

## Evaluation of Using Magnetized Water in Leaching Salts in Sandy Loam Soil

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### ABSTRACT

Many studies and researchers have reported significant evidence that some physical properties of water can be changed as it passes through a magnetic field that can improve water use. This can have a promising potential for applications, especially in the fields of irrigation and drainage. In this research, magnetized water was used to leach salt-affected sandy loam soil. A test rig was designed and constructed to investigate the effects of magnetized water on leaching soil. The rig consists of a magnetization device that can provide variable intensity. Water was supplied from a constant head reservoir to the magnetization device then to the soils that were placed in plastic columns. Five different magnetic intensities and five different times of exposing the flow of water to the magnetic field were applied. The time of exposure to the magnetic field was represented by the flow velocity of the flow passing through the magnetic field. The treated water is applied to leach each soil column in three consecutive leaching processes. Leaching water drained from the soil samples were tested for EC and pH,  $K^+$ ,  $Na^+$ ,  $Mg^{+2}$ ,  $Ca^{+2}$ ,  $Cl^-$ ,  $HCO_3^-$ , and  $SO_4^{-2}$ . The results showed that the efficiency of magnetized water in removing salts from the soil is more than the untreated water. As the magnetic intensity and exposure time are increased, more salts were leached out of the soil. When comparing the experiments conducted with magnetized water with that untreated water, the maximum increase in the EC value was 58.6%, and in the pH values was of 2.4%.

**Keywords:** magnetized water, soil salinity, salt-affected soil, leaching of soil.

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## المعالجة باستخدام الماء الممغنط في غسل الاملاح لترربة رملية مزيجية

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### الخلاصة

ذكرت العديد من الدراسات والبحوث أدلة كبيرة على أن بعض خصائص المياه الفيزيائية يمكن أن تتغير عندما تمر عبر مجال مغناطيسي يؤدي إلى تحسين استخدامات المياه والذي يطبق في عدة مجالات خاصة في مجالي الري والبلز. في هذا البحث، تم استخدام الماء الممغنط لغسل التربة الرملية المزيجية من الاملاح. تم تصميم وبناء جهاز مختبري لغرض فحص تأثير الماء الممغنط على التربة الرملية، يتألف من جهاز المغنطة الذي يمكن أن يوفر شدة مغناطيسية متغيرة. تم اخذ المياه من خزان ذو سعة ثابتة لجهاز المغنطة ثم إلى التربة التي وضعت في أعمدة بلاستيكية. تم استخدام خمسة شدد مغناطيسية مختلفة وخمسة أوقات مختلفة. وكان وقت التعرض للمجال المغناطيسي ممثلاً بسرعة تدفق المياه التي تمر عبر جهاز المغنطة. تم استخدام المياه الممغنطة لغسل كل عمود للتربة في ثلاث غسلات متتالية. تم فحص عينات مياه التربة التي تم تصريفها من اعمدة التربة وقياس التوصيلية الكهربائية، الدالة الحامضية، البوتاسيوم، الصوديوم، المغنيسيوم، الكالسيوم، البيكاربونات، الكلوريدات والكبريتات. تم تحليل النتائج ومقارنتها مع نتائج اختبارات غسل التربة باستخدام المياه غير المعالجة. وأظهرت النتائج أن كفاءة الماء الممغنط في إزالة الأملاح من التربة أكثر من المياه غير المعالجة. ومع زيادة الشدة المغناطيسية ووقت التعرض، تم غسل المزيد من الأملاح من التربة. وبمقارنة إزالة التوصيلية الكهربائية للتربة التي غسلت بالماء المغناطيسي والتي غسلت بالماء غير المعالج، كان أعلى فرق للتوصيل الكهربائي 58.6%. وان أعلى زيادة في دالة الحامضية وصلت الى 2.4%.

**الكلمات الرئيسية:** المياه الممغنطة، ملوحة التربة، التربة المتأثرة بالاملاح، غسل التربة.

### 1. INTRODUCTION

Over the past few decades, many studies and researches have reported significant evidence that some properties of water can be changed as it passes through a magnetic field. The change in the physical properties of water can improve the use of water. Magnetically treated water has more than three times the efficiency of the non-magnetized water in leaching salts out of soils (Yasser, 2010). Magnetized water makes it possible to provide a minimal quantity of water in the reclamation of additional areas of saline soils or in irrigation, so this new technology is important, especially in conditions of water scarcity (Kadhim, 2010). Magnetically treated water showed a good ability to remove the negative effect of the exchangeable sodium on the structural properties of soil. Reducing the irrigation intervals showed significant effects on decreasing the crust hardness of the soil surface (Abid, 2012). Magnetized water helps to dissolve salts at a high rate compared to non-magnetized water (Mohammed and Ebead, 2013). Increasing the magnetization of irrigation water, the electrical conductivity, and available phosphorus increase and reduce soil pH (Mohamed, 2013). Magnetizing water directly before the application gave better results than water magnetized for 12hr. Still, both gave a good result in reducing the time needed for the solubility process (Al-Hadidi, 2014). There was an increase in the accumulated infiltration depth and hydraulic conductivity when using magnetized water (Hindal, 2016; Al-Zubaidy et al., 2017). Magnetized irrigation water exerted a significant role in increasing soil water



infiltration and soil salt leaching. Magnetized drip irrigation is a very simple and efficient way to improve soil salinization (Rui-xi, et al., 2014).

