Research Article

Kadhim N. Kadhim* and Najm O. Alghazali

Effect of magnetization of saline irrigation water of Almasab Alam on some physical properties of soil

https://doi.org/10.1515/jmbm-2022-0031
received March 22, 2022; accepted April 11, 2022

Abstract: The effect of magnetization of saline irrigation water from Almasab Alam on some soil physical properties was investigated in this study. The soil was taken from the study site and placed in pots that were identical in all aspects and planted with onion plants in three replications for each case, with the average results taken. The only difference is the quality of the water used in irrigation, which was tested in seven different ways, including irrigating with Almasab Alam drainage salty water without magnetization (NMW), irrigating with river water (CW) from the Mashroa Almusyyab Al-Kabeer river, and irrigating with magnetized Almasab Alam water with five different magnetic intensities (1,000, 2,000, 3,000, 5,000, and 7,000 gauss). When magnetized water with a strength of 3,000 gauss is used, the highest decrease in the bulk density of the soil is 27.30%, and the highest increase in the porosity and permeability of the soil is 64.52 and 651.54%, respectively. Using magnetic technology has made saline Almasab Alam water and drainage water suitable for irrigating crops and also overcome the study area's water scarcity. Using the magnetic technique of irrigation water also improved the physical properties of the soil, including density, porosity, and permeability, in the study area by washing or planting it with crops.

Keywords: magnetization, Almasab Alam, soil, bulk density, porosity, permeability, irrigation water

*** Corresponding author: Kadhim N. Kadhim,** Civil Engineering Department, University of Babylon, Hilla, Babil, Iraq, e-mail: Eng.kadhim.naief@uobabylon.edu.iq
Najm O. Alghazali: Civil Engineering Department, University of Babylon, Hilla, Babil, Iraq, e-mail: Eng.najm.obaid@uobabylon.edu.iq

1 Introduction

Studies have proven the possibility of using saltwater in irrigation by magnetizing it, as this process reduces the effect of harmful ions on the plant, improves soil properties, and reduces its salinity by washing salts away and ridding the irrigated area of its damage [1].

1.1 Soil salts leaching

Magnetically treated water can remove 50–80% of soil salts, compared to 30% with regular irrigation water. It also improves the properties of the soil and reduces the harmfulness of its salinity by increasing the speed of washing salts and ridding the root zone of its harmfulness [2]. Magnetized water is used to remove salts from the soil and wash them. It restores the matter of the soil destroyed due to the use of high concentrations of synthetic fertilizers, as the ability to remove salts from magnetized water is twice that of ordinary water [3]. Soil salinity is one of the biggest problems in agriculture as the accumulation of salts in the soil pores leads to a severe decrease in its energy and in the concentration of salts in the capillaries of the roots of plants, which leads to a reduction in the plant's yield over the amount of its nutritional needs, which leads to wilting and then the death of the plant.

The task of the magnetic systems is to break the large crystals into small crystals and allow them to pass easily through the capillaries of the roots of plants and the pores of the soil. Therefore, the amount of salt in the water does not decrease. Still, it is not harmful because the plant will take all the nutrients it needs for its growth from this type of water and throw the rest of the salt crystals and other components that are useless into the drains. The small salt crystals and their components will be easier to pass through the soil pores to reach the groundwater drains in the lower layers of the soil. Some

research has indicated that the magnetic technique is followed to obtain magnetically treated water. In agriculture, it increases the solubility of water and leaches salts from the soil [4,5].

1.2 Fertility of the soil

The magnetism technique adapts the water and makes it more capable of dissolving and has a high ability to wash salts from the soil as well as increase the readiness of the nutrients in the soil, as it was found that irrigation with magnetized water increases the speed of washing chloride by 50–80% compared to normal water at 30% and bicarbonate by a percentage of 30%, in addition to doubling the sulfate washing as the increase in the dissolved oxygen content is 10% [5,6]. The magnetized water improves the soil surface by reducing the surface tension and reducing the viscosity and osmotic pressure. It also helps to enhance the building of the soil, increase the solubility with water, and works to break up the soil masses surrounding the roots. Thus, it encourages the roots to penetrate into the soil, which in turn increases the growth and productivity of the conductive plant [2,7]. Magnetically treated water increases the readiness of nutrients in the soil through its role in dissolving salts and minerals, and this leads to an increase in the absorption of the basic elements needed by the plant, which results in increased productivity [8,9].

