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Estimation of saturated soil paste electrical conductivity and soluble salts from extract of different soil to water (1:1, 1:2.5, and 1:5) ratios in non-gypsiferous soils

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Introduction

Soil salinity is a crucial factor contributing to land degradation worldwide and poses a significant threat to sustainable agricultural development, particularly in arid and semi-arid regions. Soil salinity usually quantified by measuring the electrical conductivity (EC) of the extract of saturated soil paste (EC_e). Preparation the saturated soil paste is time consuming and also needs an experienced lab expert to check the saturation criteria. Therefore, there an interest to find an alternative extract that obtains more quickly with easier lab work, while it is reliable and represents the soil solution. The objectives of this research include determining the relationship between the electrical conductivity of saturated paste extract (EC_e) and the electrical conductivity (EC) of different ratios of soil to water extract (EC1:1, EC1:2.5, EC1:5) in different soil textures (fine, medium and coarse). Additionally, the aim is to determine and evaluate the relationship between the electrical conductivity and soluble salts of saturated soil past extract and different ratios of soil to water in non-gypsiferous soils.

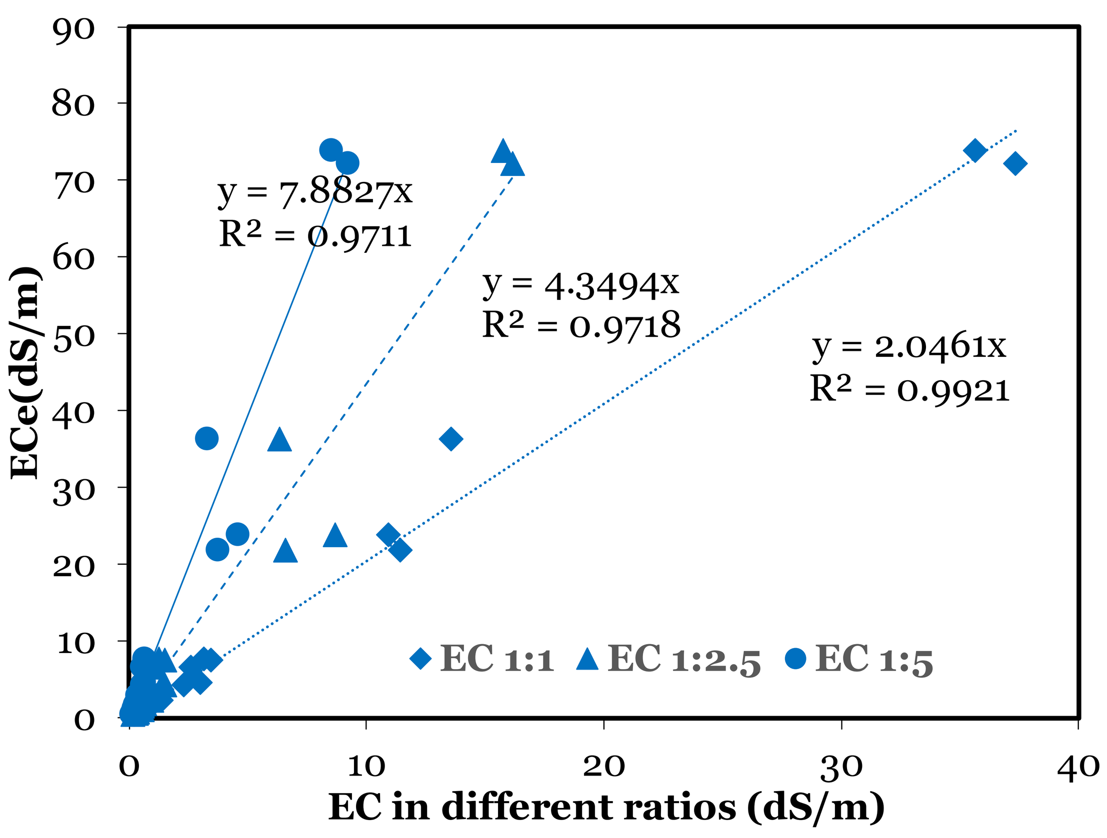

Figure 1: The relationship between ECe and $EC_{1:1}$, $EC_{1:2.5}$, $EC_{1:5}$ in fine-textured soils.