More studies are needed to investigate the effects of magnetized water on the leaching of soils under different soil type conditions, the initial salt content of the soil, salt type, magnetic intensity, time of exposure to a magnet, and quality of water to be treated. This research aimed at investigating the effect of water treated by different magnetic intensities and time of exposure to magnet on the leaching of salt affected clay loam soil. This investigation will provide new data to what is available in previous studies on the effect of magnetic treatment on water used for leaching saline soils with different variables. A laboratory test rig was prepared for this purpose. It consists of a constant head water supply reservoir, a variable intensity magnetization device, columns of salt-affected sandy loam soil, and drain water collection tanks. Water was treated under five different magnetic intensities and five different times of exposure to a magnet, represented by the flow velocity of the water flow passing through a tube within the magnetization device. Leached water from the soil samples was tested for EC, pH, K, Na, Mg, Ca, HCO<sub>3</sub>, Cl, and SO<sub>4</sub>.

## 2. MATERIALS AND METHODS

This section presents details of the experimental work that was carried out to investigate the effects of magnetized water on the treatment of salt-affected soil. These details include the description of the test rig, details of the used water and soil, magnetic treatment of water used in these experiments, and the experiments' details.

### 2.1 Description of the Test Rig

The test rig, shown in Fig. 1 and 2, was designed and constructed to investigate the effects of magnetized water on the treatment of salt-affected soil. The rig consists of a reservoir that maintains constant head water flow to a magnetization device. The flow of water from the reservoir is controlled by using two valves. The water flows to the magnetization system through two rubber tubes of 0.5cm in diameter. Each end of the tubes is directed to a soil column. The soil sample to be leached is placed inside a 10cm in diameter plastic pipe of a length of 40cm. Its top is left open, and the bottom is closed by using a filter paper, which is fixed by using a reducer of 10 to 3cm at the bottom of the pipe. The filter allows drain water to flow and prevents the soil particles from being washed out. Excess water above a certain depth over the soil surface is drained out using a 0.5cm diameter rubber tube. Water drained from the soil columns is collected by using 1000cm<sup>3</sup> beakers.

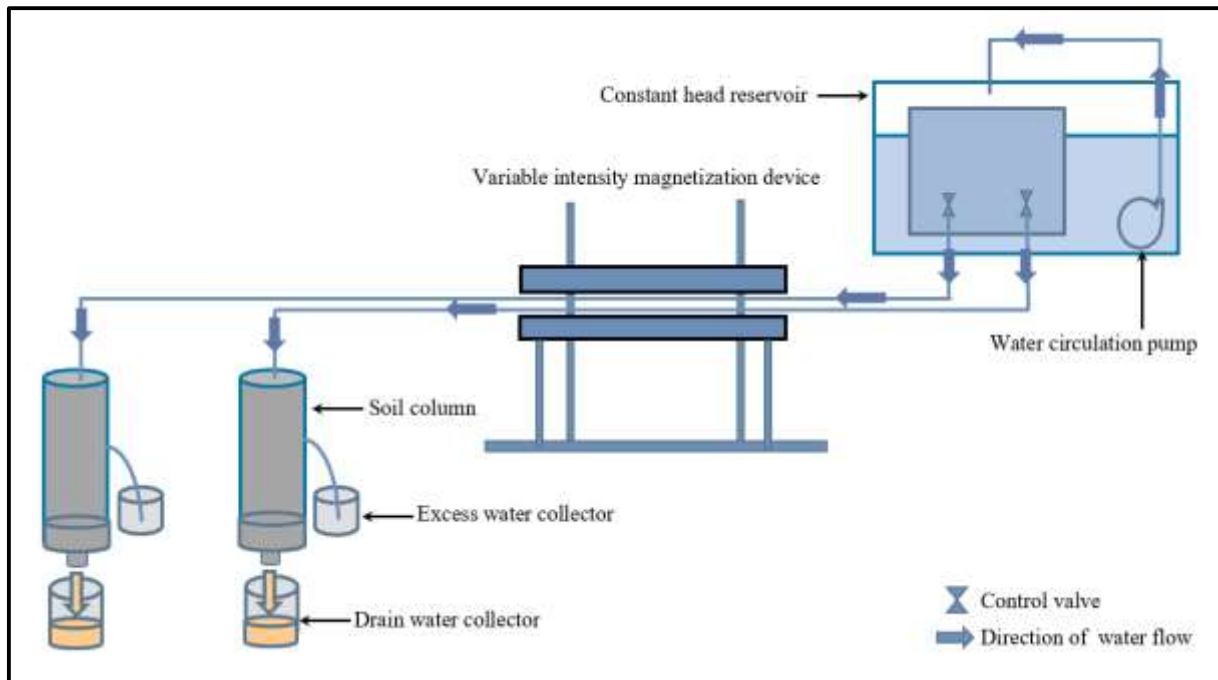


Figure 1. Schematic diagram of the test rig.