1.3 Reducing soil surface crust

The crust formed on the surface of the soil is usually characterized by high hardness, which is reflected in poor aeration conditions in the soil and some physical characteristics that are not suitable for plant growth and development. In recent times, magnetically treated water has been used to control the crust formed on the soil due to the change in its physical and chemical properties as a result of magnetic treatment. It works to increase the solubility by changing the ionic state of some and reducing the concentrations of others, especially sodium salts, thus preventing the sodium ion from sticking to the soil. It reduces the negative effect of increasing the hardness of the surface crust of soil, meaning that the water is magnetically treated, which reduces the hardness of the surface crust. Also, it has the ability to remove the negative effect of sodium salts and improve some of the soil characteristics related to construction [5].

2 Materials and methods

The project, Almasab Alam, is a major development project in Iraq because it is essential to transfer saltwater extracted from land reclamation in central and southern Iraq through the interconnected network of drainage starting from all drainage fields covered to collected drainage. The study area is located between the stations 360 + 000 with coordinates (519,159, 3,563,531) and 441 + 000 with coordinates (461,006, 3,630,087), representing the site of Almasab Alam in the governorate of Babylon, Iraq, as shown in Figure 1.

The soil was taken from the study site and placed in pots that were similar in all specifications and planted with onion plants, with three replications for each case, and the average results were taken. The only difference is in the quality of the irrigation water with which these pots were irrigated. Seven types of irrigating water were used. They are: Almasab Alam drainage salty water without magnetization; irrigating with river water located in the study area, which is the Mashroa Al-Musayyab Al-Kabeer; as well as irrigating with magnetized Almasab Alam water with five magnetic intensities (1,000, 2,000, 3,000, 5,000, and 7,000 G). The samples are identified as magnetic water (MW), no magnetic water (NMW) for Almasab Alam water, control water (CW) for river water, MW1 (1,000 G), MW2 (2,000 G), MW3 (3,000 G), MW4 (5,000 G), and MW5 (7,000 G), and the soil before the experiment (SBE).

3 Magnetized water device

The magnetized water equipment was developed at Al-Nahrain University with five different intensities (1,000, 2,000, 3,000, 5,000, and 7,000 G). The magnetic device is constructed from a 16 mm diameter plastic tube and surrounded by a constant magnetic strength required for each device. Figure 2 shows the experimental setup, which was packed from the outside by another plastic tube. The velocity of water through the system is constant for all tests and equal to 0.67 m/s. The tests were conducted for the samples in three laboratories, and the results were very close so that the average of these readings was taken for analysis. Table 1 shows the specifications of the irrigation water used in the study.

The physical properties of the soil were examined before the beginning of the experiment, as shown in Table 2. After the end of the winter agricultural season of onion plants, the effect of magnetized water (MW) on

