

Assessment of magnetization treatment effect on some physical and biological characteristics of saline irrigation water

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Abstract

The salinity of irrigation water and soil are the major challenge factors for expansion of agricultural area in Egypt. Moreover, salt concentrations cause a lot of problems for soil and plants especially under pressurized irrigation systems. However, the usage of magnetic water treatment may help in solve the problem. Therefore, this investigation was conducted to describe the effect of magnetic field on the properties of irrigation water. Magnetic devices with two intensities (1600 and 14500 Gauss “G”) were used to treat three saline water levels (tap water with 219 ppm, 1000 ppm and 2000 ppm).

It was found that magnetization affects dynamic viscosity, dissolved oxygen, surface tension and pH. Also found a positive effect of magnetization on the total number of microorganisms. On the other hand, there is a slight increase on electrical conductivity due to magnetism, and it increases more over time. The viscosity of water was decreased under magnetic treatment. The surface tension dropped by 1.5% and 3% when the salinity increased from 219 to 1000 and 2000 ppm respectively. The total number of microorganisms decreased by 17.1% and 57.3% at 219 ppm, by 38.6% and 57.5% at 1000 ppm and by 32.5% and 55.5% at 2000 ppm comparing to non-magnetic water under 1600 and 14500 G, respectively.

Keywords: Magnetization; Salinity; Water properties.

1. Introduction

Due to climate change, more than 40% of the world's population is facing water scarcity. As a result, low-quality water supplies have effectively solved water scarcity challenges in traditional irrigation systems until today [1]. However, due to limited water resources, reclaimed water with medium to high pollutants, silt, and salinity loading has been employed as a substitute to freshwater in various irrigation systems [2] and [3]. Magnetic treatment of saline water is an eco-friendly method of water treatment and crop irrigation. Magnetized water has significantly different mechanical, electromagnetic, and thermodynamic properties than conventional tap water. Because of its unique qualities, magnetized water is increasingly being used in a variety of applications, including industrial, environmental, medicinal, and agricultural domains, as magnetic devices become more advanced [4]. Magnetic treatment alters the molecular structure and characteristics of water using a magnetic field, reducing hydrogen bonding between water molecules [5]. The magnetic treatment of water has a memory effect and lasts around three days [6] and [7]. The fluctuation in water velocity influences the magnetic field of water and the time of magnetization. The variation in water velocity of 0.13 m/s resulted in a 4000G increase and a 2-hour extension of magnetization time [8]. The magnetic treatment significantly increases the density and electrical conductivity of seawater, while decreasing the viscosity when compared to ordinary seawater without magnetic treatment [9].

The stationary magnetic effect alters the physicochemical properties of water at 1000, 1500, and 2000 G [10]. The average contact angle was found to be 0.262, 0.261, and 0.295 at intensities of 1000, 1500, and 2000G, respectively, compared to tap water's 0.249. The magnetic effect increased viscosity and reduced surface

tension. Under the magnetic impact, the activation energy increased while the intramolecular energy of water decreased. As a result of the magnetic action, hydrogen bonds were formed, and the average size of the clusters increased. The EC, pH, and TDS of water all increased with the strength of the magnetic field [11] and [12]. When water travels through a magnetic field with increasing magnetization intensity, its characteristics fluctuate in proportion to the intensity.

Because the salt content inhibits bacterial development and multiplication, there are fewer bacteria in environments with high salinity, which results in higher dissolved oxygen (DO) [13]. The pH and DO concentrations rose due to the magnetic effect [14]. On the basis of the reversed electric motor principle, the magnetic effect can raise the electron density and DO concentration [15]. The results shown that when electrons are created in water as a result of the mechanical motion of water colliding with the magnetic effect at a perpendicular angle, the pH and DO concentrations in distilled water change from 5.14 to 5.54 and 6.68 to 6.90 mg L⁻¹, respectively. In addition to the magnetic action, the physicochemical characteristics of water are altered to show an increase in viscosity and a decrease in surface tension [16]. The strength of the magnetic field is correlated with the surface tension of water [17]. The surface tension coefficient is at its lowest when the magnetic field is between 2000 and 3000G, indicating that the magnetization effect is at its most and that surface tension has decreased the most. The surface tension curve starts to pick up as the magnetic field intensity increases.

Prior research has demonstrated that saline wastewater irrigation can boost soil bacterial community abundance [18], however other investigations have found no discernible change or a declining trend. Once

the magnetization process begins, the water molecule system undergoes a transformation after being exposed to a magnetic field for several hours, changing the system's overall conformational energy. However, electrical conductivity is unaffected by magnetization. In addition, magnetization stability tests conducted in labs indicate that it lasts for 48 hours [19].