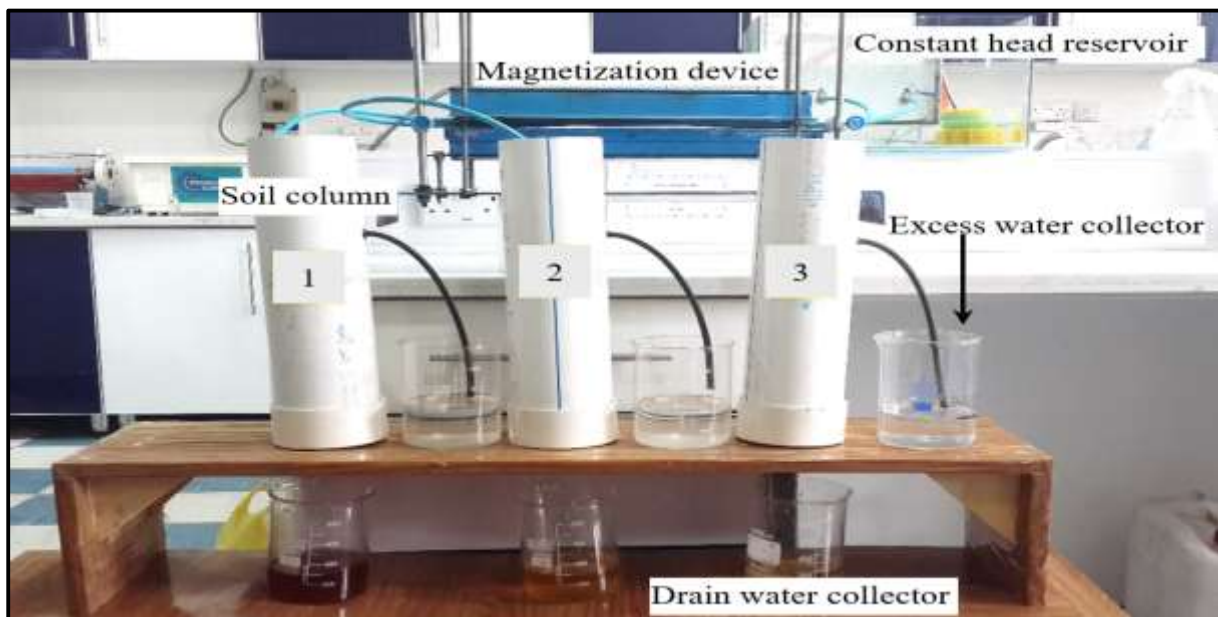


Figure 2. The rig installed in the laboratory.

The variable intensity water magnetizing device was produced by the Water Research Center of the Directorate of Environment and Water of the Ministry of Science and Technology. **Fig. 3**, provides intensities that can be varied from 500 to 9000gauss. It consists of two 44cm long parallel steel plates used to fix the magnets. The plate on the bottom is fixed, and the upper plate can be move. Four magnets are placed over and below each of these two plates. The magnate



intensity can be controlled to the desired intensity by changing the spacing between these two plates.

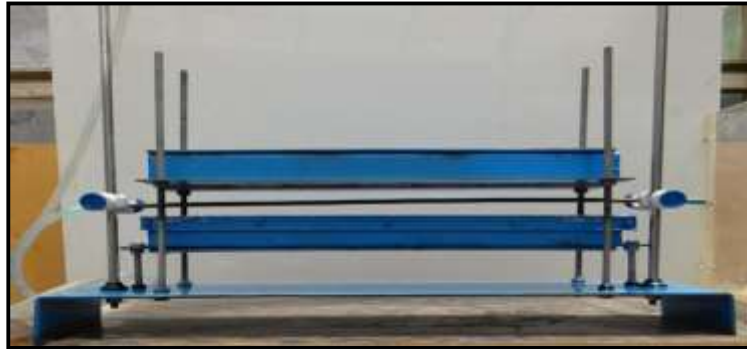


Figure 3. The variable intensity magnetization device.

**2.2 Used Soils and Water**

Water used for leaching the soil was brought from the Tigris River at Baghdad City. Soil samples used in the experiments were brought from a location known to have middle saline soil. The soil was air-dried at room temperature, disaggregation with a plastic hammer. The soil was sieved by using a 2mm sieve and then was stored in sealed plastic containers at ambient temperature to maintain the same moisture content throughout the period of the laboratory work. The soil is a sandy loam texture having 74.4% sand, 14% silt, and 11.6% clay. Results of some of the tested physical and the chemical parameters of the used water and the soil are presented in Table 1.

Table 1. Results of the tests that were carried out on the water and soil used in the study.

	EC <i>dS/m</i>	pH	TDS <i>ppm</i>	K <i>meq/l</i>	Na <i>meq/l</i>	Ca <i>meq/l</i>	Mg <i>meq/l</i>	HCO <sub>3</sub> <i>meq/l</i>	SO <sub>4</sub> <i>meq/l</i>	Cl <i>meq/l</i>
Water	1.12	7.00	717	0.45	11.20	14.60	9.67	2.00	5.04	8.76
Soil	6.52	7.44	4173	0.43	16.82	28.50	20.54	3.55	8.71	52.61

**2.3 Preparing of soil columns**

In each experiment, the soil sample is weighed so that all experiments have a typical soil weight of 2000g. The soil was added in layers of about 5cm by using a lab spatula to a depth of 25cm. Each added layer was shacked well to be distributed uniformly and gently pressed using a special plunger.

**2.4 Magnetic treatment of water**

Five different magnetic intensities were used to treat water, 1000, 3000, 5000, 7000, and 9000gauss. Using a Gauss meter, the required magnate intensity reading is achieved by changing the spacing between the two plates of the magnetization device. Five different times of exposing the flow of water to the magnetic field were used. This time of exposing water to the magnetic field is represented by the flow velocity of the water flow passing through a tube within the magnetization device; these are 0.4, 0.6, 1.0, 1.4, and 2.0m/s. Water flow is controlled to the desired discharge by the valves at the outlets of the constant head reservoir.



