Effects of Magnetized Water on the Accumulated Depth of Infiltration

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ABSTRACT

This study was carried out to investigate the effects of magnetized water on accumulated infiltration depth. A test rig was designed and constructed for this purpose was installed at the water tests laboratory of the Department of Water Resources Engineering at the University of Baghdad. The investigation was carried out by using two types of soil, different flow velocities throughout magnetizing device and different configuration of magnets over and under the water passage of the magnetizing device. The soils that were used in the experiments are clayey and sandy soils. Six different flow velocities throughout magnetizing device ranged between 0.29 to 1.19 cm/s and ten configurations of arranging the magnets over and under the water passage of the magnetizing device were used. The magnates are sintered neodymium-iron-boron type.

Tests results obtained with magnetized water were compared with those of untreated water. Results showed that magnetizing water increases the accumulated infiltration depth for the two types of soil. The highest increase in the accumulated infiltration depth is achieved under low flow velocity throughout the magnetizing device and with ten magnets. This highest increase for the clayey and sandy soils was 98.2% and 34.2%, respectively.

Key words: magnetized water, infiltration, magnetizing device, water-soil relationship, magnate.

تأثير الماء الممغنط على عمق الارتشاح المتراكم للترب

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الخلاصة

اجريت هذه الدراسة لتحري تاثير الماء الممغنط على عمق الغيض التراكمي في الترب. تم تصميم وبناء منظومة لهذا الغرض وتم نصبها في مختبر المياه التابع لقسم هندسة الموارد المائية في جامعة بغداد.اجري التحري باستخدام نوعين من الترب وسرع جريان مختلفة للماء خلال جهاز المغنطة وبترتيب مختلف للمغانيط فوق وتحت مجرى الماء في جهاز المغنطة. الترب المستخدمة في التجارب كانت تربة طينية والاخرى رملية. تراوحت قيم سرع الجريان الست بين 0.29 و 1.19سم/ثا واستخدمت عشرة من اشكال الترتيب للمغانيط في جهاز المغنطة. كانت المغانيط من نوع نيوديميوم حديد- بورون.

تمت مقارنة النتائج المستحصلة من التجارب باستخدام الماء الممغنط مع تلك المستحصلة باستخدام ماء غير معالج. بينت النتائج بان تعرض الماء للمغناطيس يؤدي الى زيادة في عمق الغيض المتراكم في الترب. تكون الزيادة في عمق الغيض التراكمي عند اقصى قيمة له عند السرعة الواطئة للجريان وعند استخدام العشرة مغانيط. بلغت نسبة هذه الزيادة 98.2% بالنسبة للتربة الطينية و 34.2% بالنسبة للتربة الرملية.

الكلمات الرئيسية: الماء الممغنط، الغيض، جهاز مغنطة، علاقة الماء-تربة، مغناطيس.

1. INTRODUCTION

Many studies and researches throughout the world over the few past decades have reported significant evidences that some properties of water can be changed as it passes through a magnetic field. A study carried out by **Al-Talib** and **Al-Sinjary, 2009** on the effect of magnetic treatment of water on uniformity of sprinkle irrigation showed an increase in irrigation uniformity when using magnetized water. **Abbas, 2009,** investigated the effect of magnetic treatment of salty and fresh irrigation water on infiltration depth and hydraulic conductivity in gypsiferous and calcareous soils. He showed that in gypsiferous soil, magnetizing salty irrigation water increases the value of saturated hydraulic conductivity, while, the magnetizing of fresh irrigation water decreases the value of saturated hydraulic conductivity. In calcareous soils, magnetizing of salty irrigation water decreases the value of saturated hydraulic conductivity, while magnetizing of fresh irrigation water increases the value of saturated hydraulic conductivity. In her study on the effect of magnetizing saline water on hydraulic characteristics for different textured soil, **Al-Kaysi, 2009**, concluded that saturated hydraulic conductivity for all used soil textures decreased when using magnetized water as compared with non-magnetized water. The electrical conductivity of magnetized water affected the saturated hydraulic conductivity, and the lowest value was when distilled water is used. The non-magnetized water was more efficient than the magnetized water to leach salt from soil for all used soil textures. **Kadhem, 2010**, carried out a study to realize the effect of magnetized water on soil reclamation and salt leaching. The main conclusion of his study was that a considerable amount of water can be saved when using magnetized water to leach salts and the magnetized water has a tendency that exceeds the tendency of non-magnetized water in reclamation of soils. The effect of magnetic treatment of irrigation water on soil chemical properties with trickle irrigation was studied by **Mostafazadeh-Fard, et al., 2012**. Their main conclusion was that the soil moisture content with magnetized water was higher than when using non-magnetized water and the magnetic treatment of irrigation water caused high leaching of soil salts. The concentration of anions in the soil such as sulfate, chloride, and bicarbonate and cations such as magnesium, sodium, and calcium at soil depths of 0–60cm when using magnetized water were lower than those when using non-magnetized water. **Mohamed, 2013**, conducted a study to investigate the effects of magnetic treatment of low quality water on some soil properties and plant growth. He concluded that utilization of magnetized water technology considered a promising technique to improve the yield of tomato. After plant harvest, the use of magnetized irrigation water increased soil electrical conductivity and available phosphorus and reduced soil reaction pH. **Al-Talib, et al., 2013**, studied the effect of magnetic treatment of irrigation water on the infiltration rate of soil. They concluded that an obvious increase in water infiltration rate is achieved when using magnetized water, this, in turn, reduces the irrigation time that needed to add the required total irrigation water depth. Magnetized water can increase the discharge and give the same amount of non-magnetized water but with less operational time with the same amount of the constant irrigation depth and, thus, serves to provide the operational capacity of the system that is powered by electricity or liquid fuel by using high irrigation rate of magnetized water without occurrence of surface runoff, which raises the efficiency of water use .