Signals generated by magnetic fields that directly impact biological cells and their critical functions can be received by water [20]. In order to reduce microbiological water pollution, which clogs emitters in drip irrigation systems and reduces their uniformity, research is being done on the use of magnetic fields. It has recently been demonstrated that biological clogging in drip irrigation can be resolved by magnetic field therapy, which is anticipated to be a successful, chemical-free, and anti-biological treatment technique [21].

The goal of the current study was to assess how magnetism affects the hydraulic and design features of pressurized irrigation systems as well as their efficiency by influencing the qualities of low-quality irrigation water. weight at term to show the most accurate formula and obtain the most effective fetal parameter.

2. Methods

The present investigation was carried out at the National Irrigation Laboratory of Agricultural Engineering Research Institute (AEnRI), Dokki, Giza, Egypt, to study the effect of salinity and magnetic treatments on water properties.

The magnetization device was supported to the inlet of the magnetic water subunit. The magnetic device is a product of Delta Water Co. for water treatment. It is constructed from stainless steel material, inner diameter size 2 inches, water flow rate up to 25 m³/h, 85 cm length, and 11 kg weight. It is working up to 100 °C temperature, working pressure up to 15 bar. It was effective for medium salinity water treatment up to 8000 ppm with a magnetic capacity of 14500 Gauss (1.45 Tesla). Another device with magnetic capacity of 1600 Gauss (0.016 Tesla) with inner diameter 0.5 inch and 50 cm length was used for the 1600 G treatment. Water passes through the magnetic field and becomes magnetized, which causes some physical changes in the composition and shape of water molecules. Main treatments were two magnetized water treatments consist of 1600 and 14500 G magnetic intensities in addition to a non-magnetic irrigation water treatment as control. The sub-treatments were three water salinity levels of 219 ppm (tap water as control), 1000 and 2000 ppm. The salinity levels were prepared by adding Rashidy salt (containing about 99% NaCl, % Na=31.64% and % Cl=67.45%) and calcium carbonate to tap water to reach the required salinity.

A PVC tank of 20 liter capacity fitted at the top of the unit served as the storage tank for the untreated water. Water from the bottom of this tank enters the magnetic device through a pipe section with 50 mm internal diameter. Then, Water passed through the magnetic field becomes magnetized water and collected

in another PVC tank after the device. This experiment was done with three replicates for each of the two magnetic intensity (1600 and 14500 G) treatments.

To measure water density for each treatment, the magnetic water was placed in a 250 ml volumetric flask. Then, its mass was measured using sensitive balance.

Kinematic viscosity is the ratio of dynamic viscosity in N.s/m² (Pa.s) to the density of the liquid in kg/m³. Mathematically, kinematic viscosity ν (nu),

$$\nu = \frac{\mu}{\rho}$$

Where: ν is kinematic viscosity (m²s⁻¹) and μ is dynamic viscosity of liquid, (Pa.s)

For surface tension, the equipment has been made in laboratory to measure the surface tension of water, by using the capillary tube type as described by [12]. Surface tension is responsible for the phenomenon of liquid rising in capillary tubes, this phenomenon has been used to determine the surface tension of a liquid according to the following equation:

$$\gamma = \frac{h \rho g r}{2}$$

Where:

γ : Surface tension coefficient (dyne/cm) or N/m

r : The radius of the capillary tube (cm).

h : Height of the liquid in the capillary tube (cm).

ρ : The density of the liquid (g/cm³).

g : The acceleration due to gravity on Earth, which equals cm/s².

Electrical conductivity (EC) meter (ORION 105 Model, USA, 0 to 199.99 dS m⁻¹, and 0.5% F S accuracy) and pH meter (JENCO 1671 Model, USA, with 0.1 accuracy) were used to measure the electrical conductivity and pH of water.

Dissolved O₂ was monitored during the study period at the lab using a dissolved oxygen portable (HI9142 dissolved oxygen meter). Regardless of the instrument, with different intensity of magnetic treatments and different salinity were measured in regard to dissolved oxygen (DO) in a unit of (%), considering temperatures (30o).