## 2.5 Leaching Process

The treated water is applied to leach each soil column in three consecutive leaching processes. These consecutive leaching processes were coded as L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub>. Each leaching process is ended just when the collected drained water from the soil samples reaches 300ml. A new volume of drained water is collected or, in other words, a new leaching process is started so that the total drained water during each experiment is 900ml.

## 2.6 Design of the experimental runs

To investigate the effects magnetized water on the treatment of salt affected soil, two variables were adopted in the magnetic treatment of water. These variables are the magnetic intensity and velocity of water flowing through the magnetization device. Five magnetic intensities were used to treat water; these are 1000, 3000, 5000, 7000, and 9000gauss. Five different velocities of water flow passing through the magnetization device were used. These velocities are 0.4, 0.6, 1.0, 1.4, and 2.0cm/s. Full combinations of these two variables were used to treat water used in the leaching of soils. With five levels of each variable, then there will be a twenty-five-different combination. During each experiment, a water sample from each of the three 300ml drained water is collected to be tested for EC and pH, K, Na, Mg, Ca, HCO<sub>3</sub>, Cl, and SO<sub>4</sub>.

## 2.7 Coding of experiments

Each experiment was coded. The code consists of three letters, M, V, and L, and each letter has an extension subscript number so that each general experiment code is M<sub>x</sub>V<sub>y</sub>L<sub>z</sub>. The letters refer to magnate intensity, water flow velocity, and leaching process, respectively. The extension number is an indicator of values of the magnetic intensity, the value of water flow velocity, and the sequence of the leaching process. So that M<sub>1</sub>, M<sub>3</sub>, M<sub>5</sub>, M<sub>7</sub>, and M<sub>9</sub> refer to the magnetic intensities that were used, that is, 1000, 3000, 5000, 7000, and 9000gauss, respectively. V<sub>1</sub>, V<sub>2</sub>, V<sub>3</sub>, V<sub>4</sub>, V<sub>5</sub> are the flow velocities of 0.4, 0.6, 1.0, 1.4, 2.0cm/s, respectively. L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub> refer to the first, second, and third leaching processes carried out on each soil sample, respectively. Now, M<sub>7</sub>V<sub>4</sub>L<sub>1</sub> refers to the first leaching experiment that was carried out under magnetic intensity of 7000gauss and water flow velocity of 1.4cm/s.

## 3. RESULTS AND ANALYSIS

The following subsections present the results of the tested parameters within the collected drained water during the leaching experiments that were carried out on the soil by using untreated water and magnetized water.

### 3.1 Leaching by Using Untreated Water

Fig. 4 to 12 show variation of EC, pH, K, Na, Mg, Ca, HCO<sub>3</sub>, Cl, and SO<sub>4</sub> of drained water during leaching of the soil of sandy loam texture. The value of EC of the drained water was 11.6, 4.3, and 2.5dS/m collected during L<sub>1</sub>, L<sub>2</sub>, and L<sub>3</sub> leaching processes, respectively. The value of pH during the first leaching process, L<sub>1</sub>, was 7.3, and it was reduced to 7.14 and 7.0 during L<sub>2</sub> and L<sub>3</sub>, respectively. The concentrations of K, Na, Mg, Ca, HCO<sub>3</sub>, Cl, and SO<sub>4</sub> during L<sub>1</sub> were 1.3, 14.5, 40.7, 57.4, 2.3, 79.7 and 12.5meq/l, 0.6, 9.2, 24.3, 21.3, 1.5, 35.8 and 6.5meq/l during L<sub>2</sub>, and 0.3, 4.7, 7.2, 10.3, 0.5, 10.6, and 5.2meq/l during L<sub>3</sub>, respectively.



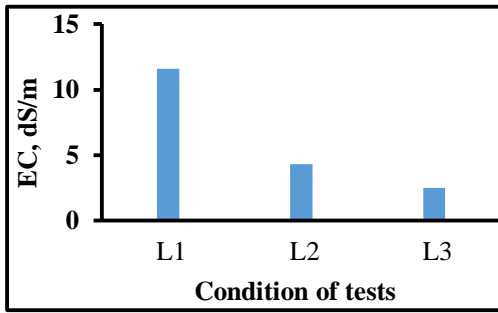


Figure 4. Variation of EC, leaching of soil with untreated water.

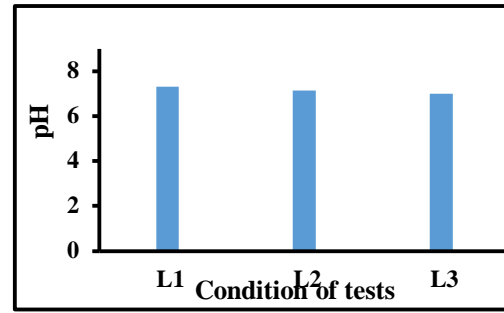


Figure 5. Variation of pH, leaching of soil with untreated water.

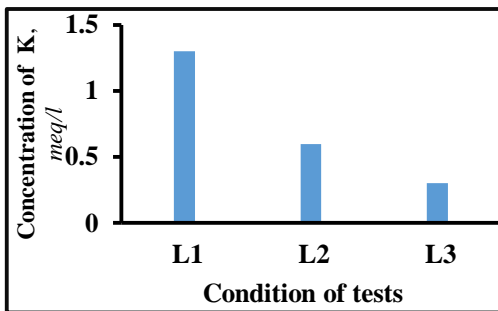


Figure 6. Variation of K, leaching of soil with untreated water.