The above mentioned evidences based on experimental tests are some of many other studies that prove that by passing water through field of a permanent magnet or electromagnet can change its physical properties. This change in the physical properties of water can improve the use of water in different areas and have promising potentials especially in the field of irrigation and drainage. These improvements in this field include increasing crops growth and yield, improving quality of irrigation water, increasing efficiency of salt leaching from soils, enhancing the soil, water, and plant relationships, and reducing blockage of emitters used in trickle irrigation. Moreover, obtaining improvements in water properties by field of magnets is so simple, of low cost, safe, and have no harmful effects. However, the effects of magnetic fields on the properties of water are not well developed and are still a challenging subject. Generally, this study was conducted to investigate the soil and magnetized water relationships, specifically, the accumulated depth of infiltration.

2. DESCRIPTION OF THE EXPERIMENTS

The following subsections present a description of the experiments that were carried out to investigate effects of magnetizing water on the accumulated depth of infiltration.

2.1 Materials Used

The physical characteristics of soils used in the experiments are presented in **Table 1**. Results of the chemical and physical characteristics of the water used in the experiments are presented in **Table 2**. Permanent magnets were used of sintered neodymium-iron-boron, NdFeB; these magnets are of BY0X04-N52 type manufactured by K&J Magnetics Inc. The magnet is 5 cm long, 2.5 cm wide, and 1.25 cm depth. Magnetization direction of these magnets is through its thickness and the highest value of its flux is reached at its surface of 7671 gauss.

2.2 The Test Rig

Test rig was designed and constructed to investigate the effects of magnetized water on the accumulated depth of infiltration. **Fig.1** shows a schematic diagram of the test rig. The rig consists of a constant head reservoir that maintains water to two identical magnetizing devices. Water following out of each of the magnetizing device is supplied to two cylinders containing soil. All these components are connected by using rubber tubes of 0.5 cm diameter. Flow throughout these tubes is controlled by using valves. **Fig.2** shows the test rig installed in the laboratory. The magnetizing device is a closed water passage made of a Perspex sheet 4 mm thick, 40 cm long, 7 cm wide, and 2.5 cm high. The water passage of the device has an inlet and an outlet controlled by a valve. Magnets are to be installed on the top and bottom sides of the water passage. **Fig.3** shows a close up photo of the magnetizing device. The cylinders containing the soils were made of a Perspex sheet 60 cm long, 10 cm internal diameter, 4 mm thick, and has a water inlet located at 15cm from the top controlled by a valve. A filtration paper and a metal screen were fixed at the bottom end of the cylinders. The filtration paper was used to prevent the soil from washing out. The metal screen is a support to the filtration paper.

2.3 Design of the Test Runs

Three variables were adopted when designing the test runs. The first was the configuration of magnets; ten configurations of arranging the magnets over and under the water passage of the magnetizing device were used. The second, was the flow velocity throughout magnetizing device, these velocities are 1.19, 0.99, 0.79, 0.69, 0.59, and 0.29 cm/sec. Finally, the third variable was the soil type. As was mentioned previously, two types of soil were used that is a clayey and sandy soil. So, the total numbers of experiments with magnetized water were 120 experiments. In addition to the experiments with magnetized water, a set of experiments was carried out without magnetizing the water as control experiments.

2.4 Configuration of Magnets

To investigate the effect of the number of magnets used, ten configurations of the magnets over and under the water passage of the magnetizing device were used as shown in **Fig.4**. Each configuration was designated with a code, that is M_{x-y}. In this code M refers to the word Magnets and x and y refers to the number of magnates used over and under the water passage of the magnetizing device, respectively. So, the code M_{4-4} refers to 4 magnates used over and under the water passage.

2.5 Preparing of Soils Columns

Four cylinders were prepared, two for the clayey and two for the sandy soil. The same method of packing was adopted in all experiments. The soil was added layer by layer to the cylinder by using a lab spatula. Each soil layer is gently compressed by using a special plunger, simultaneously with shaking until the top of the soil column does not sink any further, **Oliviera, et al., 1996**. The method of adding the layers of soil is repeated until the required total depth of the soil inside the cylinders, of 35cm, is reached. Some samples of the compacted soil layers were tested for their density. Bulk density for the pressed clayey soil has an average of 1050 kg/m^3 and that for the sandy soil is 1690 kg/m^3.

2.6 Description of the accumulated infiltration depth Tests

Infiltration tests were carried out by adding water to a depth of 15 cm over the soil surface. The infiltrated depth is measured by a graded ruler fixed on the outer side of the cylinder. The infiltrated depth is recorded at short time increment during the few minutes after adding the water then increased gradually until reaching the final time of the test. Smaller time increments were used during experiments with sandy soil compared to that with clayey soil.

3. RESULTS AND ANALYSES

One hundred and twenty laboratory test runs were conducted to investigate the effects of magnetized water on the accumulated depth of infiltration. **Fig.5** through **Fig.10** shows the variation of accumulated depth of infiltration under all configurations of magnets and different flow velocities throughout the magnetizing device for clayey soil. **Table 3** presents a summary of the effects of magnetizing water in increasing the accumulated depth of infiltration in the clayey soil under the applied velocities and all configurations of magnets used in the experiments. In general, increasing the number of magnets and reducing the flow velocity increases the accumulated depth of infiltration. At the highest applied flow velocity of 1.19 cm/s with M_{1-0} configuration, a 6.3% increase in accumulated depth of infiltration was achieved. For the same flow velocity with M_{5-5} configuration, this increase was 66.7%, which is 60.4% higher than that with M_{1-0} configuration. When reducing the velocity of flow water through the magnetizing device to its applied minimum value of 0.29 cm/s the effects of magnetizing of water are greatly increased. The increase in accumulated infiltration depth is 25% with M_{1-0} configuration and 98.2% with M_{5-5} configuration. This is about 18.7% and 31.5% increase compared to that with maximum applied flow velocity of 1.19 cm/s with one and ten magnets, respectively.

Fig.11 to **Fig.16** shows the variation of the accumulated depth of infiltration in sandy soil under all configurations of magnets and different flow velocity.

As it was noticed in the experiment with clayey soils, accumulated depth of infiltration increased when using magnetized water. This increase depends on the number of magnets and the value of flow velocity. Increasing the number of magnets and reducing the flow velocity increases the accumulated infiltration depth. But this increase in sandy soil is much less than that in clay soil.

