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The effect of magnetic treatment on some physical properties of Seawater

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Highlights

- **The present study has shown that there is a clear effect of the magnetical treatment on some physical properties of sea-water, such as density, electrical conductivity and viscosity.**
- **The study showed that there is a variation in the time of loss of magnetization according to the concentrations during the properties of density and viscosity, while for conductivity, the time of loss of magnetization in it may be prolonged.**
- **The experimental work is explained that magnetic water treatment causes a change in the hydrating water structure around the ion.**
- **The data we obtained were analyzed by using a statistical analysis program (SPSS) that have tested the least significant difference (LSD) with a probability of less than 0.05.**

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ABSTRACT

The effect of the magnetic field (14500 Gauss or 1.45 T) on density, electrical conductivity, and viscosity of seawater concentrations (20, 50, and 80%) is studied here. The results show that magnetic treatment causes a significant increase in the density and electrical conductivity of seawater, while the viscosity is decreased as compared to the ordinary seawater without magnetic treatment. The experiment was carried out during the winter of 2019, at the laboratory of physics, College of Sciences, Ajdabiya University, Libya.

1. Introduction

The basis of life on Earth as we know it is water, which is about 75% of the components of the organism, and has specifications that cannot be found in other materials. It consists of very small molecules and each molecule contains three atoms linked together by a covalent bond of two hydrogen atoms linked to single oxygen at an angle of 104.5^0. The water molecule is an asymmetrical magnetic pole, where oxygen is negative polar while hydrogen is positive, resulting in a polar covalent bonding as shown in Fig. 1 (Hardeep, 2018).

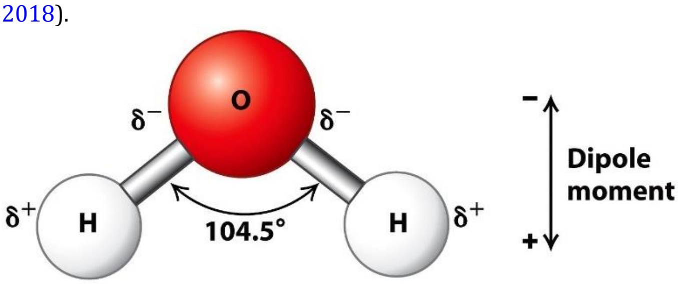

Fig. 1. Structure of water molecule.

Magnetically treated water is water that has been exposed to a magnetic field causing it to have magnetic properties that distinguish it from ordinary water. When water passes into a magnetic field, the bonds between molecules either change or break apart as shown in Fig. 1. This affects the amount of molecular bonding angle, causing a change in some physical and chemical properties of water (Reddy and Ghorpade, 2014; Nduka, 2011; Ahmed, 2009) such as surface tension, refractive index, viscosity, melting temperature, conductivity, the solubility of salts and pH (Smikhina, 1981; Srebrenik *et al*., 1993; Amiri and Dadkhah, 2006; Otsuka and Ozeki, 2006; Chang and Weng, 2008).

The water treatment is magnetized using magnetic devices called magnetic water treatment or magnetron as in Fig. 2 of a certain intensity and for a certain period, as the water flows through it. They are of different sizes which can be installed in pipes and their diameter ranges between 0.25–30 inches (Takachenko, 2005; Amin and Sami, 2009).

Previous studies of (Ahmed, 2009), showed that magnetically treated water reduces the bonding angle between the hydrogen and hydrogen atoms in the water molecule cause the following:

i. It reduces the level of bonding between the molecules and decreasing their size due to the breaking of hydrogen bonds.

ii. This makes the water molecule clustered into smaller groups of 6-7 groups after they consisted of 10-12 groups. These small concentrations lead to better absorption of water at the cell walls.

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Fig. 2. The Magnetron.