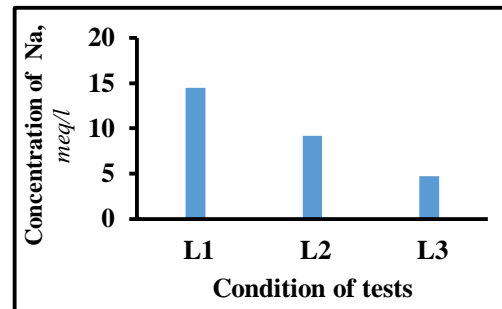


Figure 7. Variation of Na, leaching of soil with untreated water.

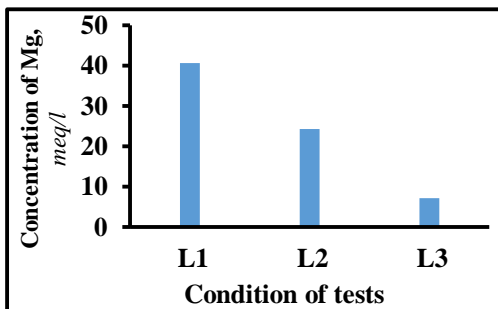


Figure 8. Variation of Mg, leaching of soil with untreated water.

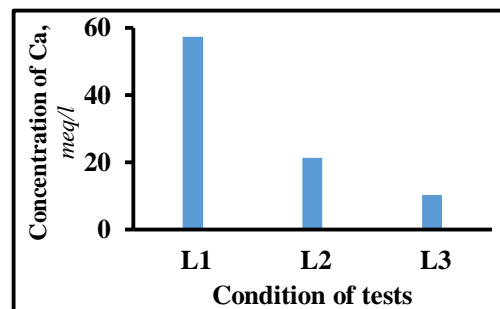


Figure 9. Variation of Ca, leaching of soil with untreated water.

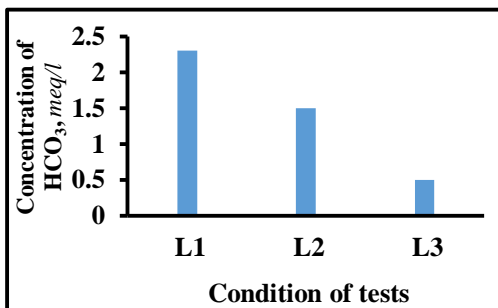


Figure 10. Variation of HCO<sub>3</sub>, leaching of soil with untreated water.

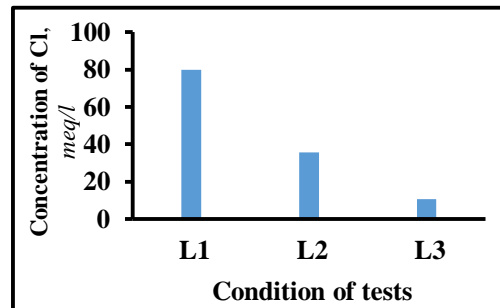


Figure 11. Variation of Cl, leaching of soil with untreated water.

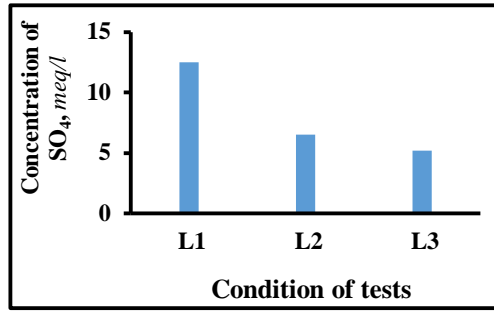


Figure 12. Variation of SO<sub>4</sub>, leaching of soil with untreated water.

### 3.2 Leaching by Using Magnetized Water

The variation of EC, pH, and the concentrations of K, Na, Mg, Ca, HCO<sub>3</sub>, Cl, and SO<sub>4</sub> of drained water collected during leaching of soil, sandy loam texture, are shown in Fig. 13 to 21. As a result, leaching was positively affected by the magnetized water. The maximum difference was obtained by comparing the results of M<sub>1</sub>V<sub>5</sub>L<sub>1</sub> and M<sub>9</sub>V<sub>1</sub>L<sub>1</sub> experiments. The higher percentage of increase in the EC value was reached 53.3%. The values of pH were affected by a maximum percentage of 1.8%. The maximum percentage of increase in the concentrations of K and Na were 42.0% and 54.8%, respectively. The difference in increases in Mg and Ca concentrations reached a percentage of 52.4% and 61.0%, respectively. The maximum increase in the concentrations HCO<sub>3</sub> and Cl as a percentage were 51.6% and 60.0%, respectively. The concentration of SO<sub>4</sub> was increased as a percentage of 53.5%. When comparing the results of all experiments conducted with magnetized water with that untreated water, the maximum increase in the EC value was 58.6%. The difference in the pH value at a percentage of increase 2.4%. The concentrations of K and Na were increased by a maximum percentage of 53.0% and 65.5%, respectively. The higher increase in the concentrations of Mg and Ca were 57.2% and 69.6%, respectively. The increase in the concentrations of HCO<sub>3</sub>, and Cl as a percentage were 64.7% and 69.0%, respectively. The maximum difference of concentration SO<sub>4</sub> was increased by a percentage of 58.3%.

