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Research paper

Magnetic Water Effect on Concrete Properties of Canal Lining

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Abstract

The present research investigated the magnetic field effect on the properties of tap water and the magnetic water effect on some properties of the concrete used for irrigation canal lining, so, for this purpose, the absorption and seepage features of concrete will be studied. The magnetic water was obtained by passing the tap water through magnetized devices with three different intensities (3000, 5000, and 7000) Gauss for 120 minutes. Some properties of magnetized water such as surface tension, viscosity, conductivity, TDS, and pH were studied. The results show that the surface tension, viscosity and electric conductivity of treated water with three different magnetization intensities were decreased about (19-22)%, (4-5)% and (6-8)% respectively as compared with results of the tap water. Also, the results show that pH was increased about (8-10)%. The magnetized water effect on the properties of concrete like compressive strength, slump, absorption, and seepage were studied. The results show that using the magnetized water (with three different intensities) instead of the tap water increased the compressive strength of concrete between (3-17)% for age of 28 days, and increased the slump between (5-13)mm. This leads to the possibility of increasing the water-cement ratio, which is, means decreasing the cost of concrete at a specified value of compressive strength. Also, the results show that the absorption and seepage were decreased about (1-9.5) % and (2-20)% respectively.

Keywords: *Absorption, Compressive strength, Magnetic water, pH, Water viscosity*.

1. Introduction

Concrete is a material one that widely used in the construction of buildings because of its properties unique as compared with the other materials. The concrete features, such as their resistance and their high ability to resist the surrounding conditions and their permanence, made many of researchers seek to develop the concrete materials through carrying experiments and researches with the aim of reaching to suitable buildings with high resistance and appropriate economic costs.

The quality of water which is used in the concrete mixture plays an important role in its impact on the concrete resistance, therefore for this reason the suitable water used for mixing must be taken into consideration.

Because the importance of water impact on different properties of concrete, it was imperative that this material must be given an interesting in research and study, hence the idea of using magnetic water in concrete mixture to improve its resistance rather than using high-cost additives. The cost of treated water was considered very low as compared with the other methods. Therefore the interest of researchers focused on the production economic concrete with high resistance by using new philosophies and modern technologies in design methods with no negative impact of the environment. Perhaps the most important of these methods using the magnetic field effect on water properties and thus affects the different properties of concrete[1-3].

Several researchers studied the using of magnetized water in different fields in addition to its using in concrete mixtures. Many researchers studied the magnetized water effects on water properties[4-9], and others studied its effect on human and animal health[10,11], as well as on plant growth[12-15].

The objective of the current study is to identify the effect of water exposed to the magnetic field on some properties of concrete. Also, this study includes the effect of different intensities of magnetic field on some water properties such as viscosity, surface tension, pH, TDS and electrical conductivity (Ec) and the effect of changing of these properties on the concrete.

2. Magnetized water

Magnetically treated water is the water obtained after passing through a specific magnetic field, or placing that magnet in or near this water for a period, thereby changing many of its properties due to exposure to the effect of those magnetic fields. The water that we drink or use during our daily lives loses many of its properties due to desalination processes by and environmental pollution by subjected to condensation high air pressure and the addition of many sterile substances. Therefore, the process of magnetic treatment of water works to revive many of the properties, which lost under the influence of desalination and environmental pollution and strengthen it. The process of magnetic treatment correctly reorganizes water ions while the form of these ions randomly in the tap water as shown in Fig. 1. Scientific research has shown that more than 14 properties change in water after passing through the magnetic field, including electrical conductivity, increase dissolved oxygen in water, increase the ability to dissolve salts and acids, crystallization, surface tension, change in the speed of reactions bye, increasing permeability, etc., and the water retains its magnetic strength for 8-12 hours and then starts in slow gradual decline, although some properties of water do not change even if this water passes for a long time in this field. The magnetical treatment of water was done using magnetic devices of a certain intensity, and for

a certain period, there are many factors influence in the process of the magnetization of water [16]:

1. The amount of exhibiting water to the magnetic field
2. Water velocity through the magnetic field.
3. The intensity of the magnetic field.