For microbiological analysis of treatments, MacConkey Agar method was used according to [22]. A round dish with a diameter of 82 mm and a height of 11 mm in which MacConkey agar is placed. It is a culture medium designed for the growth of Gram-negative bacteria and their staining by lactose fermentation. MacConkey agar contains bile salts to inhibit gram-positive bacteria, Crystal violet (it also inhibits gram-positive bacteria) Neutral red (which stains lactose-fermenting

Water samples are distributed by dipping the needle into the water sample, then dividing the dish into

squares with the needle loaded with the sample, then making zigzag lines. The dishes are placed at a temperature of 32 degrees for 48 hours. The total viable

bacterial count was enumerated on plate agar medium at 32°C for 48 hours. Coliform bacteria were enumerated on MacConkey agar medium for enumeration of coliform at 37°C for 24 hours according to [22]. Colony-forming unit (CFU) is used in microbiology to estimate the number of viable bacteria or fungi in a sample.

A colony is a cluster of bacteria growing together. To measure the CFU, bacterial cultures are added to agar plates, often by serially diluting the original sample as it might be too concentrated to count. The number of visible colonies (CFU) present on an agar plate can be multiplied by the dilution factor to provide the CFU/ml.

3. Results

Viscosity

Table (1) illustrates that water kinematic viscosity of non-magnetized water increased from 0.978 to 0.979 and 0.981 (10⁻⁶ m²/s-1) with increasing salinity from 219 to 1000 and 2000 ppm. By treating water magnetically, a decrease in viscosity was observed. At an intensity of 1600 G, a decrease in viscosity by 5.1% was observed at 219 ppm, while it decreased by 4.3%, and 1.7% at 1000 and 2000 ppm, respectively. With an increase in magnetic intensity to 14500 G, the viscosity also decreased by 10.2%, 6.8% and 3.3% compared to the non-magnetized water treatment at 219, 1000 and 2000 ppm, respectively. So, it could be concluded that higher the water salinity, the higher the water viscosity, and as water magnetization intensity increased the water viscosity decreased. This means that magnetization reduced water viscosity under all water salinity levels. These results agree with Seham et al. (2020) and Al-Douri et al. (2021) who proved under magnetic effect; the activation energy was increased and energy of water intra molecular was decreased. As a result, under magnetic effect the bonds of hydrogen were created and mean size of clusters became larger.

Table (1): Effect of magnetic and salinity on kinematic viscosity (10⁻⁶ m² s⁻¹)

Salinity(ppm)	Non magnetic	1600G	14500G
219	0.978	0.953	0.902
1000	0.979	0.952	0.918
2000	0.981	0.950	0.934

Density

As shown in Table (2) the increase in water salinity, increased water density. However, for all water salinity levels, as magnetic field strengths increased, magnetized water density decreased. This means that magnetization reduced water density under all water salinity levels. These results are similar with [9] and [13].

Table (2): Effect of magnetization on water density (g.cm⁻³)

Salinity(ppm)	Non magnetic	1600G	14500G
219	0.974	0.959	0.944
1000	0.981	0.966	0.95
2000	0.988	0.972	0.956

Surface Tension

Results in (Fig 1) showed a decrease in water surface tension of water under the influence of magnetization and salinity. The water surface tension of non-magnetized water treatments decreased with increasing water salinity. So, water surface tension decreased by 1.5% when the salinity increased from 219 to 1000 ppm and by 3% when the salinity increased to 2000 ppm. For magnetized water treatments, the water surface tension decreased with increasing magnetic field strength under all water salinity levels. When water was exposed to a magnetic field of 1600 G, the surface tension of water decreased by 4, 4.2, and 4% at 219, 1000 and 2000 ppm respectively.

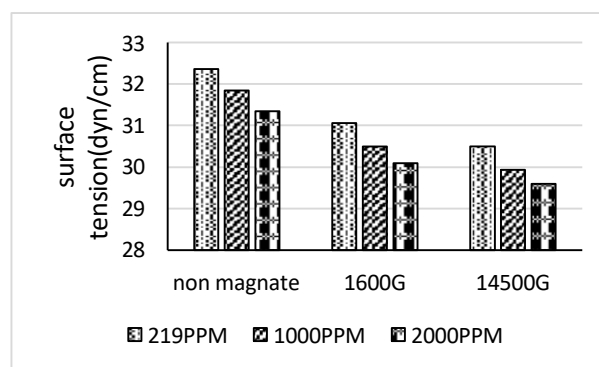


Fig (1): The relationship between water magnetization and water surface tension under different water salinity levels.

