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**ORIGINAL ARTICLE**

# MAGNETIC PROCESSING OF SALINE WATER AND ITS IMPACT ON SOME SOIL PROPERTIES

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**Abstract:** A field experiment was conducted in the College of Agriculture, University of Anbar during the winter season of 2018-2019, to study the effect of magnetic water on some soil properties. The experiment was conducted based on randomized complete block design (R.C.B.D). The experiment included saline water with three levels (1 dS/m, 4 dS/m, 7 dS/m) (S3). While the second factor was magnetic Magnetized water with three levels : magnetically ($M_0$), One time magnetization ($M_1$), two time magnetization ($M_2$). The results showed that irrigation of 7 dS/m reduced the soil saturated water conductivity, the weighted diameter (MWD) and the granulation factorial (Kc).Moreover, the values of bulk density and refraction factorial riased with the increased of water salinity. The magnetization process made a significant effect in the values of soil saturated water conductivity, the mean weighed diameter (MWD) and the granulation factorial (Kc) with one time magnetization used, while the bulk density and refraction factorial decreased. Also the co-interaction between saline water and magnetic procession has a strong effect on all of study parameters.

***Key words*:** Saline water, Magnetism, Physical soil properties.

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## 1. Introduction

Water is the main limiting factor of agricultural production, especially in arid and semi-arid climate areas. Iraq faces hard challenges in water resources deficiency depending on neighboring countries, because of the reduction of Tigris and Euphrates rivers and declining water quality [AL-Taey (2009), Mahmood *et al.* (2020)].

Soil salinity is one of the common dangerous agricultural obstacles. The cause of this process is the increase of salts in the soil leading to an obvious drop in soil fertility [AL-Taey *et al.* (2019)]. High Salt concentration prevents water transport to plants across roots and an insufficient amount of nutrients leads to plants dying [ALi *et al.* (202),Witwit *et al.* (2020)].

Therefore, it is important to find solutions and alternatives options to replace the deficiency of water imports. One of these solutions is using saline water, with the consideration of risks by their use [AL-Taey (2017), Al-Khafajy *et al.* (2020)]. The magnetic procession of water has largely limited the risks.

It is possible to magnetize water through passing water in a magnetic field to cause the dissociation of hydro-bonds and salts in the soil.

The magnetically processed water transforms from a simple liquid into a high-quality liquid, in which, many properties like density and viscosity change and the ability of magnetized water increases to solve minerals and vitamins [Jacob and Kronenberg (1985)]. The magnetic procession has given fair results, enhancing many soil properties when used in irrigation [AL- Kaysi (2009)]. Kadhum (2010) indicated that the use of magnetic procession had an important role in saving a considerable quantity of irrigation water used to reform additional areas of salty soils or for irrigation under the circumstances of water deficiency in Iraq.

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The magnetic water procession makes it more efficient to wash salts like sodium salts and reduces their adsorption percentage on the exchange compound. It leads to increase soil aggregations and large pores responsible for water downgrade, leading to increase saturated soil water conductivity [Smith (2010)]. Al-Najm (2013) referred to the decrease of saturated soil water conductivity values by increasing irrigation water salinity; while the magnetic water use caused the increase of saturated soil water conductivity values, compared with using nonmagnetic water. It is compatible with soil bulk density which increased with the increased water salinity in soil but decreased when the water's been magnetized. Al-Mosawi *et al.* (2017) studied the effect of irrigation water magnetism on mean weighed diameter and granulation index in soil aggregations (Kc) during the growth stages of malt crop, stated the presence of a significant increase in mean weighed diameter (MWD) values and granulation guide for layers (0-30) (30-60) cm when using magnetic water, compared with nonmagnetic water. Abed (2012) found that irrigation with magnetically processed water would reduce the rigidity of superficial soil cortex and the magnetic water has the ability to erase the negative effect of adsorbed sodium by the enhancement of some soil physical properties.

The study aimed to reduce the negative effect of saline water on some soil properties by magnetization process.

