Effects of Irrigation using Different Levels of the Mixture of Sugarcane Drain and Karun River Water on Physical and Hydraulic Properties of Soil

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Abstract: In most of the world's metropolitan cities, the largest portion of freshwater is allocated to drinking, health care, and industry. So, there might be a severe lack of water for irrigation of agricultural lands. In order to mitigate the effects of water crisis, certain agricultural schemes should be implemented because agriculture uses the utmost portion of water for irrigation. This study aims to consider the short term effects of irrigation with diverse levels of salinity of the mixture of Salman Farsi agro-industry sugarcane drain and Karun River water on physical and hydraulic properties of different depths of soil. The research was accomplished on the first irrigation and drainage research farm at the Faculty of Water Sciences Engineering of Shahid Chamran University of Ahvaz, without any planting conditions. Research framework had a random scheme, three repetitions, and the following irrigation treatments: 1) 75% Karun River water +25% sugarcane drain, 2) 50% Karun River water + 50% sugarcane drain, 3) 25% Karun River Water + 75% sugarcane drain. Since the primary EC of drain and Karun River water was known and three levels of irrigation treatment were defined, we examined three levels of salinity (6, 9, and 12 ds/m). The soil texture was sandy clay loam. After irrigating according to the mentioned treatments for 30, 60, 90, and 120 days, physical and hydraulic properties of soil including bulk density and porosity were measured by the intact method. Field capacity moisture was calculated as a percentage by pressure plate machine. The saturated hydraulic conductivity in depths of 0-30, 30-60, and 60-90 cm and ultimate infiltration rate of the surface layer of soil were measured by static load and double cylinder methods, respectively. Results which were statically analyzed by SPSS software, demonstrated that variations of bulk density and porosity, field capacity moisture, saturated hydraulic conductivity, and ultimate infiltration rate got significance at one percent probability level. By increasing the salinity of irrigation water bulk density and field capacity moisture increased but saturated hydraulic conductivity, ultimate infiltration rate, and total porosity of soil will decreased.
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1. Introduction

Freshwater is one of the most important requirements of human. According to global assessments, many parts of agricultural land will face water crisis fifty years later. On the one hand, rapid growth of population along with agricultural and industrial developments; on the other hand continuous drought in most of the arid belt countries entails the increasing demand for water utilization which constraints water resources in recent years. Also a significant portion of water resources become useless due to urban and industrial developments which change their quality (Parsafar et al., 2012). Due to its geographical location on earth, Iran has many arid and semi-arid zones. Therefore, low quality water is used in the process of agricultural production in most parts of Iran. Bad quality of irrigation water affects not only the plant, but also the soil (Felagella et al., 2004), therefore several factors are determined to investigate water quality. Generally, water of arid and semi-arid zones consists of soluble salts. So inappropriate and weak draining during a passage of given time aggregates the soluble salts of the soil. A bit of total additional salt of irrigation satisfies plant's requirements for absorbing water and soluble materials takes place separately. Then, by every irrigating low quality water in drain less systems aggregates some salt in the soil. Repeated irrigations during times add more salt into soil and consequently its salinity transforms the soil into barren lands (Chen et al., 2002). Accordingly, the principle condition for utilizing uncommon water is to observe some regulations which cover the continuous agricultural operations of Faryab lands not only to protect water and soil resources, but also to guarantee the survival of environmental features for the present and future generation (Feyzi, 2001).

2. Methods and Materials

This paper studies the effects of irrigating with different levels of salinity, due to mixture of sugarcane drain and Karun River water, on physical and hydraulic properties of soil. Our research was accomplished on the irrigation and drainage research farm at the Faculty of Water Sciences Engineering of Shahid Chamran University of Ahvaz without plantation. The farm was divided into 10 terraces of 1.5×1.5m and research was conducted in three depths of soil (0-30, 30-60, and 60-90 cm) during four periods of irrigation (1, 2, 3, and 4 months). This research had a random statistical scheme, three repetitions and three levels of salinity of water treatments including: 1) 75% Karun River water +25% sugarcane drain, 2) 50% Karun River water + 50% sugarcane drain, 3) 25% Karun River Water + 75% sugarcane drain. One of the terraces was selected as a standard control treatment (Karun River water) in order to compare other treatments. In each period we had 30 samplings for estimating each parameter by intact method. The soil texture of every terrace examined in diverse depths was gravelly clay loam. Terrace irrigating, turn of the dominant cultivation of the zone (wheat) was given and we assumed that the height of irrigating water on the soil was 10 cm. In each period, 225 liter of water was used for each terrace, considering its area and the height of irrigating water. We estimated bulk density, porosity, and saturated hydraulic conductivity in three depths of oil (0-30, 30-60, and 60-90 cm). Ultimate infiltration rate on the surface layer of the soil was calculated, too.