Methodology

In the current study, 64 non-gypsiferous soil samples were selected from different regions of Iran. The samples were air-dried, ground, and passed through a 10 mesh sieve. Different soil properties including ECe, EC1:1, EC1:2.5, EC 1:5 of the saturated extract, soluble cations, soluble anions, and soil texture were measured. The relationship between the results of different extracts were studied and accuracy of different relationships were evaluated using different tests including Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and deviation from 1:1 line.

Table 1: The relationship between cations and anions in saturated extract and different ratios extracts (1:1, 1:2.5, 1:5) in total soils.

Cation/Anion	Regression Eq.	R^2
Na^+	$Na_e^+ = 2.39\ Na_{1:1}^+$	**0.987**
K^+	$K_e^+ = 1.97\ K_{1:1}^+$	**0.971**
Ca^{2+}	$Ca_e^{2+} = 2.43\ Ca_{1:1}^{2+}$	**0.952**
Mg^{2+}	$Mg_e^{2+} = 1.96\ Mg_{1:1}^{2+}$	**0.921**
Cl^-	$Cl_e^- = 4.22\ Cl_{1:1}^-$	**0.988**
HCO_3^{2-}	$HCO_{3\ e}^- = 2.42\ HCO_{3\ 1:1}^-$	**0.963**
Na^+	$Na_e^+ = 6.72\ Na_{1:2.5}^+$	**0.977**
K^+	$K_e^+ = 2.77K_{1:2.5}^+$	**0.921**
Ca^{2+}	$Ca_e^{2+} = 5.61\ Ca_{1:2.5}^{2+}$	**0.970**
Mg^{2+}	$Mg_e^{2+} = 4.65\ Mg_{1:2.5}^{2+}$	**0.957**
Cl^-	$Cl_e^- = 10.12\ Cl_{1:2.5}^-$	**0.976**
HCO_3^{2-}	$HCO_{3\ e}^- = 3.89\ HCO_{3\ 1:2.5}^-$	**0.901**
Na^+	$Na_e^+ = 18.14\ Na_{1:5}^+$	**0.982**
K^+	$K_e^+ = 4.13\ K_{1:5}^+$	**0.927**
Ca^{2+}	$Ca_e^{2+} = 7.74\ Ca_{1:5}^{2+}$	**0.926**
Mg^{2+}	$Mg_e^{2+} = 12.56\ Mg_{1:5}^{2+}$	**0.924**
Cl^-	$Cl_e^- = 13.59\ Cl_{1:5}^-$	**0.993**
HCO_3^{2-}	$HCO_{3\ e}^- = 4.72\ HCO_{3\ 1:5}^-$	**0.875**

Results and Discussion

The results demonstrated that in the fine-textured soils (Figure 1), $EC_e = 2.04 \times EC_{1:1} = 4.3 \times EC_{1:2.5} = 7.9 \times EC_{1:5}$. However, in the medium-textured soils (Figure 2), $EC_e = 2.33 \times EC_{1:1} = 5.5 \times EC_{1:2.5} = 9.9 \times EC_{1:5}$. Moreover, in all the soils (Figure 3), $EC_e = 2.28 \times EC_{1:1} = 5.22 \times EC_{1:2.5} = 9.4 \times EC_{1:5}$. Also, the results of the validation of different relationships showed that the soil to water ratio of 1:1 due to the lower RMSE, lower MAE, and lower percentage of error, closer equation slope to 1:1 line, and higher determination coefficient (R^2=0.99) provides a more accurate estimate of EC_e compared to the other soil to water ratios. Moreover, the transfer function between the soluble Na^-, K^-, Ca^{2-}, Mg^{2-}, Cl^-, and HCO_3^- by saturated extract and 1:1 extract was 2.38, 1.97, 2.34, 1.95, 4.22, and 2.42 respectively.