Han *et al.* (2016) investigated the optical properties of water when placed between two strong magnets. They found that the infrared absorption property of magnetic water changed (Han *et al.*, 2016). Holysz *et al.* (2007) concluded magnetic field (MF) could enhance the conductivity and decrease the surface tension of water (Holysz *et al.*, 2007; Amiri and Dadkhah, 2006). Wang examined the effect of a static magnetic field on liquid water using frictional experiments. The results suggested the friction coefficient was smaller in the magnetic field. (Wang *et al.*, 2013) and Cai et al. studied the effect of the magnetic field on the hydrogen bonds of water and discussed the mechanism of magnetization based on molecular dynamics simulation, both experimental and theoretical models. (Cai *et al.*, 2009; Toledo *et al.*, 2008; Chang and Weng, 2006). Liu *et al.* (2011) described the magnetic field could accelerate the degradation of organic substances of pulp and paper wastewater. The pH values of wastewater first increased to the climax and then decreased when MFS ranges from 0 mT to 900 mT (Liu *et al.*, 2011).

Takachenko proved that the water exposed to the magnetic field has the characteristics of surface tension and viscosity with the lowest values compared to ordinary water (Takachenko, 1997). Furthermore, (Al-Nasiri and Abdul Majeed, 2006) have explained that the water treated magnetically with the strength of a magnetic field of 500 Gauss leads to a decrease in density, surface tension, and viscosity of water. Hilal showed that the magnetically treated water in the magnetic field increases the thickness of hydrogenation around the surface of the ions and thus increases the strength of the interference of these ions with water (Hilal and Hilal, 2000a and b). Ahmed (2009); Ali *et al.* (2015); Afshin *et al.*, (2010) investigated the influence of magnetic water on compressive strength and workability (consistency) of concrete. Results show that the compressive strength of concrete samples prepared with magnetic water increases more than that of the tap water samples.

These features make magnetic water a bio-friendly compound for plant and animal cells (Wang *et al.*, 2013). Magnetic water can be used to increase crop yield, induce seed germination, and benefit the health of livestock (Hilal *et al.*, 2013; Maheshwari and Grewal, 2009). Studies have demonstrated that using make magnetic for irrigation can improve water productivity; thus, conserving water supplies for the expected future global water scarcity. In addition, make magnetic is reportedly effective at preventing and removing scale deposits in pipes and water-containing structures (Hilal *et al.*, 2013). The main objective of the present study is to know the effect of the magnetic field on different concentrations of seawater especially providing the knowledge about how long magnetic retention remains in the mentioned concentrations.

2. Experimental work

The distilled water scale and seawater at different concentrations (20%, 50%, 80%) were passed through a magnetic water treatment by the magnetron device, which is from the Egyptian Delta Water company with Japanese technology with a magnetic field of magnitude (1.45 T). The effect of temperature ranges between 21.5±0.5 °C and the magnetization duration was 10 minutes at a lifetime (0, 1, 2) days of water exposed to the magnetic field. Thereafter, laboratory experiments were conducted on this magnetized water and the results were compared with non-magnetized water. This was to determine the effect of magnetization on the density, the electrical conductivity, and the viscosity (Delta water Egypt company, 2018).

2.1 The Density

The density of water was tested before and after magnetization by the volumetric density bottle (V=50 mL). The mass was measured using the sensitive scale with a high accuracy. The relationship below describes how to calculate the density of water:

$$\rho = \frac{m}{V} \tag{1}$$

where m is the mass, V is the volume and ρ is the density of water.

2.2 Electrical Conductivity

The values of conductivity were calculated using the electrical conductivity device (Conductivity/Temp./TDS8302) by immersing the electrode of the device in the sample after washing the electrode with distilled water and then water from the same sample and taking the readings directly from the device screen.

2.3 The Viscosity

The viscosity was measured using a Viscometer for water samples. This is to install the viscometer in a vertical position by a holder. The known volume of sample liquid (20 cm^3) is then placed using a pipe. In the viscometer, the liquid was withdrawn into the bulge (B) until it exceeded the mark (C). The fluid flow is left inside the viscometer up to the IIth mark, and the time of fluid passage is calculated between the signs (II, C) (flow time in seconds). Then, this procedure is repeated 3 times and then take the average flow time as Fig. 3.