## 2. Materials and Methods

A field experiment was conducted in the College of Agriculture, Al- Anbar University during the winter season 2018-2019, to study the effect of magnetically processed water on some physical properties of soil. The farm soil has been classified within series [USDA (1954)]. Soil samples were brought from the specified farm to execute the experiment at depth of (0-30) cm using soil auger, air-dried and grinded with wood hammer. Then the soil samples passed through a sieve of 2 mm pit diameter. The soil texture has been estimated with condenser method and the bulk density with soil sampler, while the real density was estimated using the bottle of density and the soil total perforation was computed from the relationship between the bulk and real density. So the physical properties were estimated according to the methods described by Black (1965). The percentage of humidity has been estimated at tensions 0, 33, 100 and 300 kilopascal using the Pressure plate apparatus, while the tensions 500 and 1500 kilopascal were estimated using the Pressure Membrane apparatus according to the method described in Richards (1954).

Table 1 explains these properties, following the methods mentioned in Jackson (1958). The soil pH was measured using the pH-meter and the electrical conductivity in saturated paste extract was measured using the Ec-meter, while the organic substance was measured using Walkally and Black method; while ions like magnesium ($Mg^{+2}$), calcium ($Ca^{+2}$), chloride ($Cl^{-1}$), potassium ($K^{+1}$) and sodium ($Na^{+1}$) solved in saturated paste extract, were detected by flame photometer [Page *et al.* (1982)]. Sulfate ($SO_4^{-2}$) was detected by turbidity method in spectrophotometer device. Carbonate and bicarbonate ($CO_3^{+3}$ and $HCO_3^{-2}$) were measured by titration as mentioned in Richards (1954). The irrigation water samples were analyzed in the lab as shown in Table 2.

**Table 1:** Pre cultivation Physical and Chemical properties of soil.

| Physical properties | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (cm)** | **Texture** | **Soil separates** | | | **Bulk density** | **Particle density** | **Porosity %** | **Gravimetric** | | | **Available water %** |
| | | **sand** | **silt** | **Clay** | **($Mgm.m^{-3}$)** | **($Mgm.m^{-3}$)** | | **At 0 Kps** | **At 33 Kps** | **At 1500 Kps** | |
| | | **$gm.kg^{-1}$** | | | | | | | | | |
| 30 – 0 | Silty loam | 392 | 500 | 108 | 1.36 | 2.55 | 0.46 | 32.45 | 31.50 | 14.20 | 17.30 |

Kps = kilopascal, Mgm = mega gram, gm = gram.

| Chemical properties | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Depth (m)** | **pH** | **$EC_e$ $dS.m^{-1}$** | **$Ca^{2+}$** | **$Mg^{2+}$** | **$Na^{+}$** | **$K^{+}$** | **$Cl^{-}$** | **$HCO_3^{-}$** | **$CO_3^{=}$** | **$SO_4^{=}$** | **OM $g.kg^{-1}$** |
| | | | **$Mmole.L^{-1}$** | | | | | | | | |
| 0.30 – 0.00 | 7.35 | 2.20 | 5.20 | 4.23 | 1.60 | 0.73 | 4.10 | 2.15 | 2.44 | 3.10 | 0.40 |

dS= deci semis, Mmole= mil mole.

**Table 2:** Chemical analysis of irrigation water.

| Trait | Well water | Unit |
|---|---|---|
| EC | 7 | $dS.m^{-1}$ |
| PH | 7.3 | |
| $Ca^{+2}$ | 2.8 | $Mmole.L^{-1}$ |
| $Mg^{+2}$ | 1.7 | |
| $Na^{+1}$ | 4.1 | |
| $K^{+1}$ | 0.02 | |
| $Cl^{-1}$ | 5.5 | |
| $SO_4^{-2}$ | 1.9 | |
| $CO_3^{+3}$ | ---- | |
| $HCO_3^{-2}$ | 1.21 | |
| SAR | 2.73 | |

The treatments were distributed according to randomized complete block design (R.C.B.D.) with three replications. The experimental treatments were:

1- Water of 1 dS/m salinity (S1).

2- Water of 4 dS/m salinity (S2).

3- Water of 7 dS/m salinity (S3).

4- Non-magnetically processed water (M0).

5- Magnetically processed water (M1).

6- Magnetically processed water twice (M2).

Water magnet device of 3,000-kaos magnetic pull and a diameter of 1 inch manufactured by the ALFORATAIN Company.

