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Variation of total dissolved solids, conductivity and surface tensions of selected solutions under magnetic treatment

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ABSTRACT

Magnetic water treatment was carried out on six different solutions to study the variation of total dissolved solids, conductivity and surface tensions values of the selected solutions. During magnetic treatment, the measurements show a clear reduction in total dissolved solids, conductivity and surface tensions values of the selected solutions, which confirm that the magnet attracts the anions that present in the different selected solutions. The results have shown a remarkable variability in the magnetic treatment efficiencies due to the changes in solution and the monitoring method. A reduction is about 48% in total dissolved solids and conductivity values were observed for 0.1 M NaCl, whereas the reduction of surface tension of the selected solutions was approximately the same and around 7%.

Keywords: Magnetic water treatment; Surface tension; Total dissolved solids; Conductivity

1. Introduction

Water purification is one of the most important action for improving the life quality of any society. The development of a new, simple and low-cost water purification method is a big challenge and the most important issue for any research related to the field of water treatment. Recently, the water treatment methodologies that do not use chemical reagents such as electromagnetic field (EMF) has attracted many researchers and proposed as eco-friendly methods [1].

Electromagnetic methods are based on exposing the water to an electromagnetic field by surrounding water with the magnet for a specific period of time. As the hydrogen bonds between water molecules change or disintegrate, this disintegration works to absorb magnetic energy and reduces the anion of water molecules [2]. Magnetized water term is used to describe the water which has been exposed to magnetic fields that can lead to physical changes. The passage of the magnetic field alters some of the physical and biological properties of water, including; decrease of total dissolved solid (TDS), decrease of electrical conductivity and surface tension, reduce water pH, increasing the water's ability to dissolve salts and loss of the water smell like the smell of sulfur and chlorine [3].

Many properties of water that influenced by magnetic field have been reported by many studies [4–11]. Current study aims at providing preliminary information about the possibility of using electromagnetic field as a method to reduce the dissolved ions in different solutions containing different minerals. This study focuses on the variation of total dissolved solid, electrical conductivity and surface tension that occur to six selected solutions exposed to an electromagnetic field treatment.

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2. Experimental methods

The magnetic treatment device and setup used to produce magnetized water is demonstrated in Fig. 1. The drum in the magnetic separation system was filled with the tested solutions, separately. The TDS, conductivity and surface tension values were measured every 10 min for a period of 70 min. The composition of the selected solutions that exposed to magnetic treatment experiments are indicated in Table 1.

2.1. Magnetic treatment

A commercial magnetic device (GMX model 400) was used to study the effect of magnetic treatment on the different selected solutions. All measurements were carried out at room temperature (20°C ± 1°C).

2.2. Total dissolved solid (TDS) measurements

The total dissolved solid of the investigated solutions was measured using digital TDS-3 TDS Meter (Maxpure-India), resolution 0–999 ppm with 2% accuracy.

2.3. Electrical conductivity measurement

The electrical conductivity of the investigated solutions was measured using CC-501 conductometer (Elmetron, Witosa, Poland). The meter is fitted with custom LCDs to allow the measured function and temperature to be observed simultaneously.

2.4. Surface tension measurement

Surface tension measurements were carried out at room temperature with A CSC-DU NOUY ring tensiometer from CSC Scientific Company (Fairfax, USA). The instrument was calibrated with distilled water.

3. Result and discussion

The magnetic water treatment compared to traditional ion softening methods like ion exchange and reverse osmosis technology is simple, economic and environmentally safe. The principle of operation of magnetic devices is based on the influence of the exposed magnetic field generated by permanent magnets to the dissolved anions in selected solutions [12].

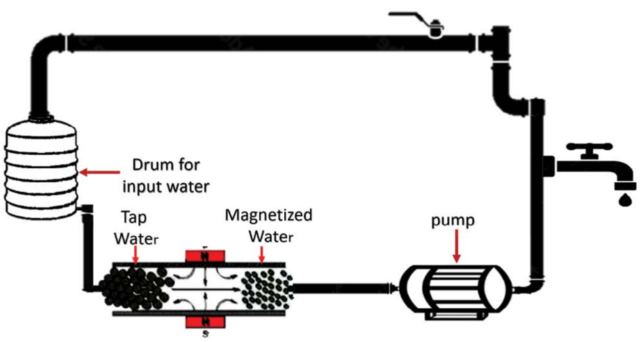

Fig. 1. The magnetic separation system.