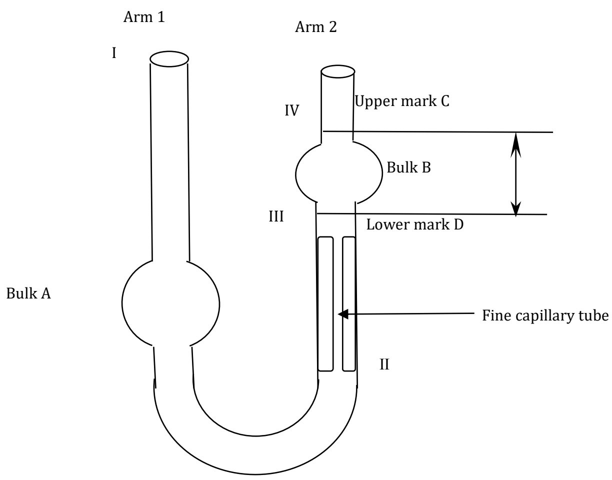

Fig. 3. The tool of measuring the viscosity.

The viscosity η of the water sample is calculated using the relationship:

$$\eta = \frac{\pi\, P\, r^4\, T}{8\, L\, V} \tag{2}$$

Where P is the atmospheric pressure, which is 1.0 atm or 1.013×10^5 N/m^2, r is the radius of the tube, which is 1.0 mm, T is the time of the fluid flow, L is the length of the tube and V is the volume of the fluid.

2.4 Data analysis

The data obtained were analyzed by a statistical analysis (SPSS) program, which has tested the least significant difference (LSD) with a probability of less than 0.05.

3. Results and discussion

From the results shown in Table 1, it is clear that the magnetized water led to a significant increase in the density values of all concentrations (0, 20, 50, 80%) during the first day. So, the highest value increased from 0.99690 g/cm³ non-magnetized water to 1.06060 g/cm³ to magnetized water at the highest concentration, while the lowest height value was recorded at concentration 20% from 0.99300 g/cm³ non-magnetized water to 0.99638 g/cm³ for magnetized water, as shown clearly in Fig. 4. The reason for this is the increase in the quantities of dissolved salts at the higher concentration of water, which leads to an increase in the density of water and thus an increase in its mass (Grzesiuk and Mikulski, 2006). In addition, the results in Table 1 showed significant differences in density values on the first day, while no significant differences appeared in the values during the second and third days. Fig. 5 shows the decrease in the density values of magnetic water during the second and third days and this is explained by the occurrence of a loss of magnetization with the length of time (Hilal and Hilal, 2000(a) and (b)).

Table 1

The density of seawater concentrations (Magnetized & Pre-magnetized) (g/cm³).

Concentrations (%)	Day one (t = 21.3 °C)		Day Two (t = 22 °C)		Day Three (t = 21 °C)	
	pre-magnetized	magnetized	pre-magnetized	magnetized	pre-magnetized	magnetized
0	1.00204	1.02012	1.00248	0.99640	1.00248	0.99618
20	0.99300	0.99638	0.99332	0.99646	0.99338	0.99638
50	1.00296	1.01210	1.00296	0.99266	1.00292	0.99256
80	0.99690	1.06060	0.99692	1.02682	0.99718	1.02686
	LSD=0.00130		LSD=0.02890		LSD=0.02890	

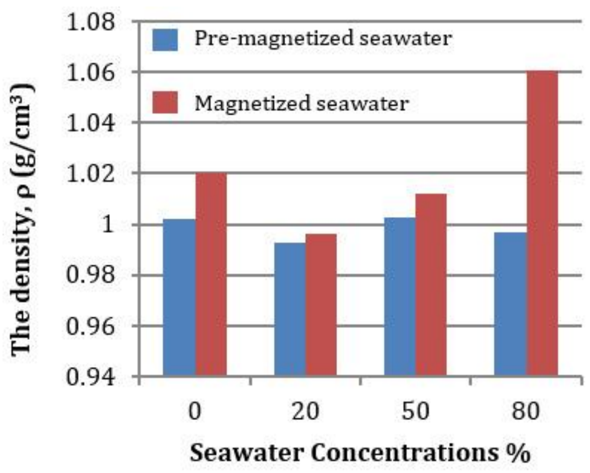

Fig. 4. The density of sea water Concentrations (Magnetized & Pre-magnetized) at 21.3 °C.