The experimental units were 27 as (3×3×3), randomization has been applied within each of the three blocks. A drip irrigation system was used to irrigate the broad bean crop. The single treatment consisted of three drip lines; the length of the drip line is 4 m and the distance between one line and another is within the 1 m experimental unit, the distance between one sector and another is 2 m, to ensure that treatment are not interfered with each other.

About the studied standard; the hydraulic conductivity was calculated, based on the Darcy's Law, described by Klute (1965) according to the following formula:

$$K = \left[\frac{Q}{At}\right]\left[\frac{L}{\Delta h}\right] \quad (1)$$

where, K = hydraulic conductivity ($cm.h^{-1}$), Q = water volume ($cm^3$), A = area of runoff section, t = time of water collection (hour), L = length of soil column (cm), Δh = the difference between water input and output in the column (cm).

The bulk density of the soil was estimated according to the Core Method [Black (1965)] for all experiment treatments, the modulus of rupture was estimated (KPa) according to the method mentioned in Richard (1954). The Youder machine [Youder (1936)] was used in the wet seiving method to measure the weight diameter based on the following equation.

$$MWD = \sum_{i=1}^{n} XiWi \quad (2)$$

where, MWD = mean of weight diameter (mm), Xi = the volumetric range of separated soil aggregates (mm), Wi = the ratio of soil aggregates mass to the total soil dry mass (gm).

The granulation index (Kc), in accordance with the formula proposed by Mukhtar *et al.* (1974) is as follows:

$$Kc = \frac{X2 + X3 + X4 + X5}{X1 + X6} \quad (3)$$

where, X1 = the remaining dry aggregate mass on the sieve of4 mm.

X2 = the remaining dry aggregate mass on the sieve of 2 mm

X3 = the remaining dry aggregate mass on the of sieve 1 mm

X4 = the remaining dry aggregate mass on the sieve of 0.5 mm

X5 = the remaining dry aggregate mass on the sieve of 0.25 mm

X6 = the mass of dry aggregates passing through the sieve 0.25 mm

## 3. Results and Discussion

It is clear from Table 3 that the magnetic processing of saline water has an impact on the saturated water conductivity of soil, the salinity of irrigation water has reducing the values of saturated water conductivity to the soil where it reached the lowest value of 2.2 52 $cm.h^{-1}$ at the salinity level of irrigation water 7ds/m and the highest value of 2.69 $cm.h^{-1}$ for salinity level of irrigation water 1ds/m at a decrease percent of 6.3%.

The magnetic processing of saline water had a positive impact on soil-saturated water conductivity, as saturated water conductivity values have increased from

**Table 3:** The effect of interaction between saline water and magnetic processing in the soil-saturated water conductivity (cm. hour-1).

| Salinity | Magnetism | | | Ave-rage |
|---|---|---|---|---|
| | M0 | M1 | M2 | |
| S1 | 2.68 | 2.71 | 2.70 | 2.69 |
| S2 | 2.60 | 2.63 | 2.64 | 2.62 |
| S3 | 2.50 | 2.54 | 2.54 | 2.52 |
| Average | 2.59 | 2.62 | 2.62 | |
| LSD0.05 | S=0.01892 | M=0.01892 | S*M=0.03277 | |

2.59 to 1 2.62 $cm.h^{-1}$ when magnetic processing is not used, the one-time use of magnetic water processing increase by 1.27%, while magnetic processing twice had no significant effect on soil-saturated water conductivity values.

The bilateral interaction between saline water and magnetic processing had a significant effect on saturated water conductivity values, with a value of 2.71 $cm.hour^{-1}$ at the S1M1 treatment, while the lowest value amounted to 2.50 $cm.hour^{-1}$ for the S3M0 treatment.

The low level of soil-saturated water conductivity by increasing the level of salinity in the water is due to the cracking of the aggregates and the detachment of clay particles and their movement through the flow paths and the closure of the soil pores through which they pass [Gee *et al.* (2002)] and this goes with AL-Najm (2013). Furthermore, the high values of soil-saturated water conductivity are also due to the fact that magnetic processing of saline water makes it more capable to leach salts and among leached salts are sodium salts, which reduces their adsorption on the exchangeable complex, thus leads to increase large pores that are responsible for the movement of water downwards [Smith (2010)]. The use of electromagnetic procession of saline water has improved soil pores, thereby improving soil structure and through pores, water is spreading in the soil profile [Malak *et al.* (2020)].