When the magnetic intensity was increased to 14500 G, the decrease was about 5.7, 6, and 5.6% at the same salinity levels. [10] reported that magnetic field changes the molecules structure of water. The stationary magnetic effect varies the water physicochemical properties at 1000, 1500 and 2000 G. Average contact angle was noticed to be 0.262, 0.261 and 0.295 for intensities 1000, 1500 and 2000G, respectively, compared with tap water 0.249. The magnetic effect brought down surface tension.

Electrical Conductivity (EC)

The results showed that in the absence of exposure to magnetism, there is no change in the value of EC as shown in Table (4). However, when the water was subjected to a magnetic field of 1600 G, EC increased by 17.4%, 26.9% and 30.6% after magnetization directly at (time zero), 24 h and 48 h respectively compared with EC of non-magnetized water of the control treatment (219 ppm). The magnetic water treatment of 14500 G intensity increased EC by 24.2% at time (0 h). However, increased EC by 37.4% and 37% after 24 h and 48 h respectively, in

comparable with Ec in control treatment of 219 ppm salinity level.

Similar slight magnetization effect on EC was obtained under 1000 and 2000 ppm water salinity treatments as well. This result agreed with that obtained by [15] and [19] who explained that the electrical conductivity increased due to the water structure being changed by the magnetic treatment. It could be concluded that under all the studied water salinity levels, with the increase in magnetic field density, water electrical conductivity EC was slightly increased with increasing time as well.

Table (4): Effect of intensity and time after magnetization on the electrical conductivity at different salinity levels.

EC	219 ppm			1000 ppm			2000 ppm		
	0 h	24h	48h	0 h	24 h	48 h	0 h	24h	48 h
Non magnet	0.342	0.342	0.342	1.73	1.73	1.73	2.97	2.97	2.97
1600 G	0.401	0.434	0.447	1.733	1.75	1.75	2.98	3.01	3.04
14500 G	0.425	0.470	0.483	1.73	1.76	1.76	3.03	3.04	3.06

Potential of Hydrogen (pH)

The pH increased due to magnetization of 1600 G with 2.5%, 2.7% and 2.6% at water salinity treatments of 219, 1000 and 2000 ppm respectively compared to non-magnetized treatment as shown in Fig (2). When the magnetic intensity was increased to 14,500 G, pH increased with 6.8%, 6.6%, and 5.1% at the same three treatments of water salinity levels, respectively, compared to non-magnetized water. Four magnets were used by Amor et al. (2018) with different size and intensity and noticed that the pH increased slightly over time, then return to its original value, confirming the memory of water effect.

Over time 42 h, the treatment of water magnetization by 1600 G intensity increased the pH value by 4.7%, 3.3%, and 1.9% for treatments of water salinity levels of 219, 1000, and 2000 ppm respectively. As well as, after 48 h, the pH increased by 6.8%, 4.5%, and 2.8% for the same three water salinity treatments, respectively. As for the effect of increasing the magnetic intensity to 14500 G, water pH also increased with (8.8%, 6.6%, and 4.4%) and (10.8%, 7.2%, and 4.8%) after 24 and 48 h, for the three water salinity treatments respectively. This is agreed with [11] who observed that magnetic field has affected the pH value. Once the process of magnetization starts, the molecular system of water is changed after several hours of exposure to magnetic field which resulted in the alteration of the total conformation energy of the system, the observed changes in proton concentration value increases with the increment of intensity, reaching 17.22% as the water was exposed to intensity of 8000 G.

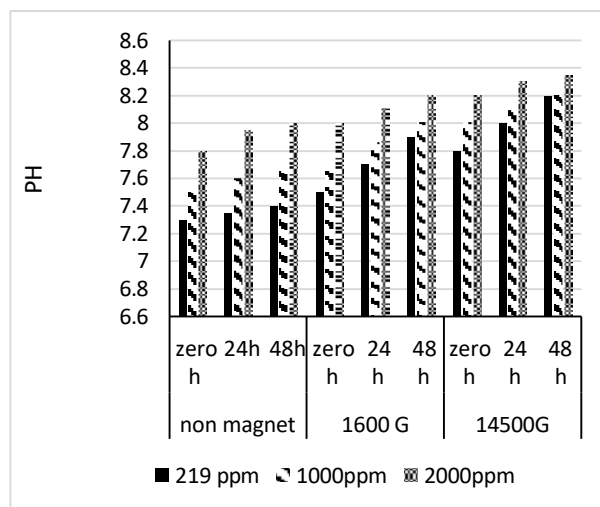


Fig (2): The relationship between magnetization intensity, magnetization time, and water salinity on water pH.