The increase of the accumulated depth of infiltration for sandy soil is 2.2% at the highest applied flow velocity of 1.19 cm/s with M_{1-0} configuration, which is less by 4.1% than that with clayey soil. When M_{5-5} configuration is used with the same velocity, the increase is 17.5%, which is 15.3% less than that with M_{1-0} configuration and less by 49.2% than that with clayey soil. The highest increase is 34.2% at the minimum value of applied flow velocity with $M_{5\text{-}5}$ configuration, which is 16.7% higher than that with the maximum applied flow velocity and less by 64% than that with clayey soil. A summary of the percentage of increase in accumulated depth of infiltration in sandy soil is presented in **Table 4**.

4. CONCLOSIONS

This study aimed to evaluate and investigate the effects of magnetized water on the accumulated depth of infiltration in the two types of soil. The results showed that the accumulated infiltration depth of the two soil types increased when magnetized water is used compared to that with non-magnetized water. The maximum percentage of this increase was 98.2% and 34.2% for clayey soil and sandy soil, respectively. This maximum increase was achieved under the condition of minimum applied flow velocity through magnetizing device of 0.29 cm/s and with ten used magnets. The accumulated infiltration depth in clayey soil is affected by the magnetized water by a maximum value of 64% more than that in sandy soil.

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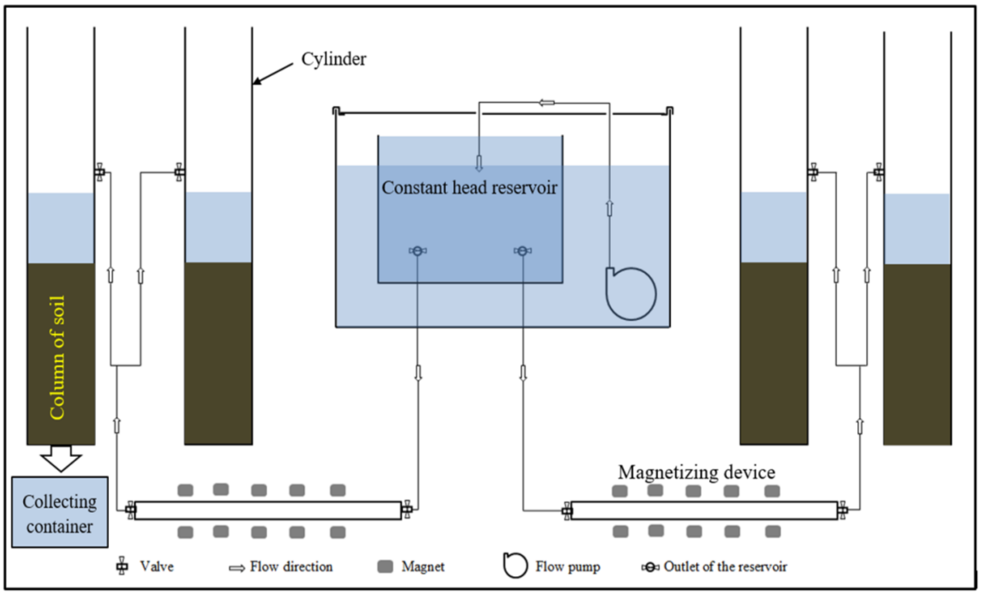

Figure 1. Schematic diagram of the test rig.

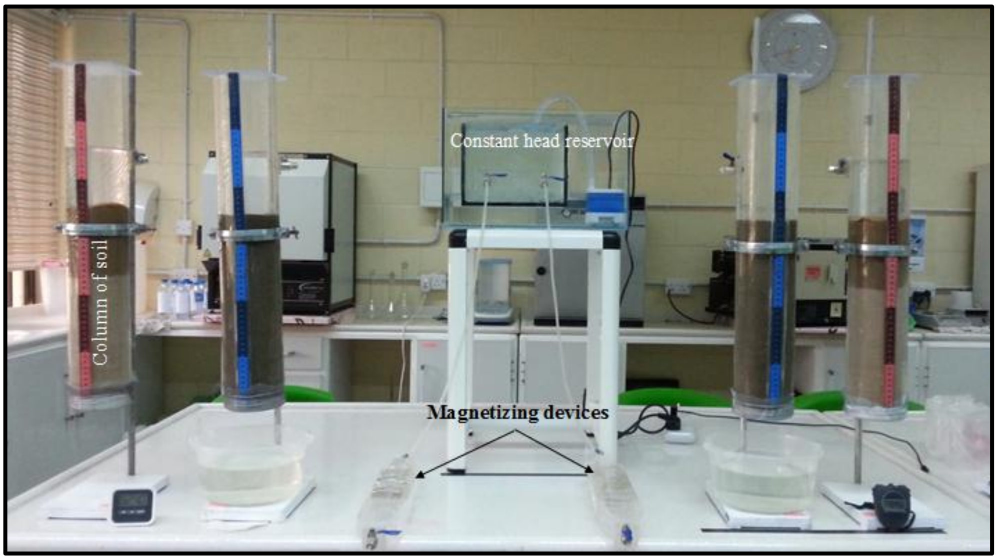

Figure 2. The test rig installed in the laboratory.

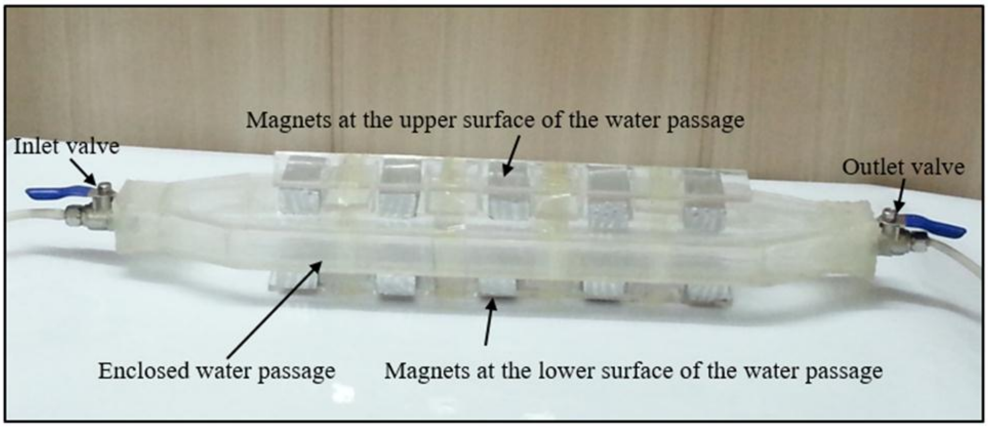

Figure 3. Close up photo of the magnetizing device.