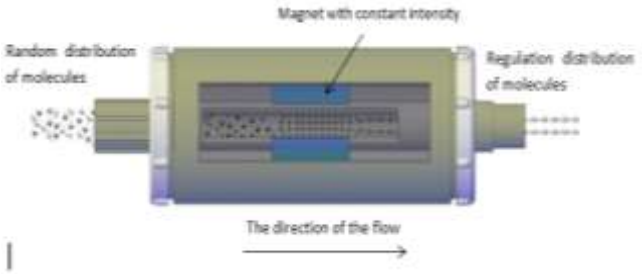

Fig. 1: Magnetic field effect on the distribution of water molecules

3. Magnetic device

According to the advantages of magnetic water, a lot of company and researchers try to manufacturing the magnetization devices. Firstly, a Belgian engineer invented machine, in 1945, for magnetization water, this machine utilized in more than 50 countries around the world and these countries including Russia and America, this machine was introducing to the market since 1950, and according to many studies and researches it was developed to its present perfect and improved form. There are many types of magnetization devices, these devices may take many shapes, many intensities and many sizes, but all of them have the same concept of work, Fig. 2 illustrates some types of magnetized water devices.

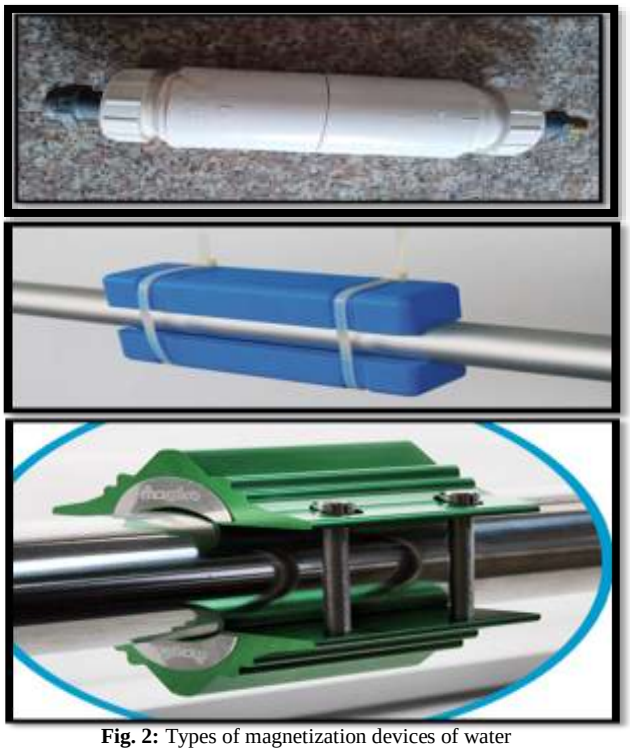

Fig. 2: Types of magnetization devices of water

4. Materials and experimental works

4.1. Cement

Iraqi (MAS) Ordinary Portland Cement (Type I) was used in all laboratory concrete mixtures. The usage of this type of cement because the laboratory tests results of its properties are successful and compatible with the standard specifications. The physical properties of this cement are presented in Table 1; these properties satisfied the limits of Iraqi specifications (IQS No.5 /1984)[17].

Table 1. Physical properties of cement

Physical Properties	Test results	Limits of Iraqi Specification No.5/1984[17]
Specific surface area (Blaine method)	305.5	230 m^2/Kg lower limit
Setting time (VICAT Apparatus)		
Initial setting (hrs. :min)	1:30	Not less than 45 min.
Final setting.(hrs. :min)	7:10	Not more than 10 hrs.
Compressive strength: for 3 days	34.2	15 MPa lower limit
for 7 days	36.15	23 MPa lower limit

4.2. Coarse aggregate

Well-graded 12.5mm nominal maximum size of local (Al-Touz region) river gravel was used in all tests according to (ASTM C 33-10)[18], with the absorption of 0.8%, the oven-dry relative density of 2.68 and the moisture content of course aggregate is 0.3%. The course aggregate was cleaning by water and packaging into a bags to ensure that this course aggregate to be saturated and has a dry surface.

4.3. Fine aggregate

Natural river sand extracted from Al-Touz region and the passes the sieve 4.75mm was used, this sand satisfied the limits of Iraqi specifications (IQS No.45 /1984)[19]. The absorption of this aggregate is 1.21%, and the oven-dry relative density is 2.6. The laboratory sample has a moisture content of 1.7%, and fineness modulus is 2.8.