Dissolved Oxygen (DO)

As shown in Table 5 as water salinity increased, the percentage of dissolved oxygen OD in the saline water increased. As well as, water magnetization also increased OD in saline water. For example in non-magnetized water treatments OD increased from 79 to 82.4 and 84.1% as water salinity increased from 219 to 1000 and 2000 ppm, respectively. This results explained by [13] who said with high salinity there is a lower quantity of bacteria as a result of salt content suppressing bacterial growth and multiplication, and thus high DO is produced, resulting in low DO. Previous studies have shown that irrigation with saline effluent can increase the abundance of soil bacterial communities [18]

However, when the three water salinity treatments magnetically treated at 1600 G, and 14500 G intensity the DO percentage increased from 79% to 81.6, and 86.4 respectively, at 0 time after magnetization. As time passes, the DO% at both 1600G and 14500G magnetization intensity decreased with time increase. [23] explained that the DO increased due to the angle between the two hydrogen and oxygen atoms within the water molecule being lowered from 104° to 103° by the influence of the external magnetic field As it dropped from 81.6% to 76.5 and 63.1 after 24 h and 48 h respectively, at 1600 G. This result agreed with [14] who said that magnetization process increased pH and DO concentration while decreased the Oxidation and reduction potential (ORP) of water.

Table (5): Effect of magnetization and magnetization time on DO% with different salinity levels

Microbiological Analysis

Using magnetization reduced the microbial

DO	219 ppm			1000 ppm			2000 ppm		
	0 h	24h	48h	0 h	24 h	48 h	0 h	24h	48 h
Non magnet	79	75.2	74.6	82.4	76.2	67.5	84.1	70.7	65.1
1600 G	81.6	76.5	63.1	84	77.2	61.8	88.4	82.5	78.5
14500 G	86.4	80.5	73.7	88.3	83.2	79.2	96.9	94.2	88.3

activity of microbes in water compared to the non-magnetized water treatment (Table 6). The use of 1600 G and 14500 G magnetization field caused 17.1 and 57.3% reduction in the total number of microbes ,respectively, compared with non- magnetization treatment of 219 ppm water salinity , measured directly after (zero time). However, when the salinity level rises to 1000 ppm, the total number of microbes decreased by 38.6% and 57.5% at magnetization of 1600 and 14500 G, respectively. As well as, t at salinity level of 2000 ppm, the microbes decreased by 32.5% and 55.5% at the same two magnetization levels, respectively.

When using magnetic water or using the direct magnetic field to which the fungi colonies were exposed, the usage of magnetic technology demonstrated positive results in discontinuing the fungal growth of the chosen fungi in the experiment [24]. It was also observed that time has an effect on magnetized water, as it was found that at zero magnetization time, the number of bacteria is at its lowest count compared to no magnetization. However, after 24 hours, the number increases, and after 48 hours, it doubles.

Table (6): The total count of microbes with varying exposure time to magnetism and different magnetism intensities.

Degree of salinityMagnet intensity Time (h)
Total number of microbes (cfu/ml)
219 ppmNon magnet Zero 11700

	24	30600		
	48	57300		
1600 G	Zero	9700		
	24	27800		
	48	55400		
14500 G	Zero	5000		
	24	16900		
	48	34500		
1000 ppm	Non magnet	Zero		
25900				
	24	48200		
	48	78900		
1600 G	Zero	15900		
	24	43300		
	48	75300		
14500 G	Zero	11000		
	24	35200		
	48	44320		
2000ppm	Non magnet	Zero		
30800				
	24	52100		
	48	93500		
1600G	Zero	20800		
	24	47630		
	48	89500		
14500 G	Zero	13700		
	24	40700		
	48	45930		

5. Conclusions

This work was conducted to descript the effect of magnetic field on the properties of irrigation water. Magnetic devices with two intensities (1600 and 14500 G) were used to treat three saline water levels (tap water with 219 ppm, 1000 ppm and 2000 ppm). The effect of magnetization on viscosity, density, surface tension, electrical conductivity, water pH, dissolved oxygen content, and microbiological analysis were studied.

It was found that magnetization affects viscosity, dissolved oxygen, surface tension and pH. Also, found a positive effect of magnetization on the total number of microorganisms. On the other hand, magnetization does not affect electrical conductivity. The viscosity, surface tension and microorganisms count of water was decreased under magnetic treatment. Therefore, it is recommended using the magnetic treatment for improving saline water properties for irrigation and other agricultural practices.

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