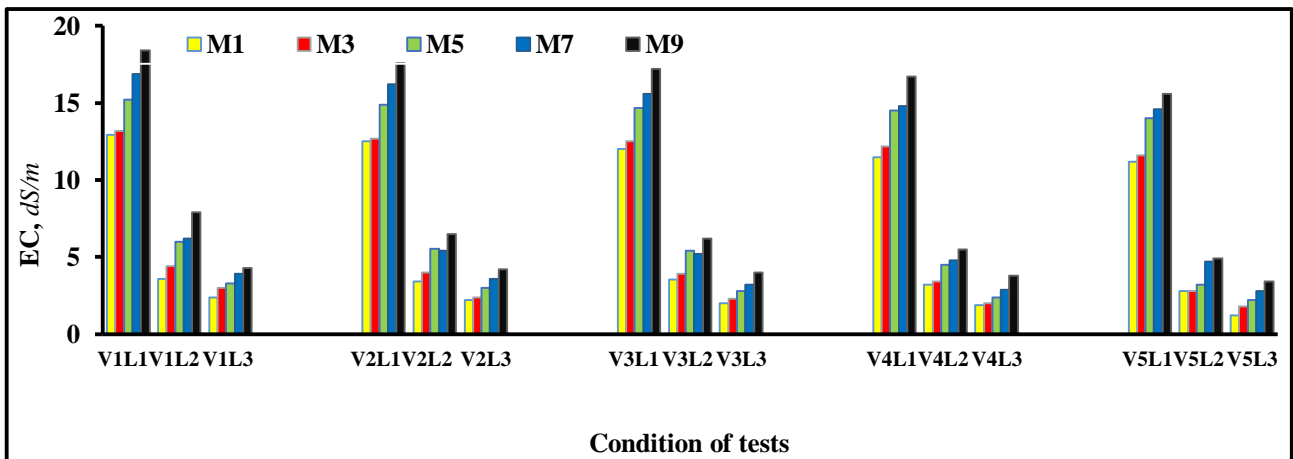


Figure 13. Variation of EC, leaching of soil by using magnetized water.



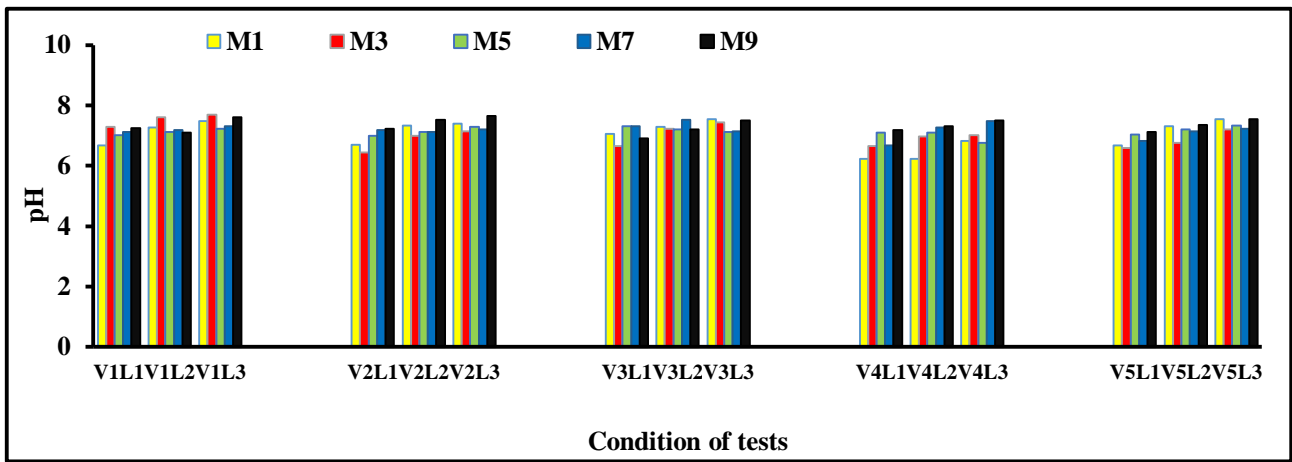


Figure 14. Variation of pH, leaching of soil by using magnetized water.

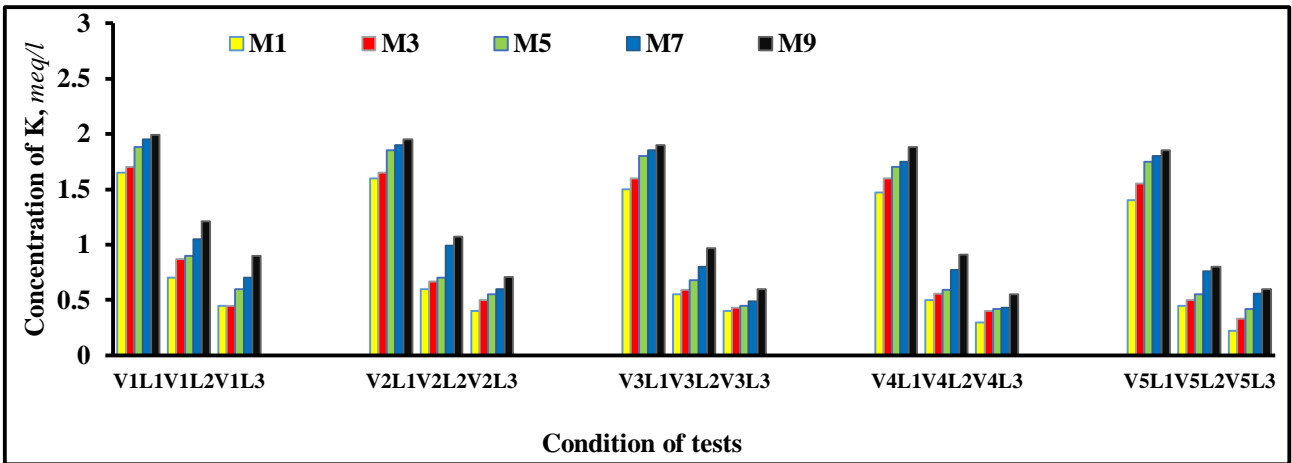


Figure 15. Variation of K, leaching of soil by using magnetized water.