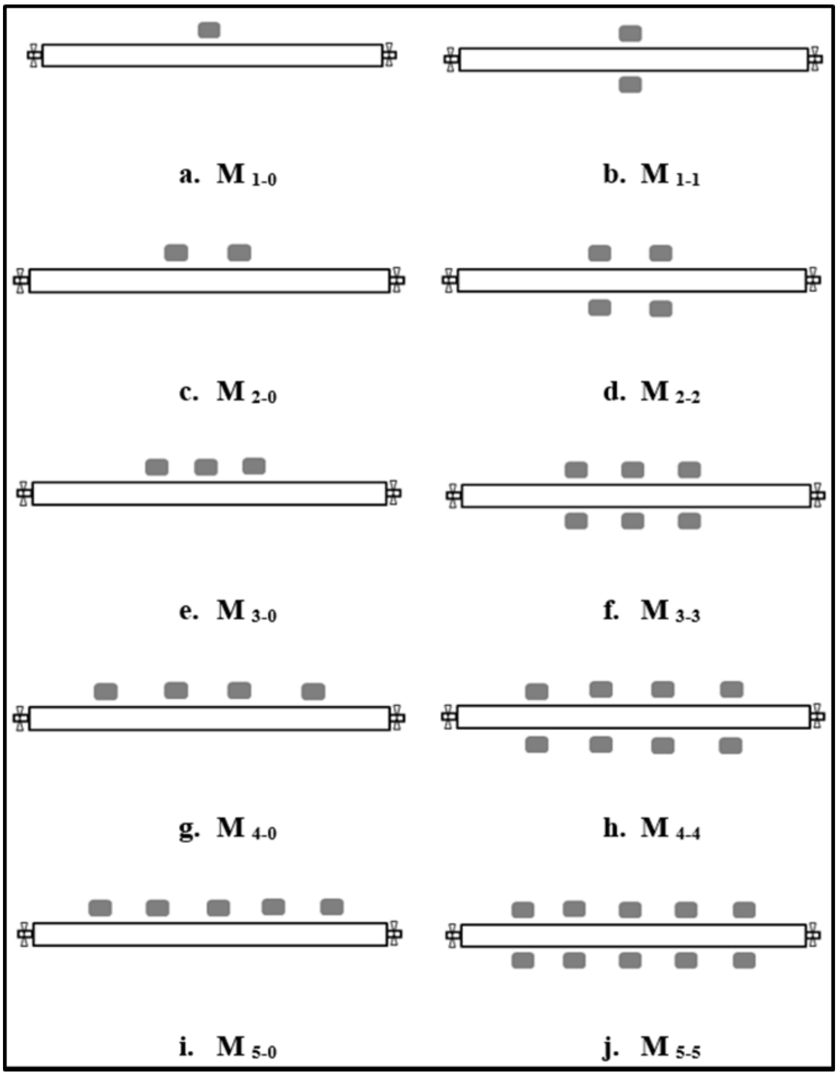

Figure 4. Schematic diagram showing the configurations of magnates.

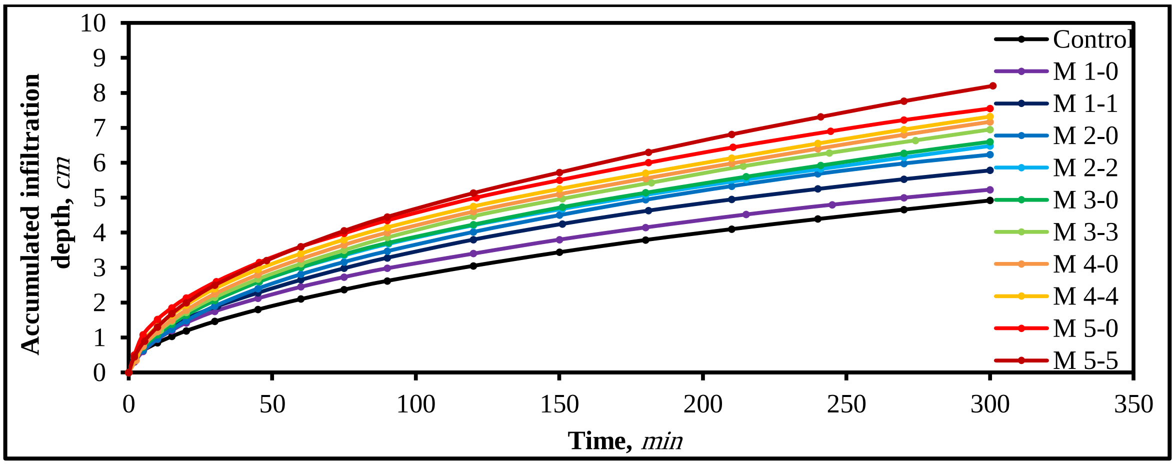

Figure 5. Variation of accumulated infiltration depth with time, for clayey soil,v=1.19*cm/s*.