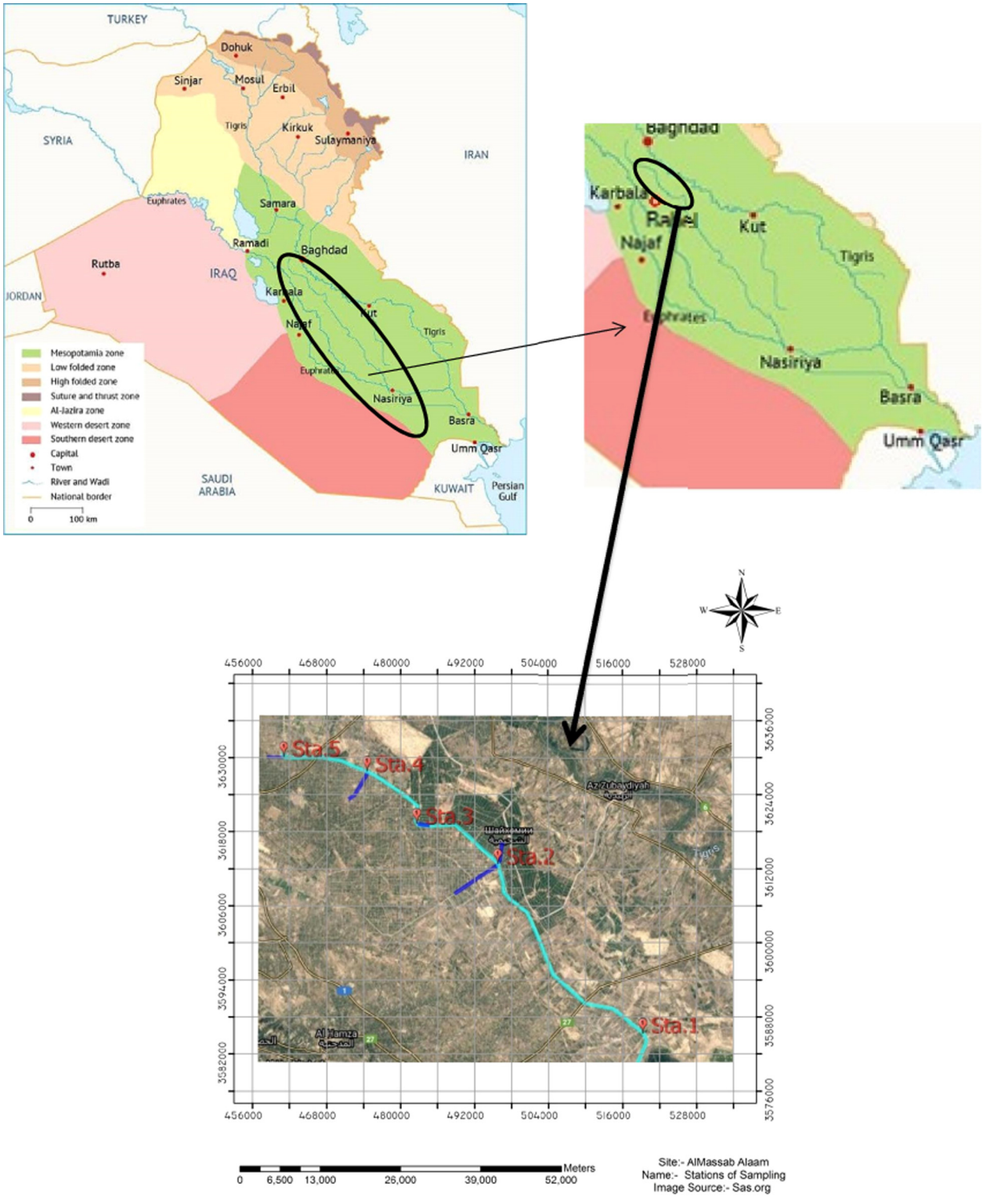

Figure 1: Study area.

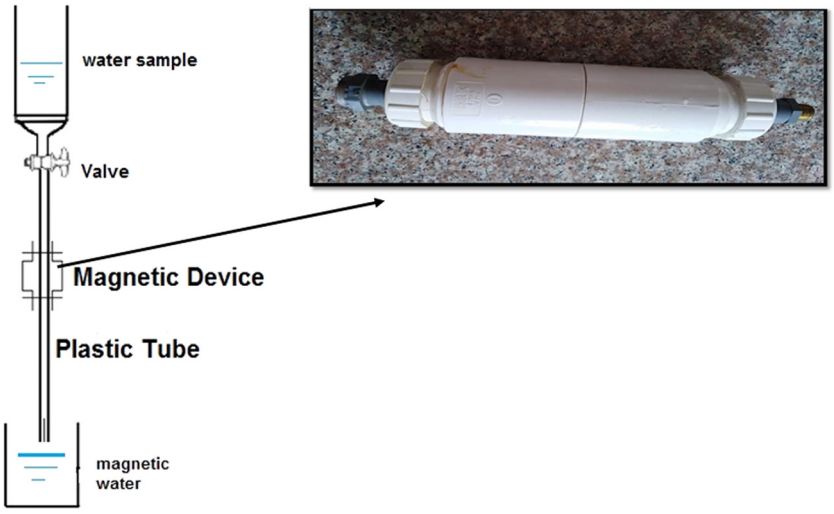

Figure 2: Schematic diagram of the experiment.