4.4. Water

The water that used in the concrete mixture was from Al-Alam city; this water is potable and suitable to make concrete.

4.5. Preparation of magnetic water

The magnetized water prepared by passing the tap water through the magnetization devices with different specific intensities and different velocities. Water has been rotated through system combined from a small submersible pump with a flow velocity of about (0.6, 0.9 and 1.2) m/sec. Water was supplied from a basin filled with water of about 10 liters to a plastic tube of 1-meter length, this tube was connected to magnetization device with the specific intensity and then the water return to the basin again, Fig. 3 shows the magnetization system was used in this study. The circulation time of water through the system is 120 minutes, where the water would acquire the magnetization properties. Three intensities (3000, 5000 and 7000) Gauss of magnetization were used in this study. It worth to mention, the treated water obtained from passing water in magnetization system with velocity 1.2m/sec were used because this velocity gave best results for concrete properties.

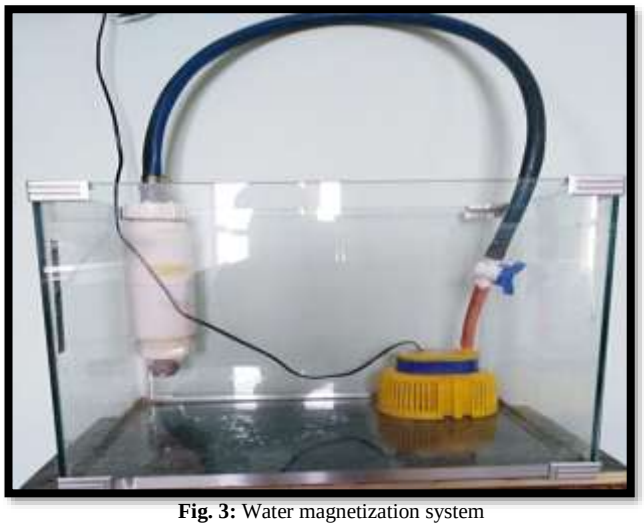

Fig. 3: Water magnetization system

4.6. Mix proportion

The concrete mix design was carried out according to ACI code to make concrete that required for casting a slab. Compressive strength for cubes 38MPa at 28 days. Slump should be between 25mm and 75mm. A nominal maximum size aggregate of 12.5 mm is required. The proportion of materials are shown in Table 2.

Table 2. Trial mix proportion for $1m^3$ of concrete

Material	Weight (Kg)
Water	219.3
Cement	405.25
Coarse aggregate	882.64
Fine aggregate	855.3

5. Results of Magnetization Effects on Water Properties

5.1. pH of water

It is a measure of acidity or alkalinity of water-soluble substances (pH stands for 'potential of Hydrogen'). A pH value is a number from 1 to 14, with 7 as the middle (neutral) point. The value of pH is a good indicator of whether water is hard or soft. In the present research the results show that there are increasing of the value of pH with the progress of the time of magnetization with each intensity of magnetization. Table 3 and Fig. 4 illustrate the effect of magnetic field on the pH value of water.

Table 3. Magnetic field effect on the pH value of water

Time min.	pH of Water						
	Tap	3000 Gauss	Increasing %	5000 Gauss	Increasing %	7000 Gauss	Increasing %
0	7.00	7.00	----	7.00	----	7.00	----
30	7.00	7.14	2.4%	7.18	2.6%	7.15	2.1%
60	7.00	7.25	3.4%	7.30	4.3%	7.20	2.9%
90	7.00	7.35	5.0%	7.50	7.14%	7.30	4.3%
120	7.00	7.48	6.9%	7.61	8.7%	7.38	5.4%
180	7.00	7.67	9.6%	7.70	10.0%	7.60	8.6%