3.1. TDS measurements

TDS is a measure of dissolved organic and inorganic substances present in a liquid in molecular, ionized or micro-granular suspended form. Figs. 2–7 show the variation of TDS values of the tested solutions under magnetic treatment experiments.

The results that demonstrate in Figs. 2–7 show that the magnet was able to reduce the values of TDS for the selected solutions. The slope and the correlation between the variables (R^2) of Figs. 2–7 are listed in Table 2.

Table 2 shows very high value of R^2 which means there is very good relation between decreasing the conductivity with time when exposure to magnetic force.

The efficiency of decreasing in TDS reading was calculated by the following equation:

$$\text{The precent efficiency of TDS reduction} = \frac{\text{TDS before treatment} - \text{TDS after treatment}}{\text{TDS before treatment}} \times 100\%$$

Table 3 shows the calculated efficiency of TDS reduction by magnetic treatment.

Table 1
Tested solutions under magnetic treatment experiments

No.	Tested solution
1	Tap water
2	Dilute dead seawater (1:9)
3	Copper(II) sulfate (0.1 M)
4	Sodium chloride (0.1 M)
5	Calcium chloride (0.1 M)
6	Iron(II) sulfate (0.1 M)

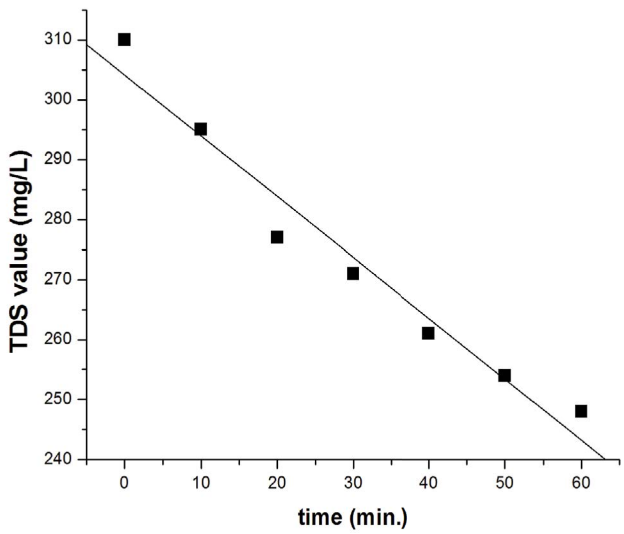

Fig. 2. The variation of TDS values of tap water under magnetic treatment.

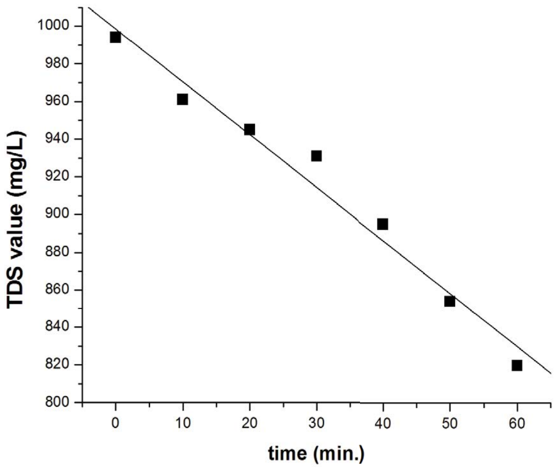

Fig. 3. The variation of TDS values of 0.1 M NaCl solution under magnetic treatment.

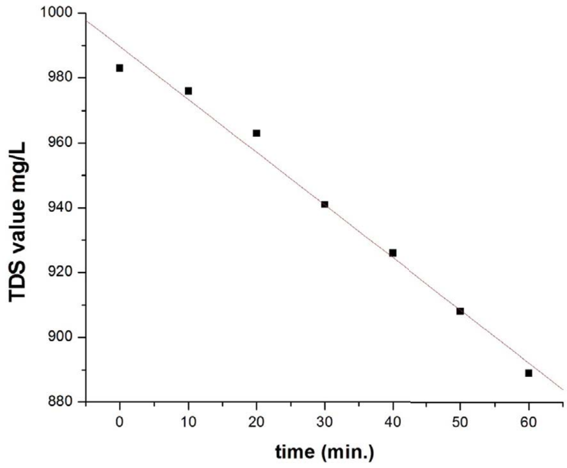

Fig. 5. The variation of TDS values of 0.1 M copper(II) sulfate solution under magnetic treatment.