Table 1: The average characteristics of the studied river and saltwater from Almasab Alam drainage before and after the magnetization

Water type	River	Almasab	1,000 G	2,000 G	3,000 G	5,000 G	7,000 G
Ec (µs/cm)	0.97	5.84	5.85	5.86	5.88	5.90	5.96
TDS (ppm)	665	3,700	3,704	3,711	3,715	3,741	3,774
Cl (ppm)	68	568	568	554	501	516	565
SO_4 (ppm)	295	823	824	829	839	844	848
Na^+ (ppm)	142	392	392	395	399	401	403
K (ppm)	8.1	9.5	9.50	9.50	9.75	9.50	9.60
Mg^{2+} (ppm)	50	110.5	111	114	126	128	130
Ca^{2+} (ppm)	164	254.5	255	263	290	295	301
NO_3 (ppm)	1.4	1.3	1.30	1.53	1.85	1.32	1.39
PO_4 (ppm)	0.72	0.27	0.27	0.32	0.66	0.40	0.45
pH	7.62	7.90	7.90	7.97	8.10	8.20	8.25
T.H (pm)	441	966	1,014	1,043	1,146	1,162	1,189
Do (ppm)	14.50	9.50	9.50	9.96	10.90	10.10	10.35

soil physical properties of the soil of the study area are investigated. This soil is characterized by silty clay loam.

4 Results of tests

Table 3 shows the results of the tests for some important physical properties such as the bulk density, porosity, and permeability of the soil of the study area before the start of the experiments (SBE) and after the end of the onion-planting season.

Table 2: The physical properties of the soil before the beginning of the experiment

Physical property	Bulk density (g/cm^3)	Porosity (%)	Permeability (cm/s)
SBE	1.87	31	1.18×10^{-6}

Table 3: The physical properties of the soil before and after the experiments

Physical properties	Bulk density (g/cm^3)	Porosity (%)	Permeability (cm/s)
SBE	1.87	31	1.18×10^{-6}
NMW	1.98	28	1.0×10^{-6}
CW	1.70	45	2.98×10^{-4}
MW1	1.82	32	1.20×10^{-6}
MW2	1.67	46	3.80×10^{-4}
MW3	1.36	51	7.70×10^{-4}
MW4	1.78	40	4.30×10^{-5}
MW5	1.50	48	5.12×10^{-4}

Table 4: The percentage of decrease and increase in the amount of bulk density of the soil

Soil case	Bulk density (g/cm^3)	The difference with bulk density for SBE (%)
SBE	1.87	—
NMW	1.98	+5.90
CW	1.70	−9.10
MW1	1.82	−2.70
MW2	1.67	−10.70
MW3	1.36	−27.30
MW4	1.78	−4.80
MW5	1.50	−19.80

Table 5: The percentage of increase and decrease in the amount of porosity of the soil

Soil case	Porosity (%)	The difference with bulk density for SBE (%)
SBE	31	—
NMW	28	−9.60
CW	45	+45.16
MW1	32	+3.23
MW2	46	+48.39
MW3	51	+64.52
MW4	40	+29.03
MW5	48	+54.48

4.1 Bulk density

The results in Table 4 indicate that the values of the bulk density of the soil decreased when irrigated with river water, and in all cases of magnetized Almasab Alam saline water. The value of the bulk density of the soil in the study area increased when it was irrigated with saline Almasab Alam water without magnetization. The percentages of decrease and increase in soil density are shown in Table 4 and Figure 3.

The decrease in bulk density ranged from 2.70% to 27.30%. The lowest value of the reduction in the bulk density of the soil occurs in the case of magnetized water with a strength of 1,000 G (MW1), while the highest percentage of decrease (27.30%) occurs in the case of irrigation with magnetized water of a strength of 3,000 G (MW3). In the case of irrigation with river water (CW), the percentage decrease is 9.10%. The bulk density of the soil increases when irrigated with the saline, non-magnetized Almasab Alam water (NMW) (5.90%) due to the salt content increase in the soil, which in turn leads to a decrease in porosity and an increase in the hardening of the surface crust of the soil. This finding is consistent with refs. [9,11].