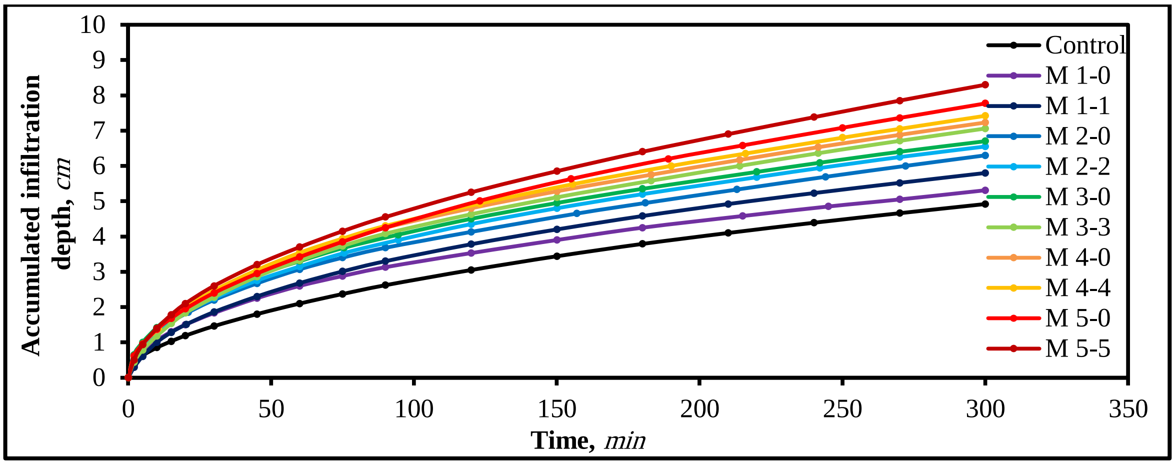

Figure 6. Variation of accumulated infiltration depth with time for clayey soil, *v*=0.99*cm/s*.

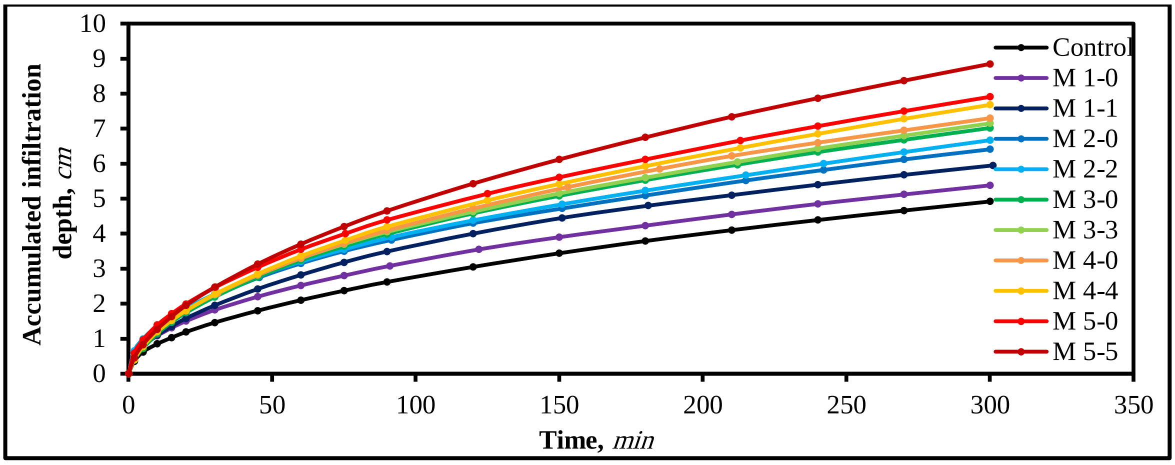

Figure 7. Variation of accumulated infiltration depth with time for clayey soil, *v*=0.79*cm/s*.

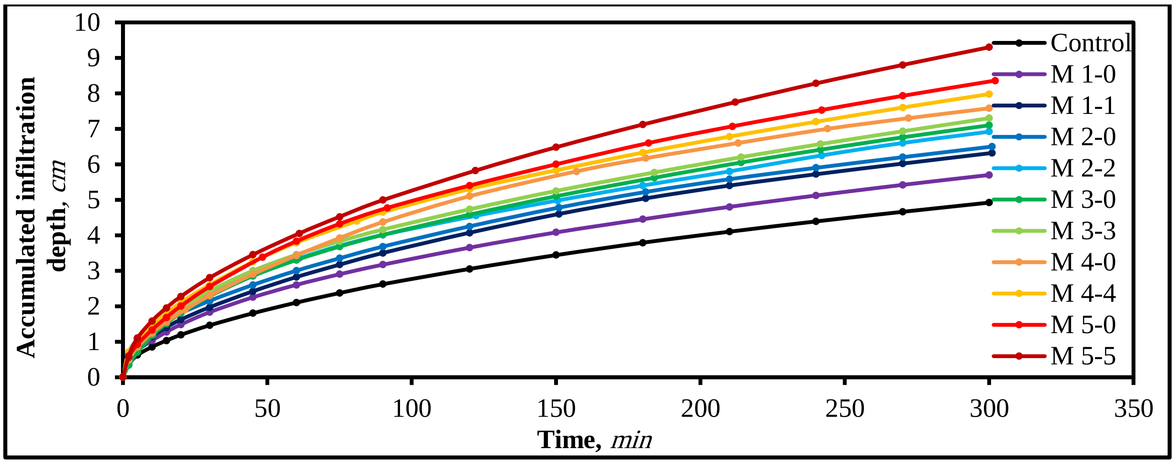

Figure 8. Variation of accumulated infiltration depth with time for clayey soil, *v*=0.69*cm/s*.