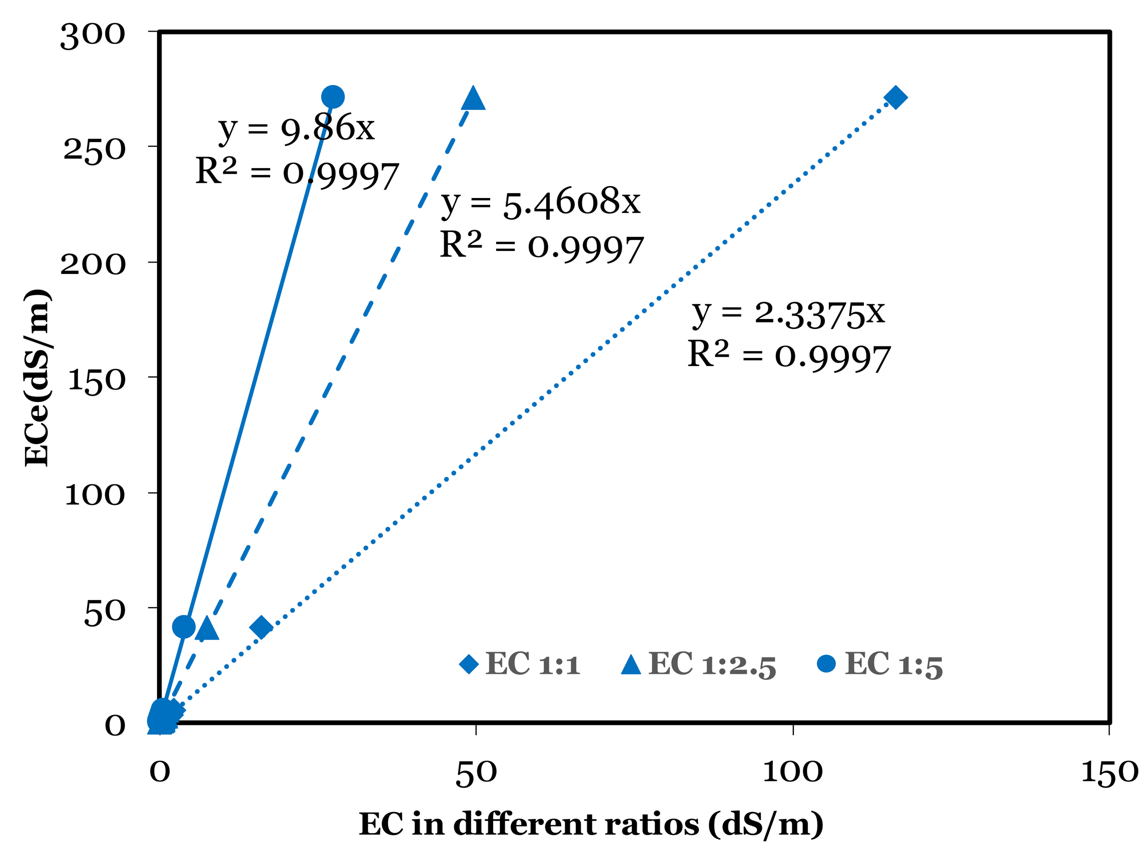

Figure 2: The relationship between ECe and $EC_{1:1}$, $EC_{1:2.5}$, $EC_{1:5}$ in moderate-textured soils.

