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Prognostication of the quantity of reclamation water requirement for salt leaching of problematic soils via empirical simulation models in South of Iran

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Abstract

Study area called "Mianab – Shushtar" is located in the middle part of the Khuzestan province, Iran. Soil survey and land evaluation conducted in the area should that from the total area of about 41855 ha, almost over 14100 ha (33.7%) faced with the problem of salinity/or salinity and sodicity, with different levels. In order to determine the possibility of their desalination and desodification, 6 experiments of salt leaching with a depth of 1.0 meter in 4 intervals of 0.25 m water application were done in the same area. Soil samples were taken before, during and after each dose of leaching water application .The collected samples sent to the laboratory to be analyzed. The source of applied water was from the Karun River, which can be considered as suitable, according to USSL (1954). Data obtained from soil and water analysis in the leaching experiments, were treated by making use of different softwares such as SPSS and Curve Expert. Results showed that reclamation of the soils of the study area seems to be possible and there is no need to use any chemical amendment in this sense. Also detail studies created a new empirical mathematical relationship for estimating the amount of reclamation water requirement, and prediction of the final soil salt salinity or final soil sodicity (ESP). As a result it was concluded that if some type of drainage system (open or subsurface) is installed with optimum distance and depth and also leaching practices with appropriate water depth is carried , there is a good possibility for physic-chemical reclamation of the soils in the study area. As there are rich source of natural calcium in the soils and in applied irrigation water, it seems that no special problem is expected.

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Introduction

The most important parameter in saline soils and Sodic-Saline soils is determination of relevant leaching method along with estimation of water amount needed in the procedure of leaching dissolved salts from the soil profile (Pazira *et al.*, 1999).

As it is a very time and cost consuming procedure and due to the existing limitations in the fields, it's better to use computer simulation models along with some field controls in order to estimate the amount of water in the process of leaching. Different studies prove that it gives reasonable results (Pazira *et al.*, 1981; Mashali, 1989; Nogués *et al.*, 2000). Scientists have done some experiments in this regard. The main object of this research is to determine the most relevant empirical models for desalination of the soils, also determination of water amount needed and estimation of salinity and final (ESP) of the soils in the study area has been taken into account.

Saline and Sodic soils make up 13% of the total arable lands of the world. One of the main problems in the field of agriculture is land salinity. Various Studies show that using salty water, severe evaporation, insufficient leaching and deficit irrigation are the main causes of land salinity. In the salty soils due to the increase in the soluble salts, the water absorption via osmotic processes is disrupted (Bahçeci̇, 2009). This In turn, results in growing disorders (Lal *et al.*, 2003).

Reclamation of salt affected soils is accomplished by either an addition of chemical amendment commonly mixed with the upper parts of the soil or directly dissolved in water, or recently by planting crops capable of accumulating salts (phytoremediation) in their parts (Qadir *et al.*, 2002).

In Jordan, it is estimated that more than 30% of agricultural land in the Jordan valley is salt affected soils (Mashali, 1989). Salinity and sodicity problems are expected to be enlarged in future as a result of using poor quality irrigation water (Gharaibeh *et al.*, 2009).

Moreover, little work has been done to evaluate the efficiency of moderate saline-sodic water in soil reclamation. It is reported that such water contains adequate calcium and magnesium ions that can potentially prevent destruction of soil structure and improve water penetration (Mace, 2001).

The main purpose of this study was to determine the most appropriate experimental models for predicting the final salinity and exchangeable sodium percentage (ESP) of regional soils in response to water applications to achieve desalinization and desodification of the soils.

Methods and materials

Soil texture of the study area is varied from moderate to heavy and very heavy. As for the land classification, it should be noted that they are located in class from S_3-A_3 to S_4-A_3 (very saline and sodic). The research took place with 6 experiments with applied water depth of 100 Cm. (in 4 alteration of 0.25 m. Before any operation, samples of the soils were taken down to the depth of 1.5 meters using auger drills. The samples were sent to the lab so that soil texture, moisture rate, color and grey taint and other chemical tests to be done (Sarraf, 2008; Vahdat *et al.*, 2010).