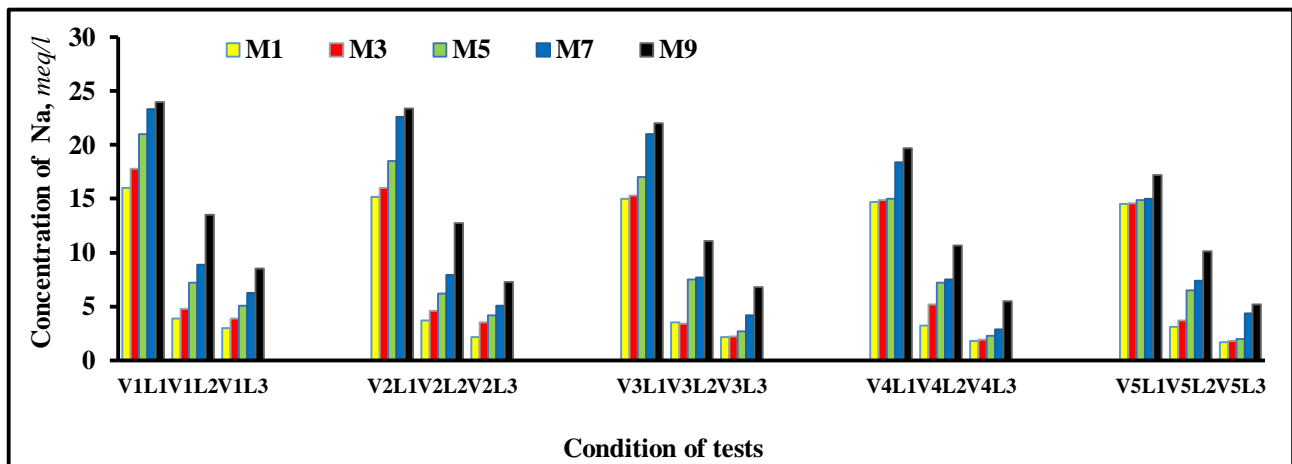


Figure 16. Variation of Na, leaching of soil by using magnetized water.

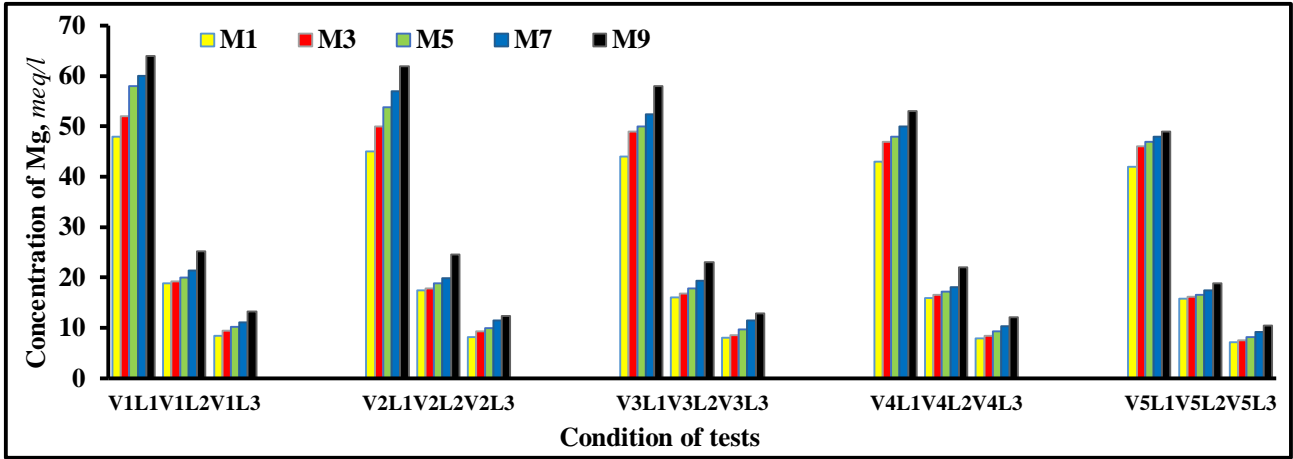


Figure 17. Variation of Mg, leaching of soil by using magnetized water.