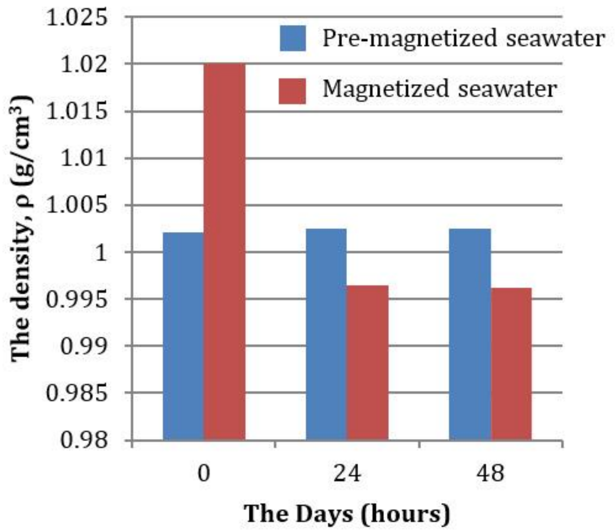

Fig. 5. The density of control water concentrations (Magnetized & Pre-magnetized) during days at 0%.

Table 2 shows that a non-significant increase was detected in the electrical conductivity values of magnetic water compared to non-magnetized water and this is confirmed by Pang and Shen (2013) and Munther and Mubarak (2002). The data shows that as it rose to the highest value from 598 µs/cm non-magnetized water to 602.5 µs/cm magnetized water at 80%, while the lowest value was at the control concentration 6.48 µs/cm for non-magnetic water, which has risen to 15.3 µs/cm for magnetic water, shown in Fig. 6. The effects of magnetic treatment on electrical conductivity reported in this study were may probably due to reorganize and arrange the charged ions of water and thus increase the electrical conductivity of water with increasing values of total dissolved salts and this is confirmed by Alwediyani (2016) and Ibrahim (2006).

The results showed in Table 2 that there were higher significant differences at 0% concentration. The electrical conductivities of seawater, on the first day, were recorded as 15.30 µs/cm and 6.48 µs/cm for magnetic and nonmagnetic water, respectively, while they were recorded as 15.55 µs/cm and 6.66 µs/cm on the second day, but they were 19.27 µs/cm and 7.85 µs/cm on the third day. In addition to the results in Fig. 7, which shows that the electrical conductivity of magnetic water was not affected by the length of time, it remained high for magnetic water compared to non-magnetic water and this was confirmed by Hilal and Hilal (2000a) and (2000b).

It is evident in the results shown in Table 3 that magnetically treated water led to a significant decrease in the viscosity values of all concentrations during the first and second days comparing with the non-magnetized water, while, on the third day, the results were fluctuated. Fig. 8 indicates the greatest level of decrease in the highest concentration so that, the value decreased from 0.72510 mpa.s to non-magnetized water to 0.71814 mPa.s for magnetized water. Also, the concentration at 20% was the lowest decrease, so the value decreased from 0.72560 mPa.s to nonmagnetic water to 0.72427 mPa.s to magnetized water. This is explained by the fact that magnetic treatment of water led to an increase in the solubility of salts, causing a breakage in the hydrogen bonds of water, which leads to a decrease in viscosity in general at all concentrations (Ahmed, 2006; Stafford, 1996).

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Table 2

The electrical conductivity of seawater concentration (Magnetized & Pre-magnetized) (μs/cm).

Concentrations (%)	Day one (t = 21.3 °C)		Day Two (t = 22 °C)		Day Three (t = 21 °C)	
	pre-magnetized	magnetized	pre-magnetized	magnetized	pre-magnetized	magnetized
0	6.48	15.3	6.66	15.55	7.85	19.27
20	167.5	168.5	164.4	168.05	165.9	167.15
50	389	394.5	384	390.5	391	392
80	598	602.5	585	594.5	590	598.5
	LSD=4.898		LSD=6.794		LSD=8.976	

Table 3

The viscosity of seawater concentrations (magnetized & pre-magnetized) ($mP_a.s$).