4.2 Porosity

The results in Table 5 indicate that the porosity of the soil is increased when irrigated with river water and when irrigated in all the cases of magnetized Almasab Alam saline water. The value of the porosity of the soil in the study area decreases when it is irrigated with saline Almasab Alam water without magnetization. The percentages of increase and decrease in the porosity of the soil are shown in Table 5 and Figure 4.

The increase ranged from 3.23 to 64.52%. The lowest value (3.23%) of the increase in the porosity of the soil occurred in the case of magnetized water with a strength of 1,000 G (MW1), while the highest percentage of increase (64.52%) occurred in the case of irrigation with magnetized water of a strength of 3,000 G (MW3). In the case of irrigation with river water (CW), the increase is 45.16%. The porosity of the soil decreases when irrigated with the saline, non-magnetized Almasab Alam water (NMW) (9.60%) due to the increase in salts in the soil, which in turn leads to a decrease in porosity and an increase in the hardening of the surface crust of the soil And this goes back to the role of magnetized water in improving the physical properties of the soil, as mentioned

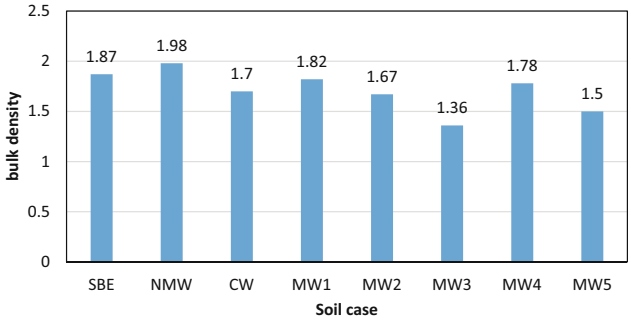

Figure 3: Bulk density of the soil.

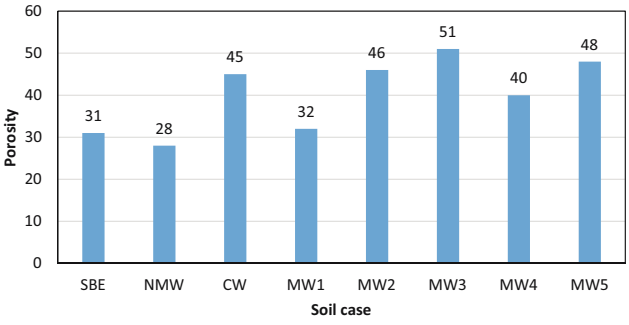

Figure 4: The porosity of the soil.

Table 6: The percentage of increase and decrease in the amount of permeability of the soil

Soil case	Permeability (%)	The difference with bulk density for SBE (%)
SBE	1.18×10^{-6}	—
NMW	1.0×10^{-6}	−15.25
CW	2.98×10^{-4}	+251.54
MW1	1.20×10^{-6}	+16.95
MW2	3.80×10^{-4}	+321
MW3	7.70×10^{-4}	+651.54
MW4	4.30×10^{-5}	+35.44
MW5	5.12×10^{-4}	+432.89

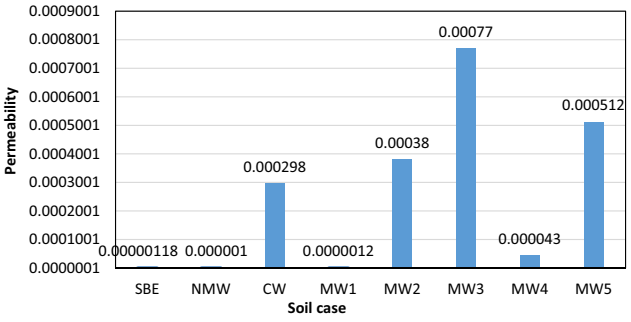

Figure 5: The permeability of the soil.

previously, and as mentioned in [11], which was reflected in reducing the bulk density as shown in Table 4.

