Determine of Constant Coefficients to Relate Total Dissolved Solids to Electrical Conductivity

M. Siosemarde, F. Kave, E. Pazira, H. Sedghi and S. J. Ghaderi

***Abstract*—**Salinity is a measure of the amount of salts in the water. Total Dissolved Solids (TDS) as salinity parameter are often determined using laborious and time consuming laboratory tests, but it may be more appropriate and economical to develop a method which uses a more simple soil salinity index. Because dissolved ions increase salinity as well as conductivity, the two measures are related. The aim of this research was determine of constant coefficients for predicting of Total Dissolved Solids (TDS) based on Electrical Conductivity (EC) with Statistics of Correlation coefficient, Root mean square error, Maximum error, Mean Bias error, Mean absolute error, Relative error and Coefficient of residual mass. For this purpose, two experimental areas (S1, S2) of Khuzestan province-IRAN were selected and four treatments with three replications by series of double rings were applied. The treatments were included 25cm, 50cm, 75cm and 100cm water application. The results showed the values 16.3 & 12.4 were the best constant coefficients for predicting of Total Dissolved Solids (TDS) based on EC in Pilot S1 and S2 with correlation coefficient 0.977 & 0.997 and 191.1 & 106.1 Root mean square errors (RMSE) respectively.

***Keywords*—**constant coefficients, electrical conductivity, Khuzestan plain and total dissolved solids.

I. Introduction

SALINITY is a measure of the amount of salts in the soil saturation extracts. Conductivity is the ability of water to conduct an electrical current, and the dissolved ions are the conductors. Electrical conductivity (EC) is a useful indicator of total dissolved solids (TDS) because the conduction of current in an electrolyte solution is primarily dependent on the concentration of ionic species. Conductivity is measured by a probe, which applies voltage between two electrodes. The drop in voltage is used to measure the resistance of the water, which is then converted to conductivity. Conductivity is reciprocal to resistance and is measured in the amount of conductance over a certain distance. The relationship between EC and TDS is complex depending on the chemical composition and ionic strength. However, there are many instances where the relative composition of water is reasonably constant in a given region or study site and, hence, the TDS-EC relation can be established in the laboratory with a reasonable accuracy over a wide concentration range [1]. Measurement of EC is fast and inexpensive. Therefore, under suitable conditions, EC measurements offer a significant advantage over the direct determination of TDS by sampling and chemical analysis [2-7].

Hem (1992) provides a detailed analysis and discussion on the relationship of conductivity to TDS. Hem plotted TDS versus EC data that ranged from about 500 to 3000 mg/L and observed that the data set fit a straight line of regression with a slope of 0.59. Hem (1992) stated that for the range of natural water evaluated the range for the ratio of TDS: EC was 0.54 to 0.96 and that for water high in sulfate could exceed the upper end of the range. Further, Hem (1992) indicated that the slope of the line of regression is not constant over a wide range of dissolved solids concentration. The relationship of TDS to EC is less well defined for waters with TDS exceeding about 50,000 mg/L [8]. In general, the range for the ratio of TDS: EC was (0.55 – 0.7) [10-11] & (0.55 – 0.9) [9].

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 regress those results against the measured specific conductance of the samples would determine the correlation [12].

Ponnamperuma et al. (1966) and Griffin and Jurinak (1973) proposed another equation in which EC was related to an ionic concentration function known as ionic strength [13-14]. Thirumalini1, S. and K. Joseph studied the correlation ratio between Total Dissolved Solids (TDS) and Electrical

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Conductivity (EC) for natural waters such as fresh water , sea water and tender coconut In sea water, the result indicates 96 % of the variability in TDS could be ascertained to the variable EC [11].

Therefore, it is necessary to determine of constant coefficients for predicting of Total Dissolved Solids (TDS) based on EC.

II. Materials and Methods

In all, soil samples were taken along the northern Ahwaz, Khuzestan province, south eastern Iran. Every soil sample was taken in lands with a high risk of salinization and/or sodification. Climate in this region is characterized by dry summers and winters, with 252.1 mm/year rainfall, and 3222.5 mm/year evapotranspiration. These conditions, in addition to the use of high to medium salt-content irrigation water and/or bad drainage, lead to an increased risk of salinization and/or sodification in agricultural areas.