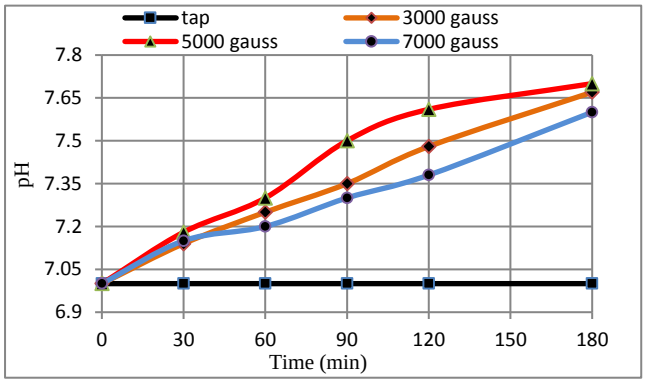

Fig. 4: Magnetic field effect on pH value of water

5.2. The surface tension of water

Surface tension is the energy, or work, required to increase the surface area of a liquid due to intermolecular forces; these intermolecular forces vary depending on the nature of the liquid. The magnetic field is one of the factors that effects of the changing of the value of the surface tension. In the present research, the effect of three intensities was studied to show the effect of the magnetic field on the surface tension values, and the results show that there are decreasing of the surface tension values with the use of magnetic field and with the progress of the time of magnetization treatment process. Table 4 and Fig. 5 illustrate the effect of magnetic field on the surface tension of water.

Table 4. Magnetic field effect on the surface tension of water

Time min.	Surface Tension of Water (N/m)						
	Tap	3000 Gauss	Decreasing %	5000 Gauss	Decreasing %	7000 Gauss	Decreasing %
0	0.09	0.09	----	0.09	----	0.09	----
30	0.09	0.077	-14.4%	0.085	-5.6%	0.088	-2.2%
60	0.09	0.076	- 15.6%	0.077	-14.4%	0.081	-10.0%
90	0.09	0.075	-16.7%	0.073	-18.9%	0.072	-20.0%
120	0.09	0.073	-18.9%	0.071	-21.1%	0.070	-22.2%
180	0.09	0.070	-22.2%	0.068	-24.4%	0.067	-25.6%

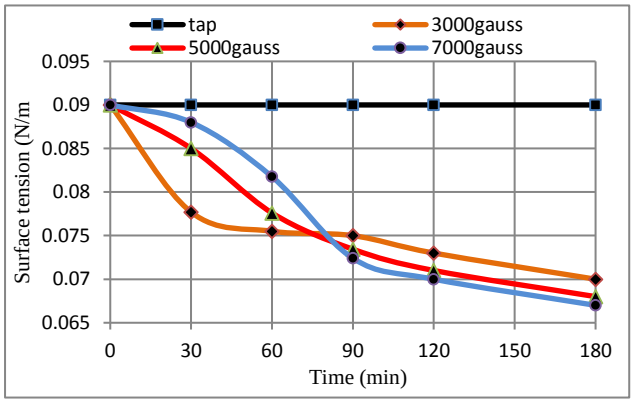

Fig. 5: Magnetic field effect on the surface tension of water

5.3. Viscosity of water

The viscosity of a fluid is the measurement of its resistance to gradual deformation by shear stress or tensile stress. For liquids, it corresponds to the informal concept of "thickness"; for example, water has a lower viscosity than honey, viscosity means friction between the molecules of the fluid. Therefore some stress (such as a difference in pressure between the two ends of the tube) is needed to overcome the friction between particle layers to keep the fluid moving. In the present study the results show that there are decreasing of the viscosity of the water after exposing it to magnetic field and that decreasing compatible with the progress of the time of magnetization treatment and that decreasing may happen because of that the magnetic field makes the hydrogen bonds of the water molecule is less than 105 degree. Table 5 and Fig. 6 illustrate the effect of magnetic field on the viscosity of water.

Table 5. Magnetic field effect on the viscosity of water

Time min.	Viscosity of Water ($N*s/m^2 \times 10^{-3}$)						
	Tap	3000 Gauss	Decreasing %	5000 Gauss	Decreasing %	7000 Gauss	Decreasing %
0	1.1786	1.1786	----	1.1786	----	1.1786	----

30	1.1786	1.1525	-2.2%	1.1710	-0.7%	1.1730	-0.5%
60	1.1786	1.1390	- 3.3%	1.1613	-1.5%	1.1520	-2.3%
90	1.1786	1.1230	-4.7%	1.1465	-2.7%	1.1450	-2.9%
120	1.1786	1.1210	-4.9%	1.1432	-3.0%	1.1310	-4.0%
180	1.1786	1.1200	-5.0%	1.1410	-3.2%	1.1300	-4.1%

