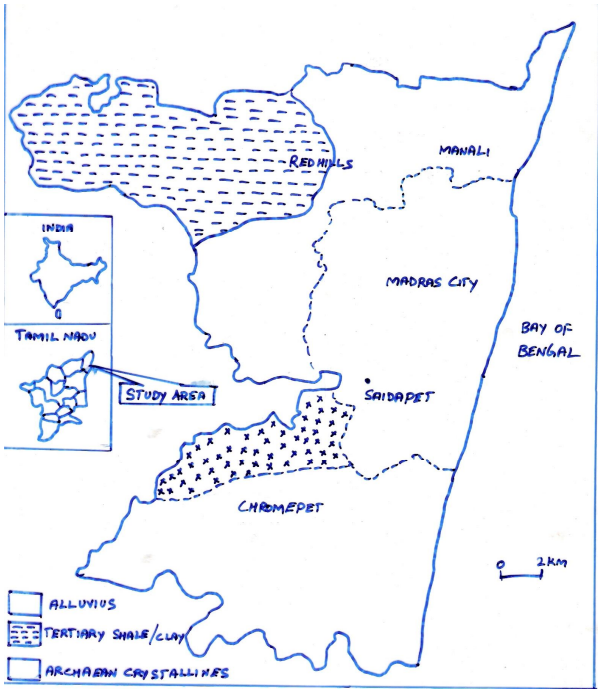

Figure 2: Location Map for fresh water samples

The twenty four water samples were collected in a clean one litre polythene bottles from various sampling wells located in the study area (Fig 2). The water samples were analyzed for various physio chemical parameters such as TDS , EC , HCO_3,chlorides, sodium , potassium , calcium , magnesium , hardness , alkalinity and sulphate as per APHA standards(6).

The TDS – EC relationship [7] as shown in the figure 3 is established and represented in the equation 2

TDS = Constant + 0.65 EC ------ Eqn 2

Table 2: Linear coefficient of correlation (r) among the various parameters in Fresh water

	TDS	EC	Na	K	HCO_3	Cl	SO_4	Ca	Mg
TDS	1	0.99	0.88	0.66	0.41	0.95	0.82	0.88	0.88
EC		1	0.90	0.72	0.42	0.96	0.79	0.90	0.88
Na			1	0.81	0.23	0.89	0.66	-0.20	0.70
K				1	0.08	0.74	0.47	-0.30	0.60
HCO_3					1	0.31	0.14	0.27	0.46
Cl						1	0.73	-0.01	0.87
SO_4							1	0.29	0.70
Ca								1	0.05
Mg									1

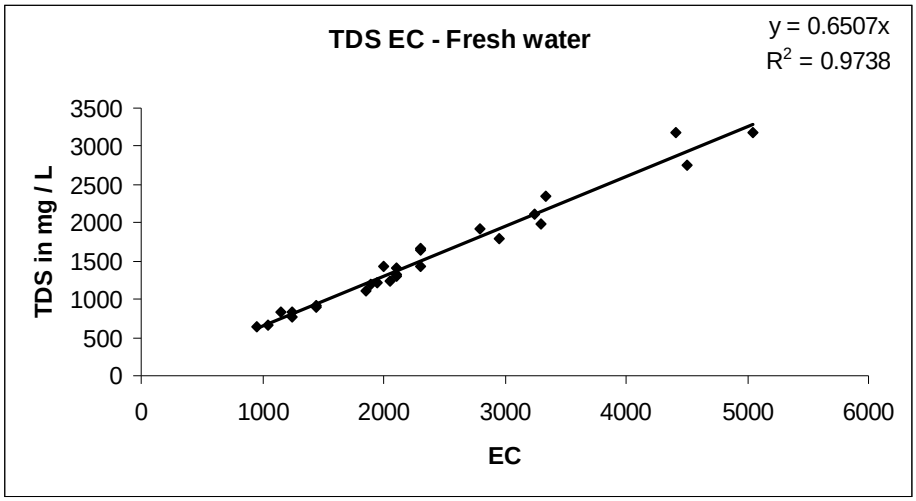

Figure 3: TDS – EC relation for Fresh Water.

The relationship between TDS and EC is a function of the type and nature of the dissolved cations and anions (5). The inter relation among the ions present in the water is represents in the Table 2. The ions such as chlorides sodium, sulphates, calcium, and magnesium are also more correlated with TDS. Of these ions, the percentage contribution of chlorides is around 30% and sulphates is 14% and sodium to extent of 20%.