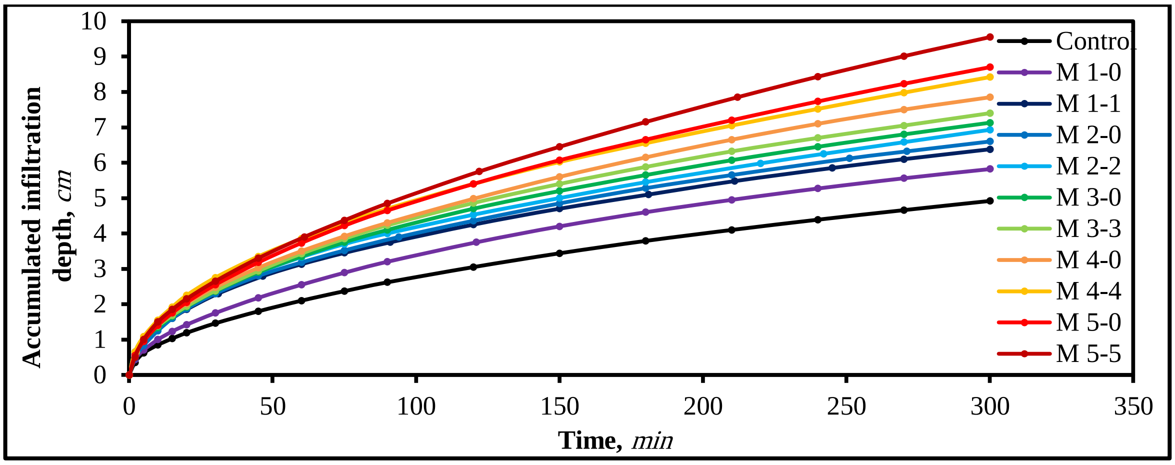

Figure 9. Variation of accumulated infiltration depth with time for clayey soil, *v*=0.59*cm/s*.

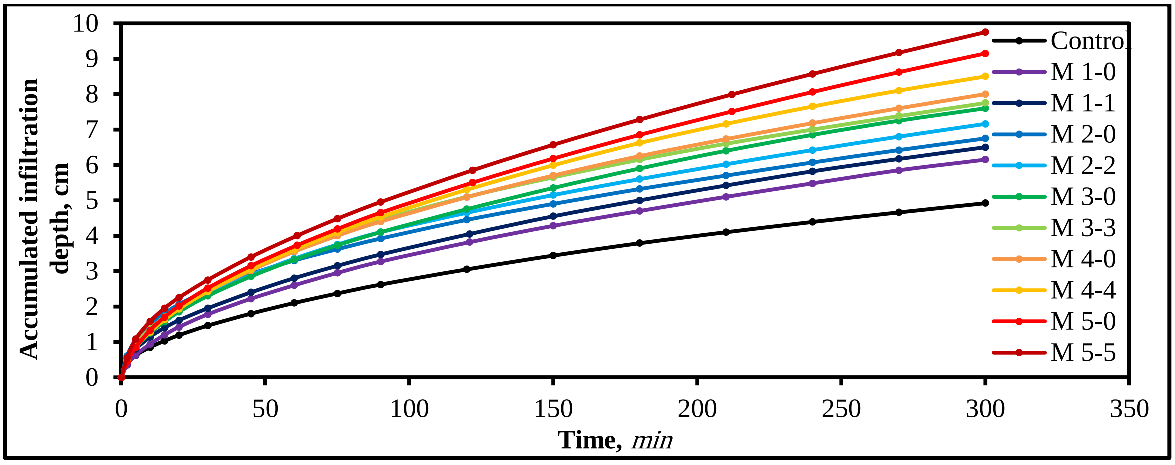

Figure 10. Variation of accumulated infiltration depth with time for clayey soil, *v*=0.29*cm/s*.

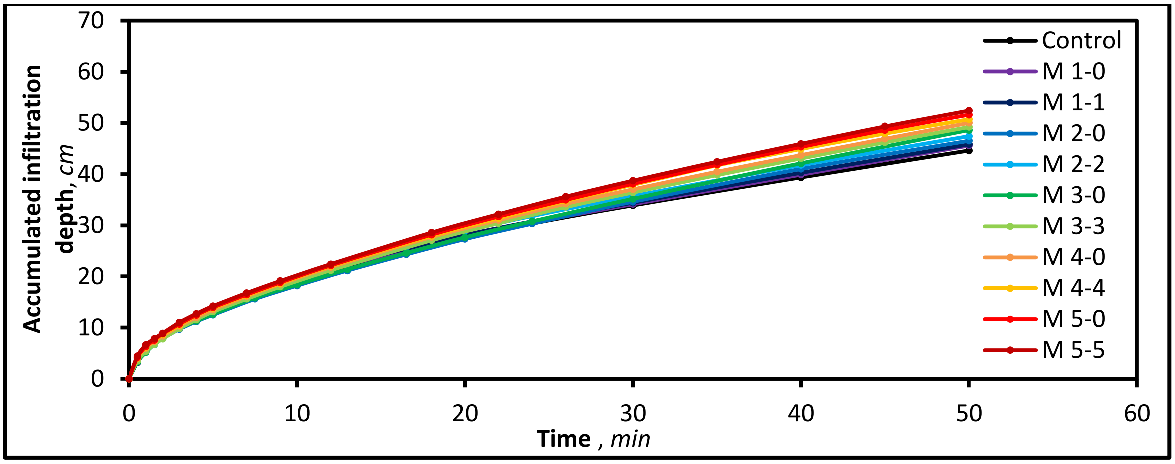

Figure 11. Variation of accumulated infiltration depth with time for sandy soil, *v*=1.19*cm/s*.

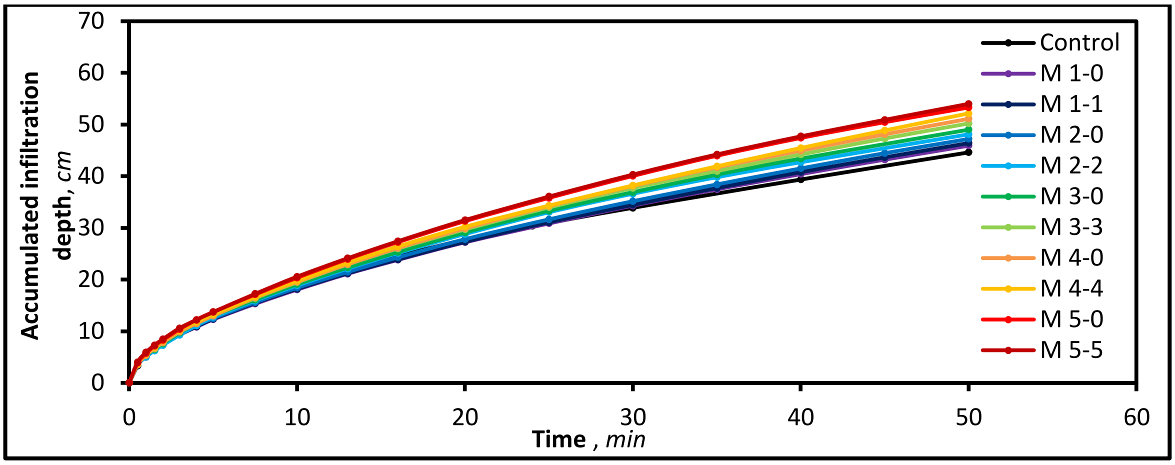

Figure 12. Variation of accumulated infiltration depth with time for sandy soil, *v*=0.99*cm/s*.