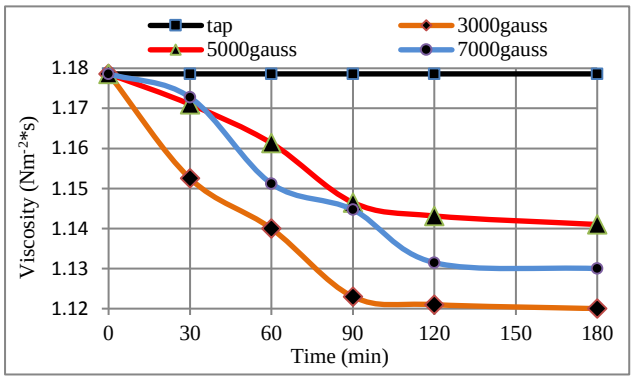

Fig. 6: Magnetic field effect on the viscosity of water

5.4. Electrical conductivity (EC)

The conductivity of a substance is defined as the ability or power to conduct or transmit heat, electricity, or sound. The electrical conductivity of the water depends on the water total dissolved solids concentration. In the present study the results show that there are decreasing in the conductivity of water with the use of the magnetic field, the decreasing of the conductivity of water may be as a result of breakage of salts according to the magnetic field which plays a big role of the conductivity of water. Table 6 and Figure 6 illustrate the effect of magnetic field on the electrical conductivity of water.

Table 6: Magnetic field effect on EC of water

Time min.	The electrical conductivity (ms)						
	Tap	3000 Gauss	Decreasing %	5000 Gauss	Decreasing %	7000 Gauss	Decreasing %
0	424	424	----	424	----	424	----
30	424	424	-0.0%	417	-1.70%	420	-0.94%
60	424	423	- 0.24%	410	-3.30%	418	-1.42%
90	424	422	-0.47%	404	-4.70%	416	-1.90%
120	424	421	-0.70%	396	-6.60%	414	-2.40%
180	424	400	-5.70%	389	-8.30%	398	-6.10%

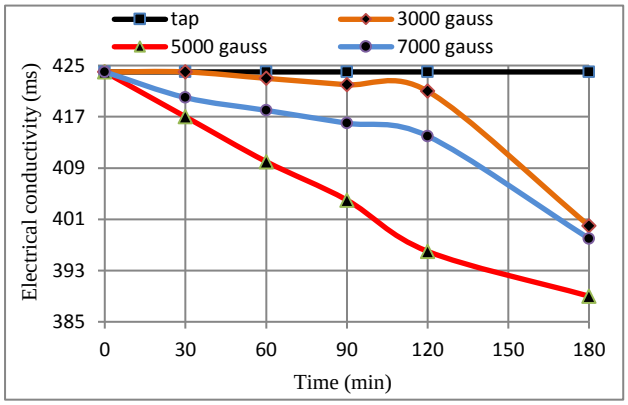

Fig. 7: Magnetic field effect on E.C. of water

6. Results of the Magnetized Water on Concrete Properties

6.1. The compressive strength of concrete

Compression resistance was performed according to British Standard (BS 1881: Part 116: 1989)[20]. For the cubes concrete samples (150×150×150) mm, they were loaded in a mono-axis direction using a compression-testing machine. The compressive strength of the average of three specimens was taken. The results show that there are increasing of the compressive strength by using magnetized water especially in the early age, the increasing of compressive strength of concrete due to the changing of the water properties and that is by the changing in the molecules of the water itself, therefore the bond angle decreases after magnetization to less than 105º because magnetic field squeezes the bond pairs to be closer together. This change in water molecules composite may cause a change in some physical and chemical properties. Table 7 and Fig. 8 illustrate the effect of magnetized water on compressive strength of concrete.

Table 7. Magnetized water effect on compressive strength of concrete

Time day	Compressive Strength (MPa)						
	Tap	3000 Gauss	Increasing %	5000 Gauss	Increasing %	7000 Gauss	Increasing %
3	17	21	23.5%	19	11.8%	23	35.3%
7	25	28	12.0%	27	8.0%	29	16.0%
14	30	34	13.3%	32	6.7%	33	10.0%
28	39	40	2.6%	45	15.4%	43	10.3%

6.2. Concrete consistency (Workability)

Concrete consistency is most frequently measured by the slump test. The slump is a good measure of the total water content in the mix. The slump of each group of concrete mixes was carried out according to BS1881: part2 (1970)[21]. The magnetized water increase the workability of fresh concrete as comprised of that which made with tap water, and that is very important to make it easier during the period of work. The increasing of workability may be because of that the magnetized water has a low value of surface tension and viscosity as compared with tap water, and that would increase the free motion of the molecules of the water. Table 8 and Fig. 9 illustrate the effect of magnetized water on the slump of concrete.