Correlation between Electrical Conductivity and Total Dissolved Solids for Sea Water.

In the Sea water, the coefficient of determination (R^2) is found to be 0. 77 as shown in the figure 4. For the direct relationship of TDS = 0.71 EC where as the R^2 value is 0.89 for the logarithmic equation of TDS = 54879Ln (EC) -558626 as shown in the Figure 5. So the same correlation ratio is not suitable for all ranges of TDS values.

Though it is present in small quantities, the in organics such as silica, manganese, iron, aluminum, strontium, boron etc present in the sea water can occur in unionized state and contribute to TDS. Hence there is no linear relation between TDS and EC.

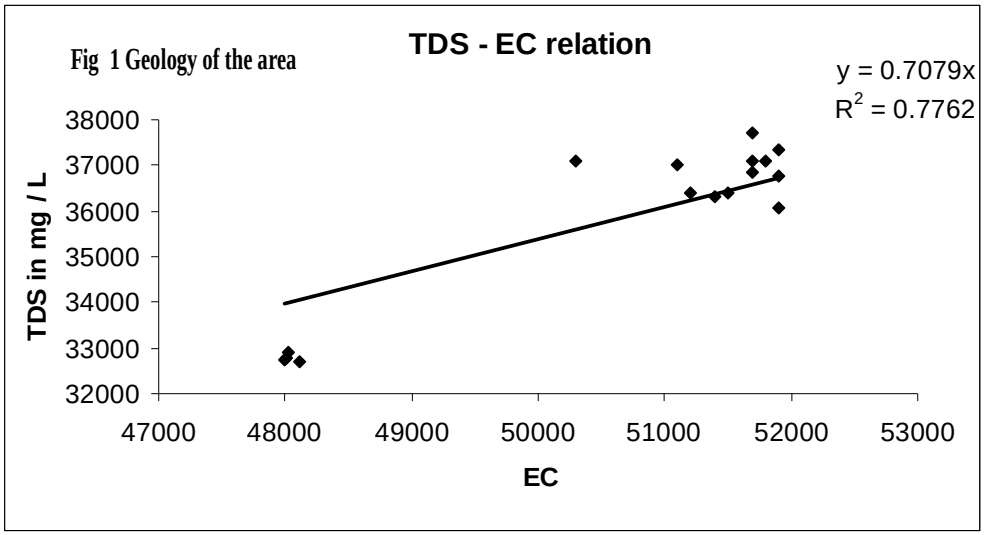

Figure 4: TDS–EC for different coefficient of determination for sea water

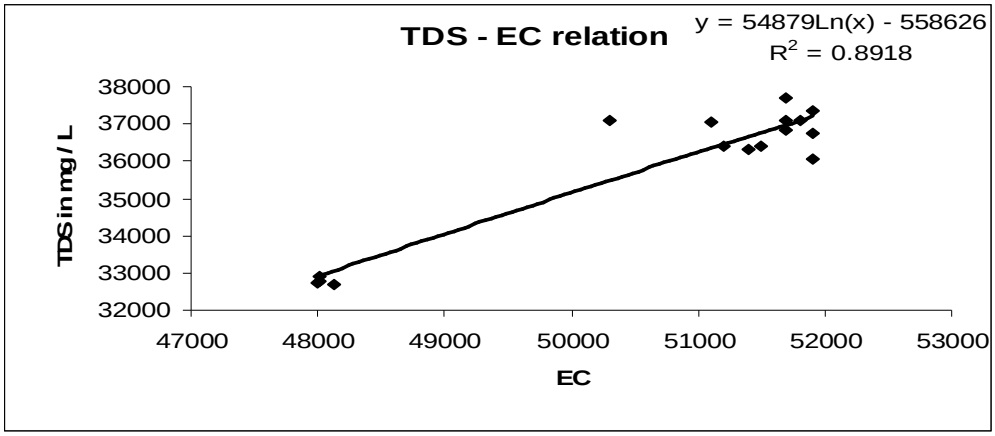

Figure 5: The best fit curve for TDS – EC value in Sea water.

Correlation between Electrical Conductivity and Total Dissolved Solids for Tender Coconut .