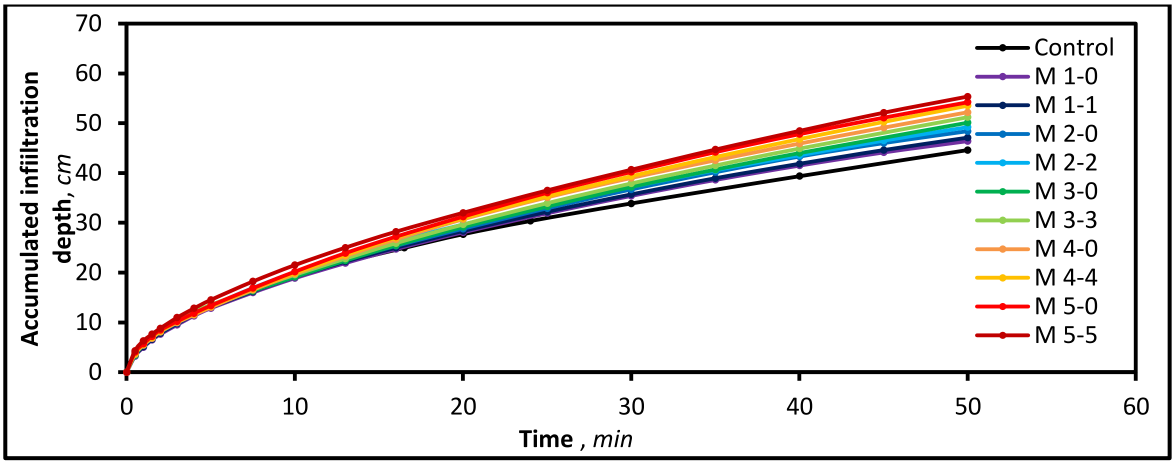

Figure 13. Variation of accumulated infiltration depth with time for sandy soil, *v*=0.79*cm/s*.

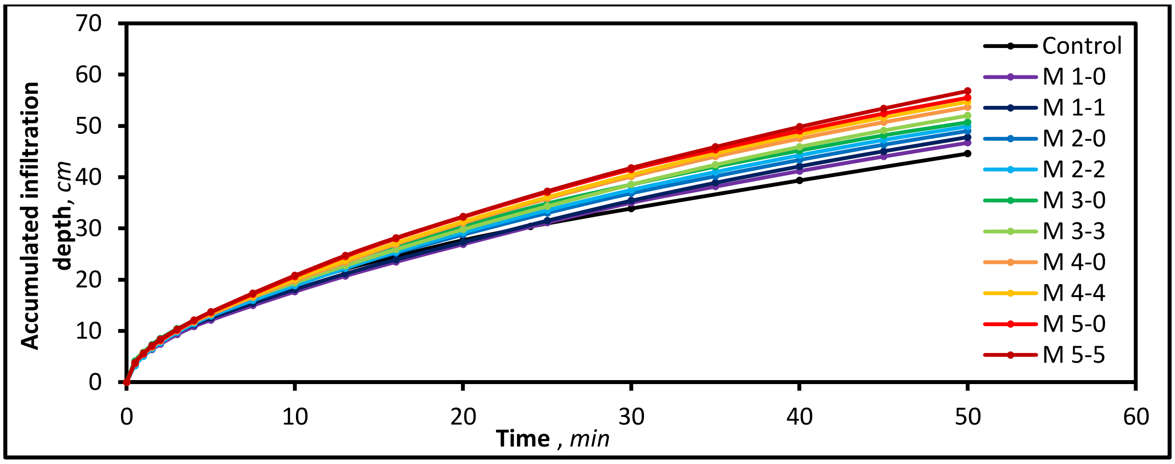

Figure 14. Variation of accumulated infiltration depth with time for sandy soil, *v*=0.69*cm/s*.

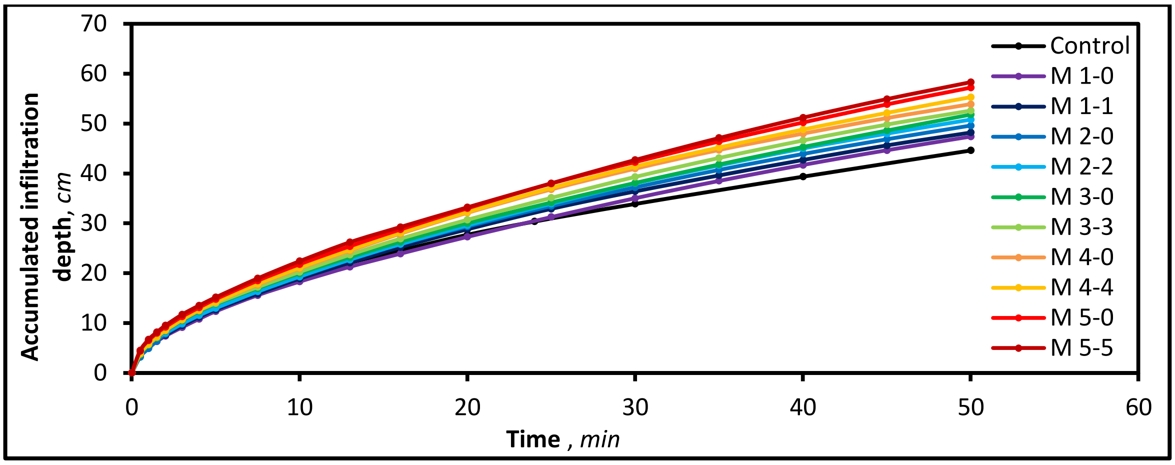

Figure 15. Variation of accumulated infiltration depth with time for sandy soil, *v*=0.59*cm/s*.