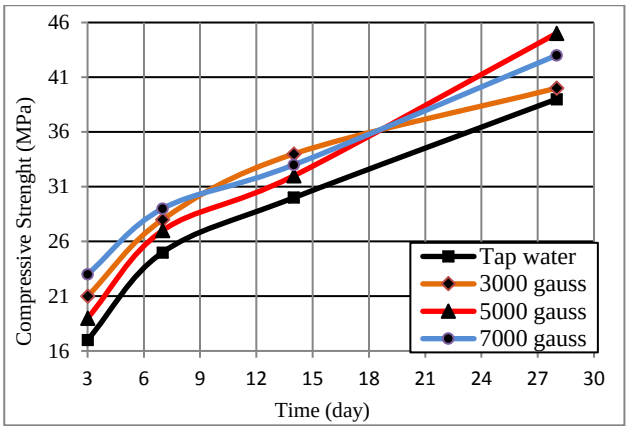

Fig. 8: Magnetized water effect on compressive strength of concrete

Table 8. Magnetized water effect on the slump of concrete

Mag. Intensity	Slump (mm)	Increasing %
Tap	33	-----
3000 Gauss	38	15.0%
5000 Gauss	40	21.1%
7000 Gauss	46	39.4%

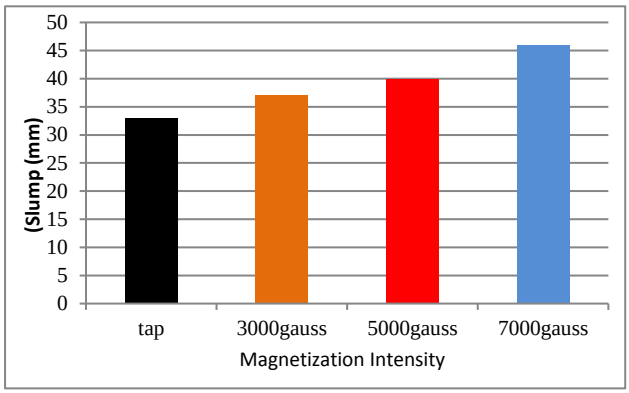

Fig. 9: Magnetized water effect on the slump of concrete

6.3. Absorption of concrete

This test was in accordance with the specifications (C 642–97)[22] of American society for testing materials. Cast the specimens of cubes concrete with tap water and magnetized water with three intensity (3000, 5000, 7000) Gauss with dimension (150×150×150) mm. The absorption is one of the most important properties of the canal concrete lining and it plays a big role in the choice of concrete in the lining of the concrete canals, the usage of the magnetized water in the concrete lead to decrease the absorption of concrete, this decreasing of absorption was because of that the magnetized water makes the proses of hydration more effective and that is leading to make the concrete with voids less than the voids that found in the concrete with tap water. Table 9 and Fig. 10 illustrate the effect of magnetized water on the absorption of concrete.

Table 9. Magnetized water effect on the absorption of concrete

Mag. Intensity	Absorption	Decreasing %
Tap	8.61%	-----
3000 Gauss	8.23%	-4.41%
5000 Gauss	8.52%	-1.00%
7000 Gauss	7.79%	-9.52%