Table 4 indicates that the magnetic processing of saline water has an impact on the soil bulk density, as it was found that the salinity of wastewater has a significant effect in increasing the values of bulk density of soil, reaching the highest value of 1.38 $Mgm.m^{-3}$ at salinity level for irrigation water 7dS/m and less than 1.31 $Mgm.m^{-3}$ for the salinity level of irrigation water 1dS/m and an increase of 5.34%.

From the same table, it is noticed that the magnetic

**Table 4:** Effect of interaction between saline and magnetic processing water in the characteristic of the bulk density of soil in ($Mgm.m^{-3}$).

| Salinity | Magnetism | | | Ave-rage |
|---|---|---|---|---|
| | M0 | M1 | M2 | |
| S1 | 1.34 | 1.31 | 1.30 | 1.31 |
| S2 | 1.37 | 1.35 | 1.35 | 1.35 |
| S3 | 1.40 | 1.38 | 1.37 | 1.38 |
| Average | 1.37 | 1.34 | 1.34 | |
| LSD0.05 | S=0.01154 | M=0.01154 | S*M=0.01999 | |

processing of saline water has a positive and significant impact in reducing the values of bulk density, reaching the highest value of 1.37 $Mgm.m^{-3}$ when not using magnetic processing for saline water and less than 1.34 $Mgm.m^{-3}$ for one-time use of water magnetic processing decreased by 2.18% and magnetic processing twice had no significant effect on the values of soil bulk density.

The bilateral interaction between saline water and magnetic processing had a significant effect on the values of the bulk density of the soil, with the highest value of 1.40 $Mgm.m^{-3}$ at the S3M0 treatment with a low value of 1.30 $Mgm.m^{-3}$ for the S1M2 treatment.

The increase in bulk density when using saline water in irrigation can be caused by the break-up or destruction of large soil aggregates, which leads to increased proportions of small peds, entry and deposition in spaces within aggregates. This, in turn, leads to compacted layers that increase the value of soil bulk density [Al-Zobai and Shaikly (2011)]. Whereas, the reason for the decrease in bulk density values when using magnetic water processing is due to increased capability of magnetic water to remove salts which improve soil structure by increasing the percentage of porosity [Abed (2012)]. Moreover, Al-Musawi and Mahdi (2019) did not have a significant impact of magnetism in the values of the bulk density of the soil.

Table 5 shows that magnetic processing of saline water has an effect on the modulus of rupture (Kilopascal), where it is found that using of saline water in irrigation lead to a significant increase in the values of modulus of rupture, with the highest value of 19,310 kPa when irrigation with saline water of 7dS/m and a lower value of 16,050 kPa when irrigation with saline water of 1 dS/m.

It is also clear from the table that magnetic processing has a significant effect on the values of

**Table 5:** The effect of interaction between saline water and magnetic processing in the modulus of rupture (kilopascal).

| Salinity | Magnetism | | | Range |
|---|---|---|---|---|
| | M0 | M1 | M2 | |
| S1 | 17.542 | 15.310 | 15.300 | 16.050 |
| S2 | 18.145 | 17.764 | 17.760 | 17.889 |
| S3 | 19.907 | 19.015 | 19.010 | 19.310 |
| Range | 18.531 | 17.363 | 17.356 | |
| LSD0.05 | S=0.02614 | M=0.02614 | S*M=0.04528 | |

modulus of rupture, with the highest value of 18,531 kPa when not using magnetic processing and the lowest value is 17,363 kPa recorded in once magnetic processing, with a clear decline reached 6.3% while the twice magnetic processing had no significant effect.

The bilateral interaction between saline water and magnetic processing had a significant effect on the values of modulus of rupture, with the highest value of 19,907 kPa at the S3M0 treatment and 15,300 kPa at the S1M2 treatment.