The magnetization also helps to reduce the salinity effects near the root area as a result of washing salts from the root area. The increase in plant activity, penetration, and improvement of the root system in the soil led to an increase in its porosity. Improving the soil structure and increasing its volume led to a decrease in its bulk density and, thus, an increase in its porosity. This is what we have noticed at the end of the planting season compared to before planting. These results are consistent with what was obtained in [13], which indicated that improving soil structure leads to an increase in porosity, and the increase in the penetration and spread of the root system in the soil makes it more porous [5,9,13].

4.3 Permeability

The results in Table 6 indicate that the permeability of the soil is increased when irrigated with river water and when irrigated in all the cases of magnetized Almasab Alam saline water. The value of the porosity of the soil in the study area decreased when it was irrigated with saline Almasab Alam water without magnetization. The percentages of increase and decrease in the amount of permeability of the soil are shown in Table 6 and Figure 5.

The increase in permeability ranged from 16.95 to 651.54%. The lowest value (16.95%) of the increase in the permeability of the soil occurs in the case of magnetized water with a strength of 1,000 G (MW1), while the highest percentage of growth (651.54%) occurs in the case of irrigation with magnetized water of a strength of 3,000 G (MW3). In the case of irrigation with river water (CW), the increase is 251.54%. The permeability of the soil decreased when irrigated with the saline, non-magnetized Almasab Alam water (NMW) (15.25%) due to the increase in salts in the soil and its high bulk density, which in turn leads to a decrease in porosity and an increase in the hardening of the surface crust of the soil It goes back to the role of magnetized water in improving the physical properties of the soil, as mentioned previously and mentioned in [12], which was reflected in reducing the bulk density, as shown in Table 4.

The magnetization also helps to reduce the salinity effects near the root area because it washes salts from the root area. The increase in plant activity, penetration, and improvement of the root system in the soil led to the rise in its porosity and permeability. Improving the soil structure and increasing its volume led to a decrease in its bulk density and thus increased the porosity and permeability, which is what we noticed at the end of the planting season compared to before planting. These results are consistent with those obtained in [12], which indicated that improving soil structure leads to an increase in porosity. The increase in the penetration and spread of the root system in the soil makes it more porous [5,9,14].

5 Discussion

The results found that irrigation with magnetized water from the Almasab Alam in cases of 2,000, 3,000, and 7,000 G outperformed irrigation with river water, and found that the best percentage of the increase occurred when irrigating with magnetized water at a strength of 3,000 G. This is due to the source of magnetized water in improving the physical properties of the soil by improving its structure and pushing the negative effects of salts away from the root area [12,14,15]. As the use of magnetized water increases the volume of pore spaces per unit volume when the roots penetrate into the soil, it increases the porosity and decreases the values of the bulk density.

It is noted above that the reason for the increase in the permeability of the soil in the study area is the increase in the porosity of the soil and the decrease in the bulk density. Also, it confirmed that plant roots reduce the bulk density of the surface layer, increase its porosity, and secrete some resinous materials that improve its structure. Thus, it causes an increase in the value of permeability as the plant progresses in growth as a result of moisture treatments. And that is what we have noticed at the end of the planting season. By analyzing the results of the effect of the magnetization of saline waters of the general estuary on the physical properties of the soil of the study area, it is possible to take advantage of this saline water, which is not suitable for irrigating, especially sensitive crops, after each growing season. The use of the magnetization technology on this water turned it into water suitable for irrigation and even for sensitive crops, as well as improved the physical properties of the soil so that it became arable soil after it was highly saline soil and not suitable for agriculture. It is concluded that by using water magnetization technology, saline water can be used for irrigation purposes and overcome severe water scarcity, especially in Iraq.

It is also possible to cultivate highly saline soils and turn them into arable land, especially in central and southern Iraq, because the soils of these areas are highly saline. In most cases, magnetized water has outperformed river water in changing the properties of the soil for the better, and the best case is magnetized water with a strength of 3,000 G. Using magnetic technology, we can say that any soil can be cultivated, regardless of its salinity, and sewage water can be used for irrigation, regardless of its salinity.