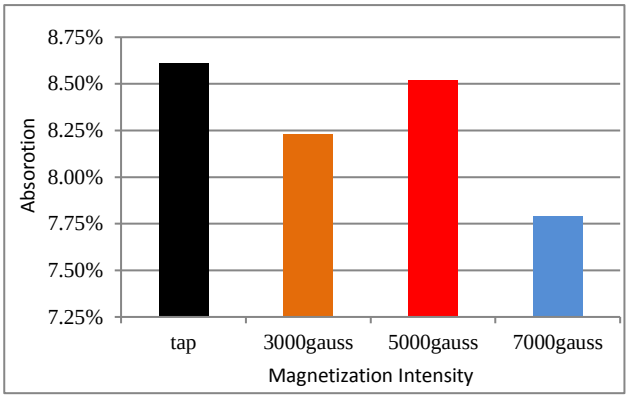

Fig. 10: Magnetized water effect on the absorption of concrete

6.4. Seepage of concrete

The main cause of lining the canals with concrete is to reduce the seepage as possible, and that is because that the seepage in the canals would cause many losses of water and that would be waste of the effort and money. This test was conducted by casting a cylinders of concrete made (with normal and magnetized water) with 10.5cm in diameter and the high of 10cm inside a plastic tube with 10.5cm in diameter and 40cm in high and after 14 days from curing full the tube with water of about 20cm and surround the edges base of the tube with polycoat to prevent the water from the seepage from the connection surface between the plastic tube and the concrete. The upper end of the tube was covered to prevent the evaporation and then observation the decrease of the water height through a period of 30 days. The results show that there is improvement of the concrete by reducing the seepage in concrete, The decreasing of the seepage in the concrete canals that made with magnetized water may because of that the concrete with magnetized water has an improvement in the hydration proses and improvement in the efficiency of the cement and that makes the cement more strong and less in voids which leads to decrease the seepage of concrete and make it better to use it for lining the canals of concrete. Table 10 and Fig. 11 illustrate the effect of magnetized water on seepage of concrete.

Table 10. Magnetized water effect on the seepage of concrete

Time day	Seepage of Water through Concrete (m^3/hr. × 10^{-8})						
	Tap	3000 Gauss	Decreasing %	5000 Gauss	Decreasing %	7000 Gauss	Decreasing %
7	8.3	7.3	-11.7%	8.1	-2.0%	6.7	-19.6%
14	4.0	3.4	-15.0%	3.9	-2.75%	3.3	-18.5%
21	4.9	4.0	- 18.4%	3.8	-22.5%	3.4	-30.6%
30	5.0	3.8	-24.0%	4.9	-2.0%	3.6	-28.0%

From the above results, the magnetic fields lead to changings in water properties, and these changings lead to improving the mechanical properties of concrete, therefore the usage of magnetized water to make concrete play a good rule of the conservation of environmental resources because it is environmentally friendly, and it leads to improving the properties of water and concrete with low costs compare with other methods that use to improve the concrete properties. The improvement of the properties of concrete leads to the possibility of increasing the water-cement ratio, which means that the amount of cement in the concrete mixtures can be reduced at a specified value of compressive strength. Therefore, for the large quantities of concrete, the magnetized water would decrease the cost of the concrete.

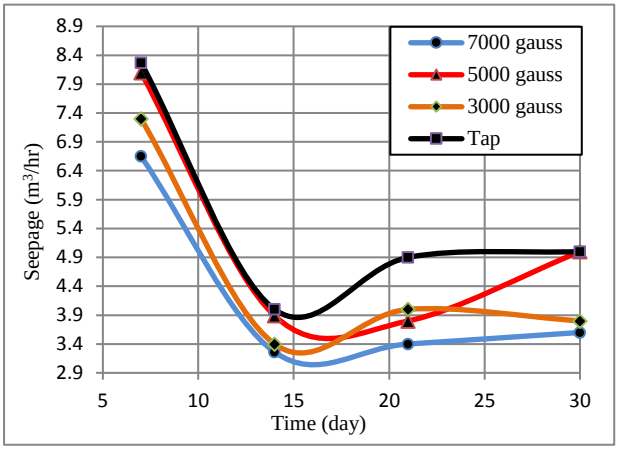

Fig. 11: Magnetized water effect on the seepage of concrete

7. Conclusions

From the current study the following points can be concluded:
Usage of the magnetic field for water treatment leads to change water properties, where the surface tension, viscosity and electrical conductivity were decreased, and pH value was increased.
The treatment of water by magnetization leads to improvement in the mechanical properties of concrete such as increasing the compressive strength and the workability of concrete and decreasing in the absorption and seepage of concrete.
The improvement of the properties of concrete leads to the possibility of increasing the water-cement ratio and decreasing the cost of concrete at a specified value of compressive strength.
The changings in concrete properties with magnetized water conduct due to the improvement of the hydration process according to the cluster concept and that because that more particles of cement are hydrated and that improve the concrete properties.

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