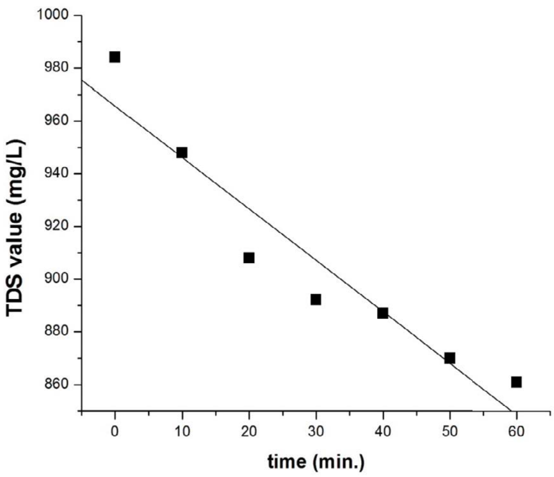

Fig. 4. The variation of TDS values of dilute dead seawater (1:9) under magnetic treatment.

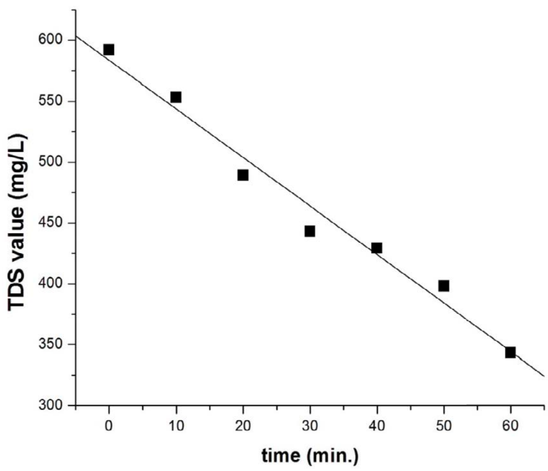

Fig. 6. The variation of TDS values of 0.1 M iron(II) sulfate solution under magnetic treatment.

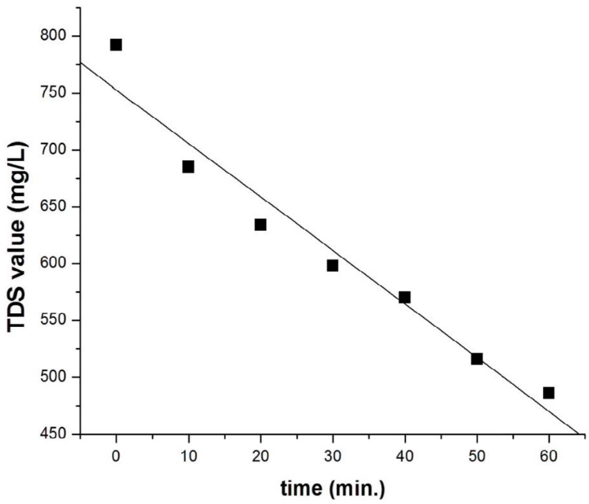

Fig. 7. The variation of TDS values of 0.1 M calcium chloride solution under magnetic treatment.

3.2. Conductivity measurements

Conductivity is related to ions concentration dissolved in water. So as shown in the result of TDS decreasing (Fig. 8), so definitely the conductivity will decrease. And it was found that the salts that had most percentage of decrease in TDS were also the same ones that had the most percentage of decrease in conductivity. Also, it is shown from the result that monovalent salts had more reduction in TDS and conductivity than divalent cations.

As shown in Fig. 8, there was significant reduction of electrical conductivity (EC) of the selected solution due to the magnetic treatment. Table 4 shows the reduction of conductivity reading of the selected solutions.