Initially eight no. tender coconut samples from the pollution free residential zone, in and around Tiruvallur area were collected and analysed for various water quality parameters. The TDS values ranges from 4200 mg / L to 6500 mg / L and the conductivity ranges from 7200 µs/cm to 9200 µs/cm with the correlation ratio between them being 0.63 as shown in the Figure 6. and the percentage contribution of chlorides is around 22 % as mentioned in Table 4 . The linear inter correlation matrix among the various water quality parameters was arrived as shown in the Table 3.

Table 3: Linear coefficient of correlation (r) for Tender coconut

	TDS	EC	Hardness	Ca	Mg	Cl	SO_4	Alkalinity
TDS	1	0.87	0.20	0.05	0.32	0.67	0.34	0.60
EC		1	0.22	-0.02	0.46	0.88	0.24	0.75
Hardness			1	0.95	0.95	0.35	0.17	-0.16
Ca				1	0.81	0.13	0.18	-0.33
Mg					1	0.54	0.13	0.04
Cl						1	0.09	0.64
SO_4							1	0.40
Alkalinity								1

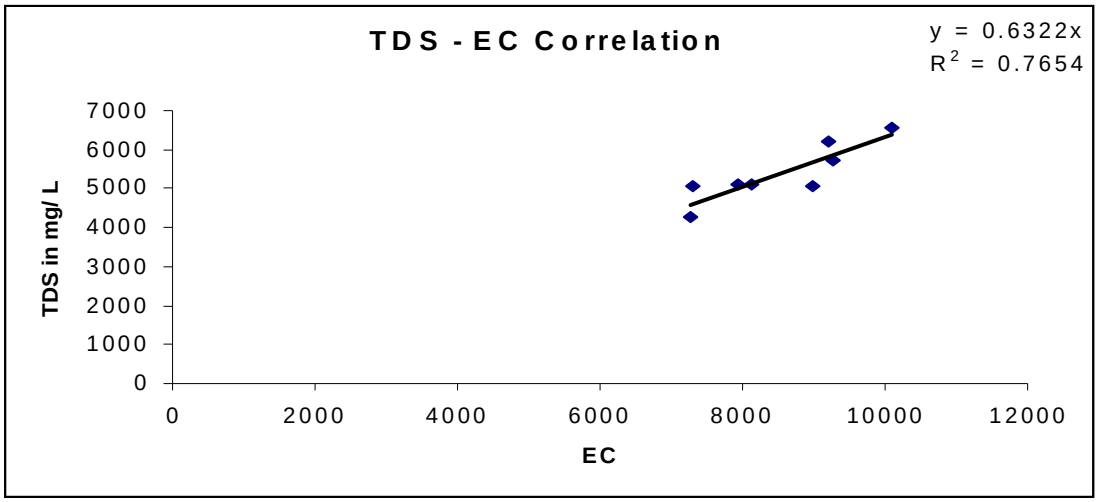

Figure 6: TDS – EC ratio for Tender coconut (Pollution Free area)

Later twenty tender coconut samples from the textile industrial belt, Tirupur town were collected and analysed for TDS, EC and other parameters. The TDS values ranges from 6000 mg / L to 9000 mg / L and the conductivity ranges between 8100 µs/cm and 11500 µs/cm with their correlation ratio widely varying form 0.59 to 0.93. This wide variation in the values of correlation ratio prevails over the individual samples. The value is below 0.69 for 7 samples, between 0.75 to 1 for 13 samples. This wide variation may be due to the fact that the TDS is mainly due to the organic content which in turn depends upon several factors such as the age of the coconut, soil condition, microorganisms present in the soil which helps in fixing of nutrients to the plants and salt resistance of the plants.

Table 4: Percentage contribution of individual ions to TDS

S.No	Inorganics contributing to TDS	Sea water	Fresh water	Tender coconut
1.	**Chloride**	**55.55**	**33**	**22**
2.	**Sulphate**	**14**	**14**	**----**
3.	**Sodium**	**31**	**20**	**----**

CONCLUSION

From the study, it is concluded that a linear relation between TDS and EC exists for fresh water with a correlation ratio of 0.65, where as there is a non linear in the relation ship of TDS and EC for sea water. In the case of tender coconut, The correlation ratio is 0.63 which comply with the fresh water ratio in a pollution free zone but the ratio varies widely between 0.59 to 0.93 in a more polluted area (land contaminated with textile effluent).Finally it is concluded that TDS -EC correlation ratio may not be same for all natural waters and it varies widely with in themselves.

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