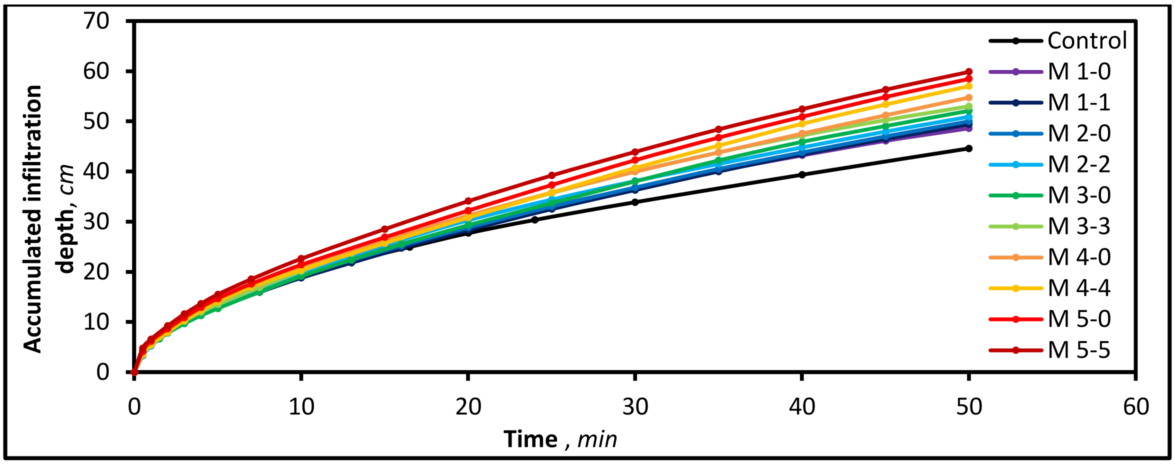

Figure 16. Variation of accumulated infiltration depth with time for sandy soil, *v*=0.29*cm/s*.

Table 1. Results of the tests carried out on the two soils used in the study.

Parameter	Soil from site1	Soil from site2
Moisture content, %	2.60	0.45
Particle size distribution:		
- % Sand	8.60	96.8
- % Silt	31.50	3.00
- % Clay	59.90	0.20
Texture class	Clay	Sand

Table 2. Results of the tests carried out on the diluted water used in the study.

Parameter	
PH	8.01
Electrical conductivity EC, *dS/m*	1.07
TDS, *mg/l*	697
TSS, *mg/l*	0.054
Alk. as $CaCO_3$, *mg/l*	90
T.H. as $CaCO_3$, *mg/l*	70
Calcium Ca^{+2}, *mg/l*	138
Magnesium Mg^{+2}, *mg/l*	60
Sodium Na^{+}, *mg/l*	152
Potassium K, *mg/l*	5.3
Chloride, Cl^{-}, *mg/l*	132
Sulfate, SO_4^{-2}, *mg/l*	145
Carbonate CO_3^{-}, *mg/l*	Nil
Bicarbonate HCO_3^{-}, *mg/l*	71
Nitrate, NO_3, *mg/l*	2.561
Phosphate, PO_4, *mg/l*	0.352
Aluminum, Al, *mg/l*	0.152
Iron, Fe, *mg/l*	0.316
Manganese, Mn, *mg/l*	0.265
Zinc, Zn, *mg/l*	0.202
Copper, Cu, *mg/l*	0.0813
Lead, Pb, *mg/l*	0.097
Cadmium, Cd, *mg/l*	0.042
Nickel, Ni, *mg/l*	0.117
Mercury, Hg, *mg/l*	0.079
Chrome, Cr, *mg/l*	0.095

Table 3. Increase in accumulated infiltration depth for clayey soil.

Magnets Configuration	**Increase in accumulated infiltration depth**, *%*					
	Velocities, *cm/sec.*					
	1.19	**0.99**	**0.79**	**0.69**	**0.59**	**0.29**
M $_{1-0}$	6.3	8.1	9.4	15.9	18.3	25
M $_{1-1}$	17.5	17.9	20.9	28.5	29.7	32.1
M $_{2-0}$	26.6	28.1	30.3	32.1	34.2	37.2
M $_{2-2}$	31.7	33.1	35.6	40.7	40.9	45.5
M $_{3-0}$	34.2	36.2	42.7	44.3	44.9	54.5
M $_{3-3}$	41.3	43.5	45.3	48.4	50.4	57.5
M $_{4-0}$	45.7	47	48.4	54.1	60	62.6
M $_{4-4}$	48.8	50.8	56.1	62.2	71.1	72.76
M $_{5-0}$	53.5	57.9	60.8	69.9	76.8	86
M $_{5-5}$	66.7	68.7	79.9	89	94.1	98.2

Table 4. Increase in accumulated infiltration depth for sandy soil.

Magnets configuration	Increase in accumulated infiltration depth, *%*					
	Velocities, *cm/sec.*					
	1.19	**0.99**	**0.79**	**0.69**	**0.59**	**0.29**
M $_{1-0}$	2.2	2.9	4	4.7	6.3	9
M $_{1-1}$	2.7	4	5.6	7.2	8.1	10.8
M $_{2-0}$	4.3	5.8	8.5	9.9	11.2	12.1
M $_{2-2}$	6.3	7.9	10.3	11.9	13.9	14.1
M $_{3-0}$	9	9.9	12.3	13.7	16.1	16.8
M $_{3-3}$	10.3	12.6	14.8	16.6	17.9	18.8
M $_{4-0}$	12.1	14.6	17	20.3	20.9	22.7
M $_{4-4}$	13.7	16.9	20	22.6	24	27.8
M $_{5-0}$	15.7	19.5	21.5	24.4	28.3	31.1
M $_{5-5}$	17.5	21.1	24.1	27.4	30.7	34.2