3.3. Surface tension measurements

The reduction of surface tension of the tested solutions under magnetic treatment experiments was listed in Table 5. As shown in Table 5, the reduction of surface tension

Table 2
Slope and the correlation between the variables (R^2) of Figs. 2–7

Tested solution	Slope	R^2
Tap water	–304.3	0.982
0.1 M NaCl	–998.5	0.987
Dilute dead seawater (1: 9)	–965.6	0.953
0.1 M copper(II) sulfate	–989.6	0.994
0.1 M iron(II) sulfate	–583.5	0.988
0.1 M calcium chloride	–753	0.976

Table 3
Calculated efficiency of TDS reduction by magnetic treatment

Test solution	Calculated efficiency of TDS reduction % ± 2
Tap water	19.4
Diluted dead seawater (9:1)	12.7
Copper(II) sulfate (0.1 M)	9.6
Sodium chloride (0.1 M)	48
Calcium chloride (0.1 M)	38.7
Iron(II) sulfate (0.1 M)	39.7

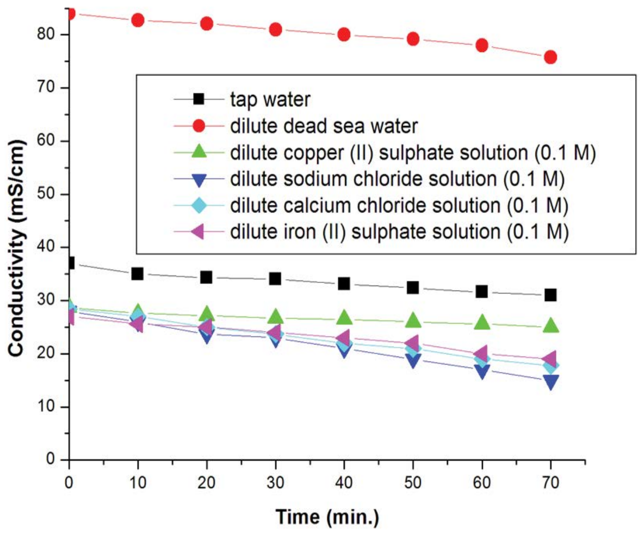

Fig. 8. The variation of conductivity readings of the tested solutions under magnetic separation experiments.

Table 4
Calculated efficiency of EC reduction by magnetic treatment

Test solution	Efficiency of EC reduction % ± 2
Tap water	13.5
Diluted dead seawater (9:1)	21.8
Copper(II) sulfate (0.1 M)	10.7
Sodium chloride (0.1 M)	33.3
Calcium chloride (0.1 M)	25.9
Iron(II) sulfate (0.1 M)	22.2

Table 5
Calculated efficiency of surface tension reduction by magnetic treatment

Test solution	Efficiency of surface tension reduction % ± 2
Tap water	7
Diluted dead seawater (9:1)	7
Copper(II) sulfate (0.1 M)	5
Sodium chloride (0.1 M)	7
Calcium chloride (0.1 M)	7
Iron(II) sulfate (0.1 M)	7

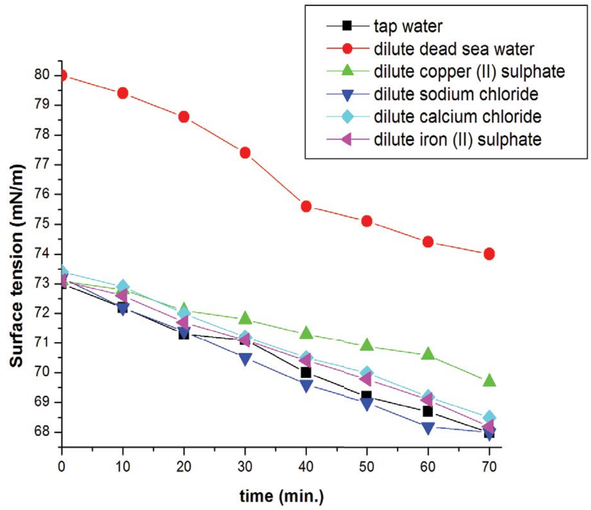

Fig. 9. The variation of surface tension readings of the tested solutions under magnetic separation experiments.

of all tested solutions was approximately the same. It is believed that the magnetic treatment increases the polarization of water that causes dipoles of the water molecules to align with the field thus reducing the hydrogen bonding.

As shown in Fig. 9, there was significant decrease in surface tension values of the tested solutions under magnetic treatment experiments. These results approve that magnetic field can decrease the electrical conductivity, surface tension and total dissolved solids of the selected test solutions [12–14].

4. Conclusions

The TDS, conductivity and surface tension analyses of six different solutions under magnetic treatment gives clear evidence for the efficiency of magnetic treatment of reducing the number of anions in the selected solutions. The efficiencies of the performed magnetic treatment experiments were ranging from 48% to 7.%

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