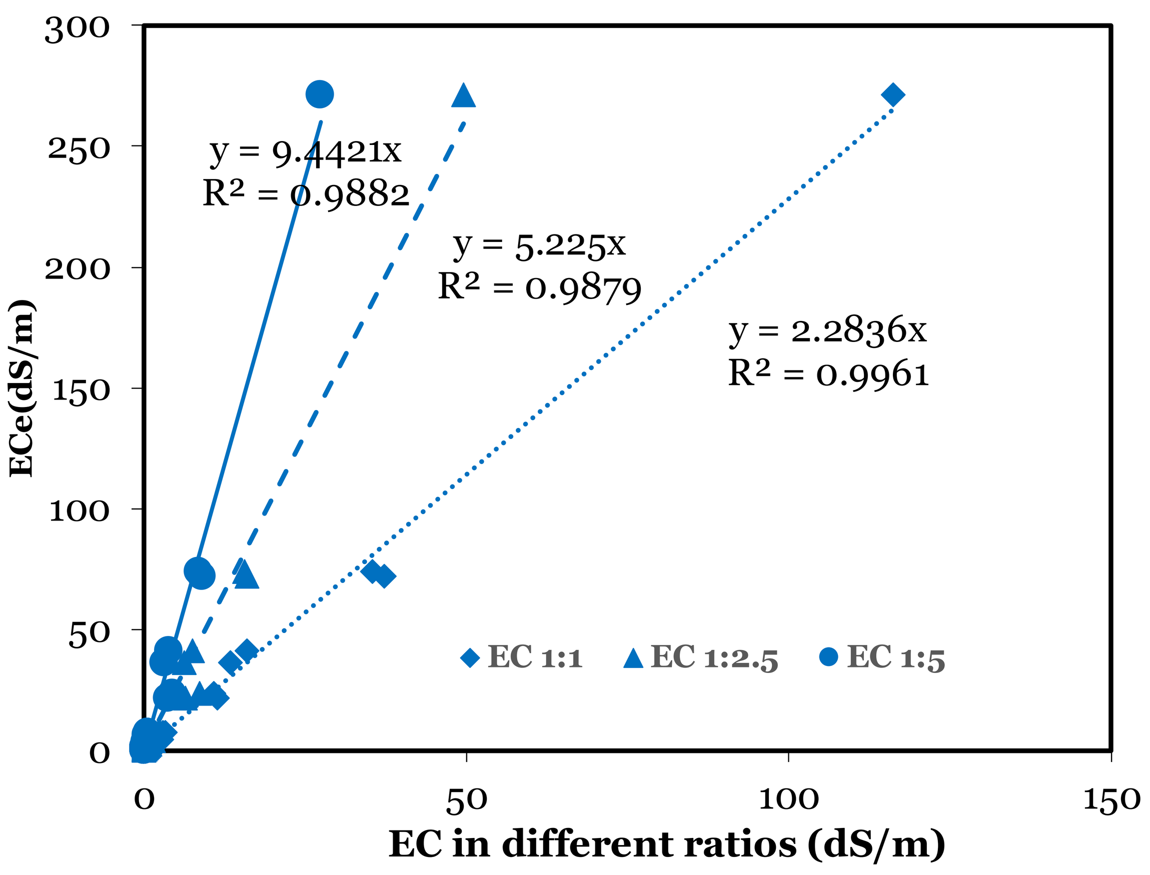

Figure 3: The relationship between ECe and $EC_{1:1}$, $EC_{1:2.5}$, $EC_{1:5}$ in total soils.

These transfer functions increases to 6.72, 2.76, 5.61, 4.65, 10.1, and 3.89 in 1:2.5 extract, and to 18.1, 4.13, 7.74, 12.5, 13.6 and 4.71 in 1:5 extract, respectively (Table 1). Increasing the water to soil ratio caused a dilution in the soil extracted and decreasing trend in EC. In different soils, depending on the climate and soil properties especially soil texture (clay content), different relationships between the EC_e and EC with different ratios are applicable and therefore different transfer functions are required. The difference in the transfer functions could be attributed the difference in salts solubility, type and quantity of the soil colloids. Soil colloids can adsorb the soluble salts (cations or anions) and therefore reduces the measured soil EC. Moreover, due to the difference in salts solubility (for example gypsum), some of the salts dissolves at higher water to soil ratios and therefore increases the soil EC.

Conclusions

The electrical conductivity of saturated extract (ECe) and also soluble salts can be estimated with acceptable accuracy from EC1:1 when it is multiplied by ~2 and it is recommended.

References

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Acknowledgements

The authors thank the Soil and Water Research Institute, Soil Chemistry, Physics, and Fertilizer Technology Department for their financial support (Grant No; 000824-021-10-10-2).

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