In this research bulk density and porosity were measured by the intact method. Field capacity moisture, saturated hydraulic conductivity, and ultimate infiltration rate of the surface layer of soil were measured by pressure plate machine, static load, and double cylinder methods, respectively.

Physical and chemical properties of the studied soil and chemical properties of irrigating water are presented in table 1, 2, and 3, respectively.

Table 1. Physical properties of the studied soil

Ksat (mm/hr)	**porosity (%)**	**soil texture**	**θpwp (%)**	**θFC (%)**	**ρ_b (gr.cm^{-3})**	**Physical properties of the soil / Depth of soil (cm)**
15.22	45.02	Sandy clay loam	9.52	17.96	1.48	0-30
15.56	45.54	Sandy clay loam	9.48	17.89	1.45	30-60
16.50	45.67	Sandy clay loam	9..15	17.35	1.43	60-90

Table 2. Chemical properties of the studied soil

EC (dS.m$^-$)	**PH**	**Hco_3^-**	**co_3^{-2}**	**Cl^-**	**Ca^{+2}**	**Na^+**	**Mg^{+2}**	**K^+**	**SAR (meq.L$^-$)$^{0.5}$**	**ESP (%)**	**Chemical properties of the soil / Depth of soil (cm)**
		(meq.L^{-1})									
7.6	7.8	7.3	0.0	66.1	18.5	30.0	23.5	5.3	6.55	39.9	0-30
6.3	7.7	6.4	0.0	54.0	16.8	28.3	22.2	4.9	6.41	39.1	30-60
5.2	7.6	5.4	0.0	44.7	15.7	26.7	20.0	4.5	6.31	38.8	60-90

Table 3. Chemical properties of irrigating water

EC (dS.m$^-$)	**PH**	**Hco_3^-**	**co_3^{-2}**	**Cl^-**	**Ca^{+2}**	**Na^+**	**Mg^{+2}**	**K^+**	**SAR (meq.L$^-$)$^{0.5}$**	**Chemical properties of water / Irrigation treatments**
		(meq.L-1)								
12	7.5	20.6	0.0	105	10.4	84	22.7	3.9	20.6	**25% River water +75% sugar cane drain**
9	7.2	20.1	0.0	85.7	7.6	62.88	19.1	3.8	17.2	**50% River water +50% sugar cane drain**
6	7.1	16	0.0	73.9	4	36.9	12	3.6	12.1	**75% River water +25% sugar cane drain**
2.39	7	3.5	0.0	46.1	3.8	8.4	4.2	1.3	4.2	**100% River water**

3. Discussion and Results

3.1. Effect of Various Levels of Salinity on Bulk Density

Results of analyzing the bulk density of soil are presented in Table 4.

Table 4. Results of analyzing bulk density

Parameter	Explanations (results)
Bulk density	• Bulk density increased by increasing the salinity. • Maximum increment of bulk density belongs to 75% drain+25% Karun River water treatment. • Bulk density decreased by increasing the depth. • Incremental effect of the quality of irrigating water on bulk density decreased in deeper depths. • Results of the statistical analysis of bulk density shows that the effect of the quality of irrigating water on bulk density has a significant variation on 5% probability level. • High amount of Sodium in irrigating water entails the above mentioned results. Sodium ion scatters soil ingredients and blocks its pores. Therefore, decreasing the volume of soil pores increases bulk density. • Our results are similar to that of Sadighi Sakir et al. (2002). They demonstrated that salinity and ESP of irrigating water increased bulk density of the soil.

3.2. Effect of Various Levels of Salinity on Total Porosity

Results of analyzing total porosity of the soil are presented in table 5.

Table 5. Results of analyzing total porosity of the soil

Parameter	Explanation (results)
Total Porosity	• Total porosity decreased by increasing the salinity. • Maximum increment of total porosity belongs to control treatment (Karun River water). • Total Porosity increased by increasing the depth. • Reduction effect of the quality of irrigating water on total porosity decreased in deeper depths. • Results of the statistical analysis of bulk density shows that the effect of the quality of irrigating water on total porosity has a significant variation on 5% probability level. • High amount of Sodium in irrigating water and soluble soil entails the above mentioned results. Sodium ion of soluble soil destroys the soil aggregates and decreases its porosity and infiltration by creating swells, scattering the ingredients, crusting, and decreasing soil pores (Ayers and Skunman, 1993).

3.3. Effect of Various Levels of Salinity on Field Capacity Moisture

Results of analyzing field capacity moisture are presented in table 6.