Concentrations (%)	Day one (t = 21.3 °C)		Day Two (t = 22 °C)		Day Three (t = 21 °C)	
	pre-magnetized	magnetized	pre-magnetized	magnetized	pre-magnetized	magnetized
0	0.72383	0.71901	0.73127	0.71310	0.70631	0.71244
20	0.72560	0.72427	0.70894	0.70807	0.72996	0.70631
50	0.72780	0.71945	0.72777	0.71923	0.71288	0.72120
80	0.72510	0.71814	0.72295	0.71660	0.72427	0.71945
	LSD=0.0006		LSD=0.0005		LSD=0.0006	

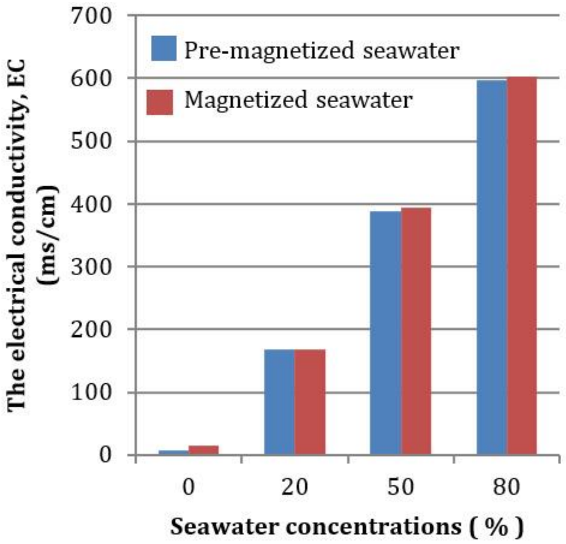

Fig. 6. The electrical conductivity of seawater concentration (Pre-magnetized & Magnetized) at 21.3 C⁰.

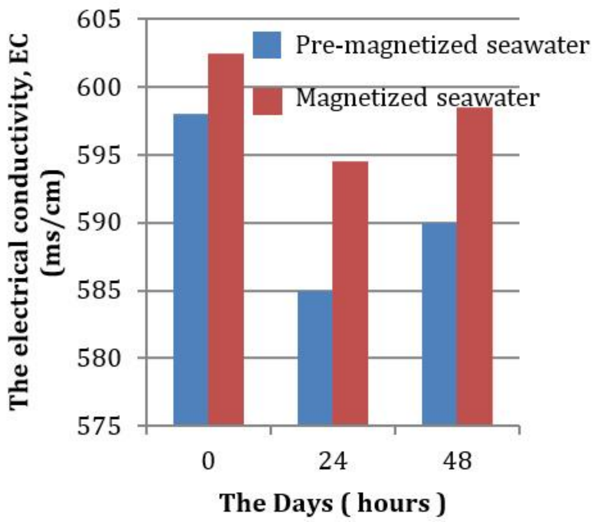

Fig. 7. The electrical conductivity of seawater concentrations during days at of 80%.

It is evident in the results shown in Table 3 that magnetically treated water led to a significant decrease in the viscosity values of all concentrations during the first and second days comparing with the non-magnetized water, while, on the third day, the results were fluctuated. Fig. 8 indicates the greatest level of decrease in the highest concentration so that, the value decreased from 0.72510 mPa.s to non-magnetized water to 0.71814 mPa.s for magnetized water. Also, the concentration at 20% was the lowest decrease, so the value decreased from 0.72560 mPa.s to nonmagnetic water to 0.72427 mPa.s to magnetized water. This is explained by the fact that magnetic treatment of water led to an increase in the solubility of salts, causing a breakage in the hydrogen bonds of water, which leads to a decrease in viscosity in general at all concentrations (Ahmed, 2006; Stafford, 1996).