In all experiments, water supply source were Gargar and Shatit (Karoon river streams). Applied water quality is classified in the category of C_3-S_2 according to Wilcox diagram (Sarraf, 2008). after soil sampling and Physic-Chemical tests, 4 types of desalinations were considered and best models were fitted on them. In each model statistical parameters such as regression (R^2) and standard error in (S.E) the significant area of 1% were analyzed.

Discussion and conclusion

As noted before, derived data from different experiments of leaching procedures (desalinization and removing of sodium particles off the soils) were combined and tried to interpret them into mathematical manner. In this regard, desalinization of the soils were analyzed using softwares such as

SPSS and Curve Expert and finally 4 models (Semi-Log, Inverse, Power, Exponential) were fitted and concluded that:

a)

b) Salinazation of the Soils: Best fitted mathematical model is as follow:

$$Y = 0.6227 \times e^{-1.5152x}$$

Where in regression coefficient is R^2 = 0.4636, standard error is S.E = 0.1764 and it is significant in 1%. After substitution of X and Y in Equation (1), the noted formula would be as follow:

$$\left(\frac{EC_f - EC_{eq}}{EC_i - EC_{eq}}\right) = 0.6227 \times e^{-1.5152(Dlw/Ds)} \quad (2)$$

In order to estimate net water needed for leaching (Dl_w), using Equation (2) the following formula was used:

$$Dl_w = 0.66 \times D_s \times \ln\left[0.6227\left(\frac{EC_i - EC_{eq}}{EC_f - EC_{eq}}\right)\right] \quad (3)$$

Also for predicting final EC, using Equation (2) following equation can be used:

$$EC_f = (EC_i - EC_{eq})\left[0.6227 \times e^{-1.5152(Dlw/Ds)}\right] + EC_{eq} \quad (4)$$

Where in EC_i and EC_f are Soil EC before and after leaching respectively (dS/m), EC_{eq} = Soil EC after equilibrium (dS/m), Dl_w = net leaching water depth (m),

D_S = Soil depth which in reclamation is due to be done (m), It should be noted that using Equation (3), (4) can be valid in heavy to very heavy soils and salinity amount between 7.12 to 30.8 (dS/m) or 9.41 to 31.80 (dS/m) percent only.

c) Removing Sodium Particles off the Soils: Best fitted mathematical model is as follow:

$$Y = 0.7184 \times e^{-0.5015x}$$

Where in regression coefficient is R^2 = 0.2631, standard error is (S.E) = 0.2543 and it is significant in 1%. After substitution of X and Y in Equation (5), the noted formula would be as follow:

$$Dl_w = 2 \times D_s \times \ln\left[0.7184\left(\frac{ESP_i - ESP_{eq}}{ESP_f - ESP_{eq}}\right)\right] \quad (6)$$

(1)

In order to estimate net water needed for leaching (Dl_w), using Equation (6) the following formula was used:

$$\left(\frac{ESP_f - ESP_{eq}}{ESP_i - ESP_{eq}}\right) = 0.7184 \times e^{-0.5015(Dlw/Ds)} \quad (7)$$

Also for predicting final ESP_f using Equation (6) following equation can be used:

$$ESP_f = (ESP_i - ESP_{eq})\left[0.7184 \times e^{-0.5015(Dlw/Ds)}\right] + ESP_{eq} \quad (8)$$

Where in ESP_i and ESP_f are ESP before and after leaching respectively (dS/m),

ESP_{eq} = Soil ESP after equilibrium (dS/m), Dl_w = Net leaching water depth (m), D_S = Soil depth which in reclamation is due to be done (m).

The Desalinization and Desodification Curves

(Dieleman, 1963; Gardner *et al.*, 1957; Rajabzadeh, 2009).

Applying the relations (2) and (7) which are the best experimental models for the studied region soil's desalinization and desodification, desalinization and desodification curves for the tested soils were drawn (Fig.s 1 and 2).