The increase in the values of modulus of rupture when using saline water is due to the dispersion of soil aggregates and an increase in bulk density values, resulting in an increase in the values of modulus of rupture [Shainberg and Singer (1985)]. Regarding the use of magnetic processing for saline water, it can be due to the decrease in the values of modulus of rupture, as magnetic processing reduces the negative impact of salts through the increase in its ability to dissolve and leach salts from soil profile and thus prevent the occurrence of surface crusting [Al-Musawi and Mahdi (2019)]. Magnetic water changes the distribution of salts among soil layers, reducing their presence in the upper layers, which are more important in agriculture [Polski (2017)].

Table 6 shows the effect of magnetic processing of saline water in the mean weighted diameter MWD (mm), as salinity has a significant effect in reducing the values of MWD, with the highest value of 0.997 mm for the level of salinity of water 1dS/m and the lowest value of 0.958 mm for the level of salinity of 7dS/m and a decrease of 3.9%.

Magnetic processing also had a significant effect in increasing the values of MWD, reaching the highest value of 0.980 mm when using magnetic processing for saline water once and the lowest value of 0.969 mm when not using magnetic processing for saline water with an increase percent of 1.13%.

**Table 6:** Impact of interaction between saline water and magnetic processing in MWD mm.

| Salinity | Magnetism | | | Range |
|---|---|---|---|---|
| | M0 | M1 | M2 | |
| S1 | 0.989 | 1.003 | 1.001 | 0.997 |
| S2 | 0.968 | 0.975 | 0.974 | 0.972 |
| S3 | 0.952 | 0.962 | 0.962 | 0.958 |
| Range | 0.969 | 0.980 | 0.979 | |
| LSD0.05 | S=0.002719 | M=0.002719 | S*M=0.004709 | |

The bilateral interaction between saline water and magnetic processing had a significant impact on the values of MWD, with the highest value of 1.003 mm at the S1M1 treatment and the lowest value of 0.952 mm at the S3M0 treatment.

The low values of MWD when using saline water can be attributed to increased salinity in wastewater, which in turn leads to the deterioration of structure as well as dispersal of soil aggregates [Aboud (1998)]. Furthermore, the increase in the MWD values when using magnetic processing is due to their ability to dissolve sodium salts that disperse soil particles and leach them from the soil profile which cause increasing in stability of soil aggregates [Al-Musawi *et al.* (2017)]. Magnetic water increases soil retention capacity and increases salts leaching from soil profile [Zhou *et al.* (2021)].

Table 7 refers to the impact of magnetic processing of saline water in the granulation index (Kc), as salinity has a significant effect in reducing the values of the granulation index (Kc), where the highest value was 0.341 at a level of salinity of irrigation water 1dS/m and the lowest value of 0.290 for level of salinity 7dS/m and a decrease of 14.95%.

**Table 7:** The effect of interaction between saline water and magnetic processing in the form of granular index (Kc).

| Salinity | Magnetism | | | Range |
|---|---|---|---|---|
| | M0 | M1 | M2 | |
| S1 | 0.323 | 0.350 | 0.350 | 0.341 |
| S2 | 0.295 | 0.310 | 0.310 | 0.305 |
| S3 | 0.286 | 0.294 | 0.292 | 0.290 |
| Range | 0.301 | 0.318 | 0.317 | |
| LSD0.05 | S=0.003325 | M=0.003325 | S*M=0.005759 | |

Magnetic processing has significantly affected the values of granulation index, where they were increased when using magnetic processing of water, reached the highest value of 0.318 for the level of magnetic processing once and the lowest value 0.301 when not using magnetic processing for saline water and an increase of 5.64% in the absence of magnetic processing twice the significant effect in the values of granulation index.

The binary interaction between saline water and magnetic processing significantly affected the values of granulation index where it reached the highest value of 0.350 for S1M1 treatment whereas the lowest value was 0.286 for S3M0 treatment.

The increase in EC value of the used water, which increases soil salinity and degradation of its physical properties, nevertheless, when using magnetic processing for saline water can be attributed to the increase in the values of granular index to improve soil properties by leaching salts, reduced sodium adsorption ratio (SAR) and increased mean weighted diameter (MWD), which reflected positively on the increase of granular index [Al-Musawi *et al.* (2017)].

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