6 Conclusion

Based on the results of the experimental test, the following main conclusions can be drawn:

- The bulk density decreases, and the porosity and permeability of the soil increase after it is irrigated with magnetized Almasab Alam water and river water.
- The highest percentage of decrease in the bulk density of the soil is 27.30%, and the highest increase in the porosity and permeability of the soil is 64.52 and 651.54%, respectively, when using magnetized water with a strength of 3,000 G.
- We recommend the use of magnetized water of 3,000 G for irrigation in the study area, and it is considered the best of all irrigation conditions, including irrigation with river water.
- The use of saline Almasab Alam water without magnetization in the study area leads to damage to the properties of the soil. It increases the hardening of its surface crust.
- Providing water suitable for irrigating crops from the saline Almasab Alam water and drainage water using magnetic technology and overcoming the water scarcity in the study area.
- Improving the physical properties of soil density, porosity, and permeability of the study area by washing it or planting it with agricultural crops using the magnetic technique of irrigation water.

Funding information: The authors state no funding is involved.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Conflict of interest: The authors state no conflict of interest.

References

[1] Amin SKM, Qassem AF. Effect of salinity of magnetized irrigation water on growth characteristics vegetative gerbera plant. Damascus Univ J Agric Sci. 2009;25(1):63–74.
[2] Abdel-Ani MM, Abdel-Gawad I, Marei NA. Impact of technology applications magnetism in the treatment of saline well water for use in the irrigation of wheat and barley. Northern Iraq, Babylon University. J Pure Appl Sci. 2015;23(1):278–86.
[3] Kazem RJM. The use of magnetized water in the reclamation of salt-affected soils. Mag Al-Furat Agric Sci. 2010;2(2):97–10.
[4] Kadhim NK, Hameed A. Experimental study of magnetization impact on ground water characteristics. Jordan J Civ Eng. 2018;12(2):254–62.
[5] Hassan DF, Mohammed RJ, Akol AM, Abd EH, Kadhim TF. Effect of magnetization of fresh and salt water for irrigation in some of the physical characteristics of the soil and the growth of wheat. Int J Innovative Res Sci Eng Technol. 2016;5(12):20861–72.
[6] AL-Ani S, Karkush MO, Zhussupbekov A, Al-Hity AA. Influence of magnetized water on the geotechnical properties of expansive soil. In Modern applications of geotechnical engineering and construction. Singapore: Springer; 2021. p. 39–50.
[7] Kadhim KN, Alghazali NO. Effect of magnetization on some physical properties of Almasab Alam salty water. In IOP

Conference Series: Earth and Environmental Science. Vol. 856. Issue 1. IOP Publishing; 2021 Sep 1. p. 012045.
[8] Karkush MO, Ahmed MD, Al-Ani SM. Magnetic field influence on the characteristics of water treated by reverse osmosis. Eng Technol Appl Sci Res. 2019;9(4):4433–9.
[9] Karkush MO, Ali SD. Effects of copper sulfate contamination on the geotechnical behavior of clayey soils. J Geoengin. 2019 Mar 1;14(1):47–52.
[10] Al-Zubaidi RAO. Effect of soil moisture content and method of adding phosphate fertilizer on phosphorous availability and its relationship to growth and water consumption of barley [dissertation]. Basrah: University of Basrah; 2007.
[11] Al-Wali RSS. Using indicators of mixed soil erosion in determining the sites threatened by desertification in the south of Basra Governorate and its effects and methods of treatment [dissertation]. Basrah: University of Basrah; 2005.
[12] Gallon PA. The magnetizer and water, internet, life streams international Mfg. Iraq: Febko Company; 2004.
[13] Al-Kubaisi WM. Correlation between factors affecting the vegetation of soil aggregates and the speed of wetting [dissertation]. Baghad: University of Baghdad; 1982.
[14] Al-Atab SMS. Effect of soil aggregate sizes on soil physical properties, water movement and maize plant growth [dissertation]. Basrah: University of Basrah; 2001.