In this work, two experimental areas were selected that Pilot 1 with silty clay texture & S_4A_4 Will Cox classification and Pilot 2 with sandy loam texture & S_3A_2 Will Cox classification and four treatments with three replications by series of double rings were designed. The treatments were included 25cm, 50cm, 75cm and 100 cm water application by Karoon River that Result of chemical analysis listed in Table 1.

TABLE I
RESULT OF CHEMICAL ANALYSIS OF LEACHING WATER QUALITY

Parameters		Pilot S1	Pilot S2
$EC(\frac{dS}{m})$		1.7	1.4
concentration (meq/lit)	Na^{1+}	9.5	7.5
	$Ca^{2+}+Mg^{2+}$	6.9	6.5
pH		8.25	7.98
T.D.S (mg/lit)		1260	993
S.A.R		5.11	4.16
Will Cox classification		C3-S2	C3-S2

EC = electrical conductivity, T.D.S = total dissolved solids, S.A.R = sodium absorption ratio.

The soil samples were air-dried and sieved to 2 mm with subsequent preparation of the saturation extract for each one. The soil saturation extracts samples were analyzed for various physiochemical parameters such as EC, carbonates, bicarbonates, chlorides, nitrates, sulfates, sodium, potassium, calcium, magnesium, hardness, alkalinity and sulphate as per APHA standards.

The aim of this research was determine of constant coefficients to relate total dissolved solids to electrical conductivity with statistics of Correlation Coefficient (R), Root Mean Square Error (RMSE), Significant, Mean Bias Error (MBE), Mean Absolute Error (MAE), Maximum Error (ME), Relative Error (RE), Coefficient of Residual Mass (CRM), Standard Error (SE) and Coefficient of Variation (CV).

III. Result and Discussion

Table 2 was indicated the various statistics of constant coefficient of predicting Total Dissolved Solids (TDS) based on EC in Pilot S1.

TABLE II
VARIOUS STATISTICS OF CONSTANT COEFFICIENT MODELS TO RELATE *TDS* TO *EC* IN PILOT S1

Statistics	CONSTANT COEFFICIENTS		
	10	12	16.3
Correlation Coefficient	0.977	0.977	0.977
Root Mean Square Error	331.0	265.2	191.1
Significant	0.000	0.000	0.000
Mean Bias Error	-116.59	-52.40	85.62
Mean Absolute Error	116.89	61.17	125.81
Maximum Error	1631	1311	623
Relative Error	26.71	13.98	28.75
Coefficient of Residual Mass	0.266	0.120	-0.196
Standard Error	312	351	479
Coefficient of Variation	71.23	80.16	109.43

Mean while presented constant coefficients, 10 & 12, for determining the sum cationic concentration in various references was evaluated. The results showed as per the table the value of 16.3 constant coefficient is much accurate than 10 and 12 constant coefficient in this site (pilot S1). The results showed that the value 16.3 constant coefficient was the best model with correlation coefficient, 0.977, and 191.1 RMSE.

The calculated equation is as follows:

$$TDS\ (meq/lit) = 16.3\ EC\ (dS/m) \quad (1)$$

Also the Comparison between observed and predicted data obtained from the mentioned model has been depicted that indicates good match (Fig. 1).

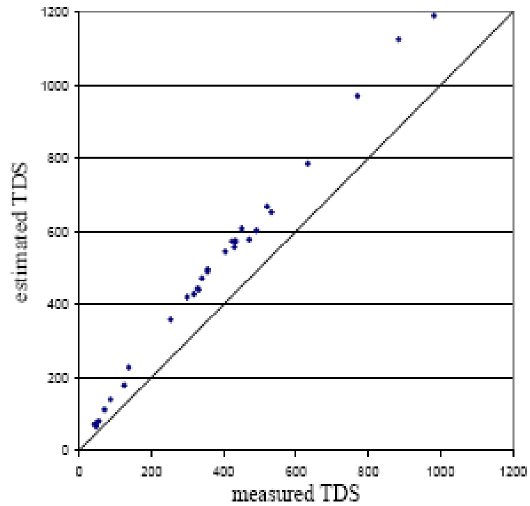

Fig. 1 Comparison of measured Total Dissolved Solids (TDS) and *TDS* estimated from *EC* in pilot S1.