The perusal of the recorded data in this study is in record with the results of (Collic *et al.*, 1998) who observed that the application of high magnetic fields to hard water that contains a large number of salts greatly affects these hydrogen bonds and this is evident in our results at the highest concentration of magnetized water, while in water less contains salts the hydrogen bonds are not affected much, and this is observed in our results when the concentration is 20%. As for the results in Table 3, a statistically significant difference was shown in the viscosity values, as the results in Fig. 9 showed that the viscosity values of magnetized water were not affected by the length of time so that magnetized water remained low compared to non-magnetized water, but changes in temperature were affected in the Inverse relationship.

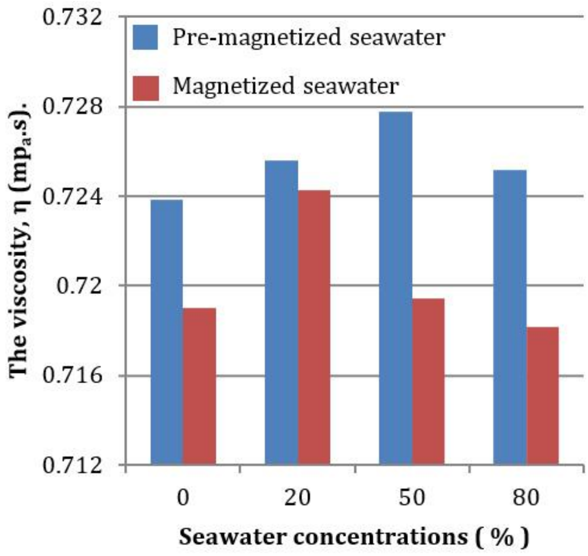

Fig. 8. The viscosity of seawater concentrations (Pre-magnetized & Magnetized) at 21.3 °C.

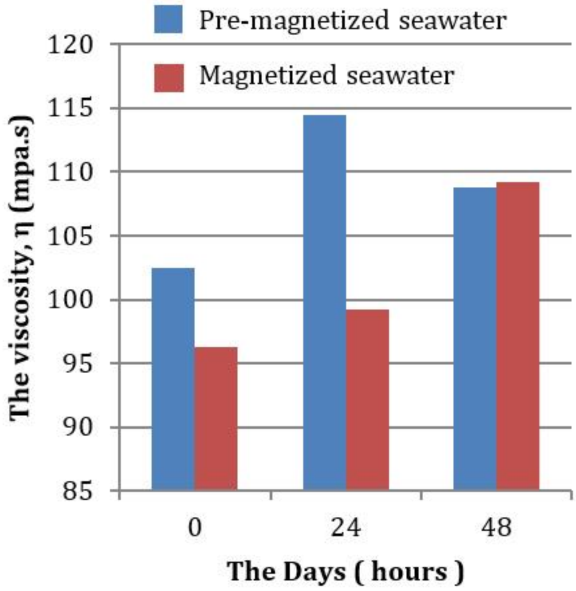

Fig. 9. The viscosity of seawater concentrations during days at 80%.

4. Conclusion

The overall results show a significant difference in density, viscosity, and electrical conductivity of magnetically treated and untreated seawater. The changed behavior depends on the nature of the ions present in the solutions, which are proportional to the thickness of the hydration shell around the ions and thermodynamic functions of hydration. The magnetic water treatment causes a change in the hydrating water structure around the ion. Thus, the magnetic treatment of seawater could be a promising technique for the soil and agricultural improvements by irrigating groups. It may also increase the efficiency of fertilization. In addition, it may improve significantly the vegetative growth and yield parameters as well as the macronutrient content of plants. It is to be mentioned here that as time passes by, the magnetization effect changes the properties, as the water retains its magnetic strength for a period of time and then begins to slow down. However, there are some properties in the water, which stays for a long time may extend for days. By noting the results achieved, we recommend providing more research on the effect of high-strength magnetic fields on other physical properties of water. In addition, future researchers might observe these changes over a longer period of time. Also, they could work on a comparative study between different methods to calculate the effect of magnetization on seawater on the property of surface tension in particular.

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