Table 6. Results of analyzing field capacity moisture

Parameter	Explanations (results)
Field Capacity Moisture	• Field capacity moisture increased by increasing the salinity. • Maximum increment of field capacity moisture belongs to 75% drain+25% Karun River water treatment. • Field capacity moisture decreased by increasing the depth. • Incremental effect of the quality of irrigating water on field capacity moisture decreased in deeper depths. • Results of the statistical analysis of field capacity moisture shows that the effect of the quality of irrigating water on field capacity moisture has a significant variation on 5% probability level. • High amount of Sodium absorption ratio (SAR) in irrigating water entails the above mentioned results. Increasing Sodium ions increases the kept moisture of soil. Due to high SAR, ingredients are scattered and soil's pores size decreases. Therefore, soil water retention increases specifically in high suction matrix (Khatar, 2008). Increasing salinity increases field capacity moisture as a percentage.

3.4. Effect of Various Levels of Salinity on Saturated Hydraulic Conductivity

Results of analyzing saturated hydraulic conductivity are presented in table 7.

Table 7. Results of analyzing saturated hydraulic conductivity

Parameter	Explanations (results)
Saturated Hydraulic Conductivity	• Saturated hydraulic conductivity decreased by increasing the salinity. • Maximum increment of saturated hydraulic conductivity belongs to control treatment (Karun River water). • Saturated hydraulic conductivity increased by increasing the depth. • Reduction effect of the quality of irrigating water on saturated hydraulic conductivity decreased in deeper depths. • Results of the statistical analysis of saturated hydraulic conductivity shows that the effect of the quality of irrigating water on total porosity has a significant variation on 5% probability level. • High amount of Sodium absorption ratio (SAR) in irrigating water entails the above mentioned results. Sodium ion destroys and scatters soil ingredients, therefore saturated hydraulic conductivity decreases. • Our results were similar to that of Warren (2002). According to this research special effect of Sodium on soil includes reduction of saturated hydraulic conductivity and infiltration and making crust. • So, reduction of saturated hydraulic conductivity of soil in our research is due to scattering the soil ingredients and blocking its pores.

3.5. Effect of Various Levels of Salinity on Ultimate Infiltration Rate

Results of analyzing ultimate infiltration rate are presented in table 8.

Table 8. Results of analyzing ultimate infiltration rate

Parameter	Explanations (results)
Ultimate Infiltration Rate	• Ultimate infiltration rate decreased by increasing the salinity. • Maximum increment of saturated hydraulic conductivity belongs to control treatment (Karun River water). • Ultimate infiltration rate decreased in longer periods of irrigation. • Reduction effect of the quality of irrigating water on ultimate infiltration rate decreased by longer periods of irrigation. • Results of the statistical analysis of ultimate infiltration rate shows that the effect of the quality of irrigating water on ultimate infiltration rate has a significant variation on 5% probability level. • Above mentioned results are due to high amount of Sodium of irrigating water which increases dispersion of soil ingredients and destruction of its structure, because the ratio of sodium to calcium is higher than 3 to 1. So, this high ratio entails some severe issues for infiltration of water for soil ingredients are scattered and its surface pores are filled and also blocked. • In this research, increasing salinity and sodium ions of irrigating water, decreases soil infiltration.

4. Conclusion

If salinity increases, saturated hydraulic conductivity and total porosity of soil might decrease. Comparing three depth levels, we observed significant variations. The surface layer of soil and the third level of depth (60-90 cm) had the lowest and highest measure of saturated hydraulic conductivity and total porosity, respectively. While SAR of irrigating water increased, sodium destroyed and scattered soil ingredients and so saturated hydraulic conductivity and total porosity decreased.

If salinity increases, bulk density might increase. There was significant variation between depths. The first level of depth (0-30 cm) had the highest bulk density and the third level (60-90 cm) had the lowest one. Due to high amount of sodium of irrigating water, soil ingredients are scattered and pores are blocked. Therefore, bulk density of soil decreased.

If salinity increases, field moisture capacity might increase. Sodium ion affected the distribution of pores size in the range of field capacity and so increased soil water retention. The highest amount of field capacity moisture belonged to the first level depth (0-30 cm) and the lowest one belonged to the third level (60-90 cm) and pores are blocked. Therefore, bulk density of soil decreased.

If salinity increases, field moisture capacity might increase. Sodium ion affected the distribution of pores size in the range of field capacity and so increased soil water retention. The highest amount of field capacity moisture belonged to the first level depth (0-30 cm) and the lowest one belonged to the third level (60-90 cm).

If salinity increases, ultimate infiltration rate of the soil might decrease. High amount of sodium and SAR of irrigating water decreased infiltration through scattering soil ingredients and filling and blocking surface pores. Primary conditions of soil (without irrigation) had the maximum ultimate infiltration rate which was minimized in the last month.

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