In general, the results showed measured TDS to EC ratio decreased relative to increasing leaching water. In away that measured TDS to EC ratio by application of 25, 50, 75 and 100 cm leaching water obtained 12.3, 11.4, 10.5 and 11.2 respectively in pilot S1.

Also table 3 was indicated the various statistics of constant coefficient of predicting Total Dissolved Solids (TDS) based on EC in Pilot S2. The results showed that 12.4 constant coefficient was the best model with 0.997 correlation coefficient and 106.1 RMSE respectively.

TABLE III
VARIOUS STATISTICS OF CONSTANT COEFFICIENT MODELS TO RELATE *TDS* TO *EC* IN PILOT S2

Statistics	CONSTANT COEFFICIENTS		
	10	12	12.4
Correlation Coefficient	0.997	0.997	0.997
Root Mean Square Error	117.2	106.7	106.1
Significant	0.000	0.000	0.000
Mean Bias Error	-32.71	-2.18	3.92
Mean Absolute Error	33.71	8.79	8.50
Maximum Error	74	32	36
Relative Error	18.19	4.74	4.59
Coefficient of Residual Mass	0.176	0.012	-0.021
Standard Error	112	129	133
Coefficient of Variation	60.64	69.63	71.97

Mean while presented constant coefficients, 10 & 12, for determining the TDS in various references were evaluated. The results showed the mentioned constant coefficients have less precision than 12.4 constant coefficients in pilot S2. The calculated equation is as follows:

$$TDS\ (meq/lit) = 12.4\ EC\ (dS/m) \quad (2)$$

Also the Comparison between observed and predicted data obtained from the mentioned model has been depicted that indicates exact match (Fig. 2).

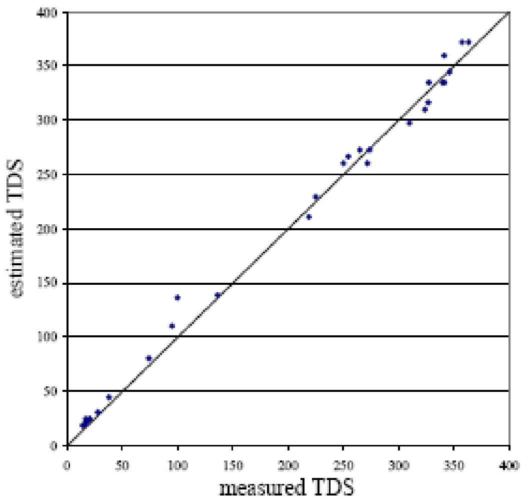

Fig. 2 Comparison of measured Total Dissolved Solids (TDS) and *TDS* estimated from *EC* in pilot S2.

It must be noted that measured TDS to EC ratio generally decreased relative to increasing leaching water. In away that measured TDS to EC ratio by application of 25, 50, 75 and 100 cm leaching water obtained 10.7, 11.2, 10.1 and 10.2 respectively in pilot S2.

IV. CONCLUSION

From the study, it is concluded that the value of *16.3* & *12.4* constant coefficients to relate Total Dissolved Solids *(TDS)* to *EC* in soil saturation extracts has been the best constant coefficients in Pilot S1 and S2 respectively and it was shown that the constant coefficient depend on salinity of soil saturation extracts. Finally it is concluded that *TDS -EC* correlation ratio may not be same for all soil saturation extracts and it varies widely with in themselves. The value of 10 & 12 constant coefficients to relate Total Dissolved Solids *(TDS)* to *EC* can be less correlation & precision than mentioned coefficients. Also, the results showed generally measured TDS to EC ratio decreased to increasing leaching water.

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