It is possible to estimate the net water depth (Dl_w) to reduce the salinity or exchangeable sodium percentage of the soil to desirable levels using these curves. The extracted values from the aforementioned curves are the net needed water depth for leaching the soluble salts. In order to estimate the total (gross) required water for leaching (D_w), the lack of moisture (5)
of the respective soil layer (up to the field capacity),

evaporation (from water and soil surfaces) and the rainfall shall be considered and applied in calculations and planning for leaching and improving the soil and lands (Jurinak *et al.*, 1990; Pazira *et al.*, 1981 and 1999; Sarraf, 2014).

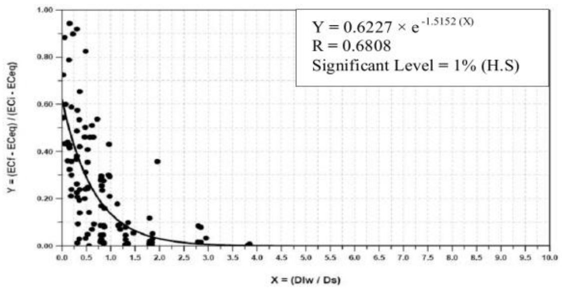

Fig. 1. Compositional Curve of the Tested Soils Desalinization Studies Results (Desalinization leaching curve).

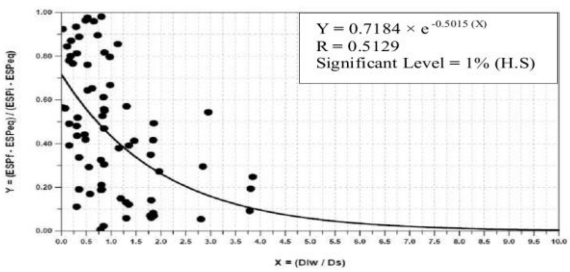

Fig. 2. Compositional Curve of the Tested Soils Desodification Studies Results (Desodification Leaching Curve).

Also, it should be noted that the noted equations can be valid in heavy to very heavy soils and salinity amount between 7.12 to 30.8 dS/m or 9.41 to 31.80 percent only.

For instance, if it is due to reach initial salinity EC_i equal to 40 (ds/m) and average soil profile to EC_f equal to 2.65 (ds/m), using Equation (1) and substitution of X and Y in Equation (2) the noted parameters solved then:

$$Dl_w = 0.66 \times 0.5 \times \ln\left[0.6227\left(\frac{40-3.68}{8-3.68}\right)\right] = 0.48\text{m} \qquad (9)$$

So (Dlw) would be equal to 0.48 m and if ESP_i = 31 and ESP_{eq} = 4.56, then using equation (5) after substitution of X and Y in Equation (6) ESP_f would be equal to 15.85.

It should be noted that this is the net water depth (Dl_w) needed for leaching salinity off the soil profile and for determination of total water needs for leaching operation (gross D_w), moisture deficit (up to field capacity), evaporation rate(from both soil and water surface) and precipitation amount during leaching process, should be considered into account. These are integrated parameters in the management of leaching and reclamation of the lands. Also it is concluded that percolation ratio in the tested soils in the first and last water use periods, are changeless or shows a little decrease and this is due to existing calcium sources in the soil and partly due to leaching water quality too. So in comparison with other studies in the study area, it is concluded that in the permanent Waterlogging method and in the similar circumstances, decreasing rate of dissolved salts and soil ESP is the same but regarding to experimental duration, in the alternative Waterlogging method, takes more time (Pazira, 1999; Sarraf *et al.*, 2010).

References

Dieleman PJEd. 1963. Reclamation of Salt Affected Soils in Iraq. I.L.R.L. Wageningen, the Netherlands.

Gardner WR, Brooks RH. 1957. A Descriptive Theory on Leaching. Soil Science, **83**, 295-304. http://dx.doi.org/10.1097/00010694-195704000-00005

Gharaibeh MA, Eltaif NI, Shunnar OF. 2009. Leaching and reclamation of calcareous saline-sodic soil by moderately saline and moderate-SAR water using gypsum and calcium chloride, J. Plant Nutr. Soil Science, **175(5)**, 713-719. http://dx.doi.org/10.1002/jpln.200700327

İdris Bahçeci. 2009. Determination of salt leaching and gypsum requirements with field tests of saline – sodic soils in central Turkey, Irrigation and Drainage **58(3)**, 332–345. http://dx.doi.org/10.1002/ird.406

Jurinak JJ, Suarez DL. 1990. The chemistry of salt-affected soils and waters. In K.K. Tanji, ed. Agricultural salinity assessment and management.

ASCE **(71)**. New York, the United States of American Society of Civil Engineers. http://dx.doi.org/10.1061/9780784411698.ch03

Lal P, Chippa BR, Arvind, K. 2003. Salt affected soils and crop production, a modern synthesis, AGROBIS (India).

Mace JE, Amrhein C. 2001. Leaching and reclamation of a soil irrigated with moderate SAR waters, Soil Science Journal, **65**,199-204. http://dx.doi.org/10.2136/sssaj2001.651199x

Mashali AM. 1989. Salinization as a Major Process of Soil Degradation in the Near East, Land and Water Development Div., FAO-AGL/RNEA--LWU/89/9, FAO: Rome (Italy), 1989, 1-9.

Nogués J, Herrero J, Rodríguez-Ochoa R, Boixadera J. 2000. Land Evaluation in a Salt-Affected Irrigated District Using an Index of Productive Potential **25(2),** 143-152. http://dx.doi.org/10.1007/s002679910011

Pazira E, Kawachi T. 1981. Studies on Appropriate Depths of Leaching Water Iran, A Case Study. Jour. Integ. Agr. Water Use and Fresh. Reservoir **6**, 39-49. Faculty of Agriculture, Kyoto University. Japan.

Pazira E, Keshavarz A. 1999. Studies on Appropriate Depth of Leaching Water, A Case Study for Reclamation of Saline and Sodic Soils of Southeastern Part of the Khuzestan Province, Journal of Iranian Agricultural Engineering Research Institute **4(16)** (in Farsi).

Pazira E. 1999. Land Reclamation Research on Soil Physico – Chemical Improvement by Salt Leaching in South – Western Part of Iran, Innovation of Agricultural Engineering Technologies for The 21st Century, P.R. China.

Qadir M, Oster JD. 2002. Vegetative Bioremediation of Calcareous Sodic Soils: History, Mechanisms and Evaluation, Irrigation Science journal **21**, 91–101. http://dx.doi.org/10.1007/s00271-001-0055-6

Rajabzadeh F, Pazira E, Mahdian MH. 2009. Leaching Saline and sodic soils along with reclamation-rotation program in the mid-Part of khuzestan, Iran, Applied Sciences journal **9(22),** 4020-4025. http://dx.doi.org/10.3923/jas.2009.4020.4025

Sarraf AP. 2008. Simulation of Water Table Variations and Estimating Drainage Water Quality for Subsurface Systems under Unsteady Inflows, Science and Research Branch, Islamic Azad University, Tehran - Iran.

Sarraf AP, Vahdat F, Pazira E, Sedghi H. 2010. Estimating Reclamation Water Requirement and Predicting Final Soil Salinity for Soil Desalinization, 9th International Drainage Symposium held jointly with CIGR and CSBE/SCGAB Proceedings, 13-16 June 2010. http://dx.doi.org/10.13031/2013.32129

Vahdat F, Sarraf AP, Pazira E, Sedghi H. 2010. Determining Optimized Distance and Depth of Subsurface Drains under Unsteady Flow Conditions at Multiple Cropping Pattern, 9th International Drainage Symposium held jointly with CIGR and CSBE/SCGAB Proceedings, 13-16 June 2010. http://dx.doi.org/10.13031/2013.32108

Sarraf AP. 2014. Study on Prediction of the Final Soil Salinity for Soil Desalinization and the Amount of Reclamation Water Requirement for Salt Leaching of Saline and Sodic Soils Using Empirical Simulation Models in Khuzestan Province, Iran, International Journal of Biosciences (IJB) **5(1),** 389-396. http://dx.doi.org/10.12692/ijb/5.1.389-396