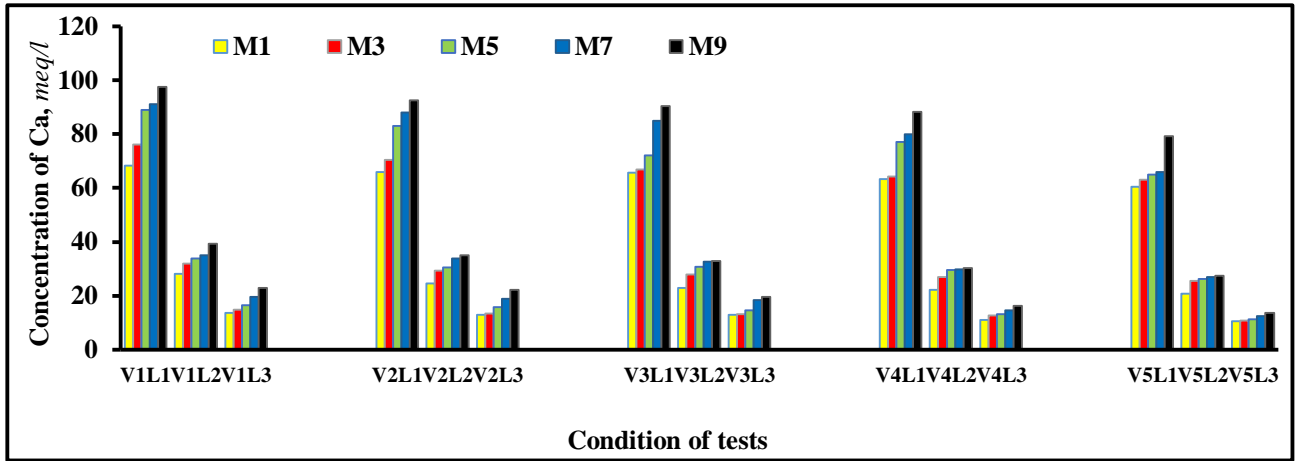


Figure 18. Variation of Ca, leaching of soil by using magnetized water.

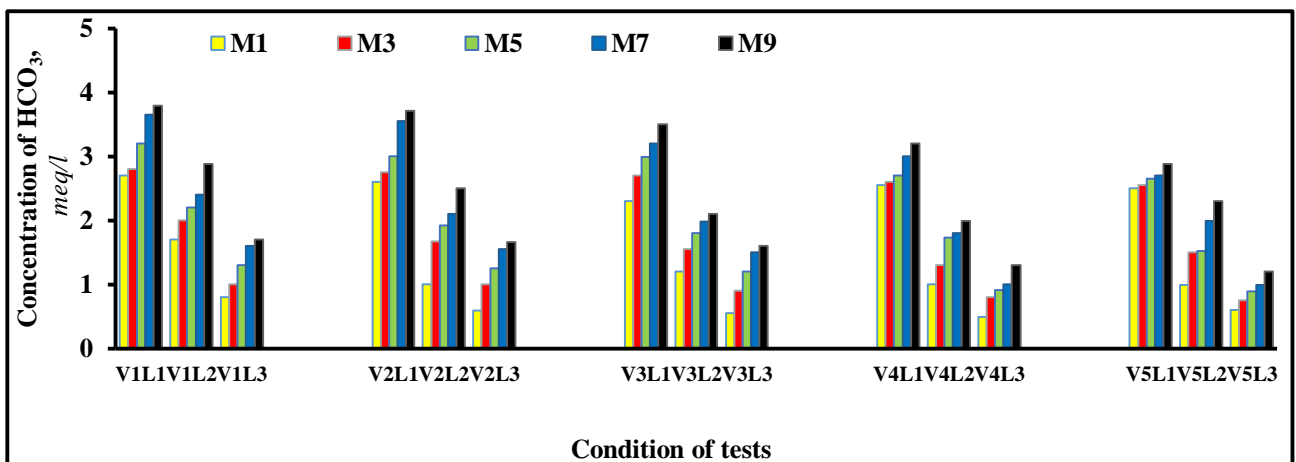


Figure 19. Variation of HCO<sub>3</sub><sup>-</sup>, leaching of soil by using magnetized water.

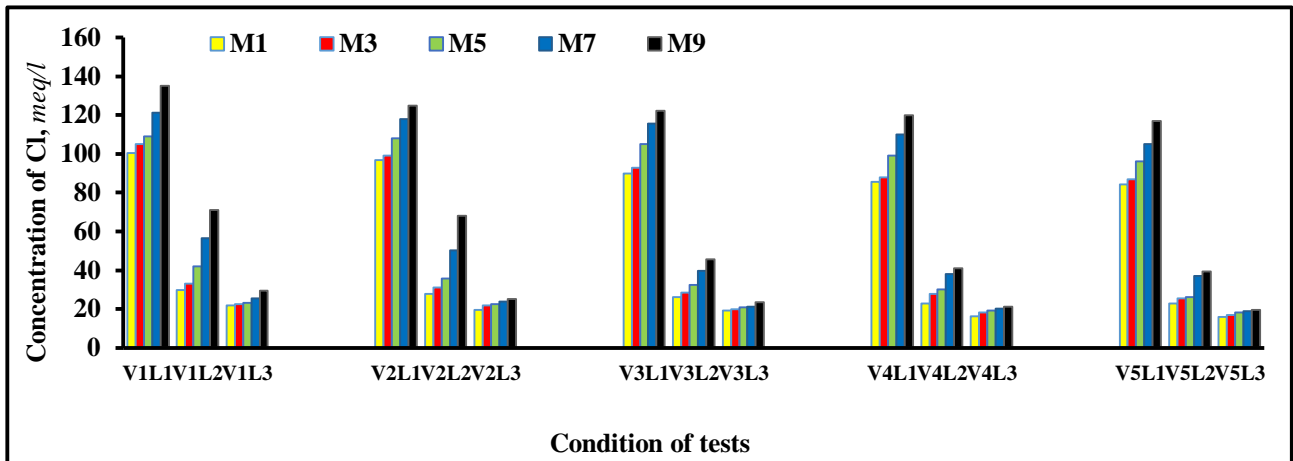


Figure 20. Variation of Cl, leaching of soil by using magnetized water.

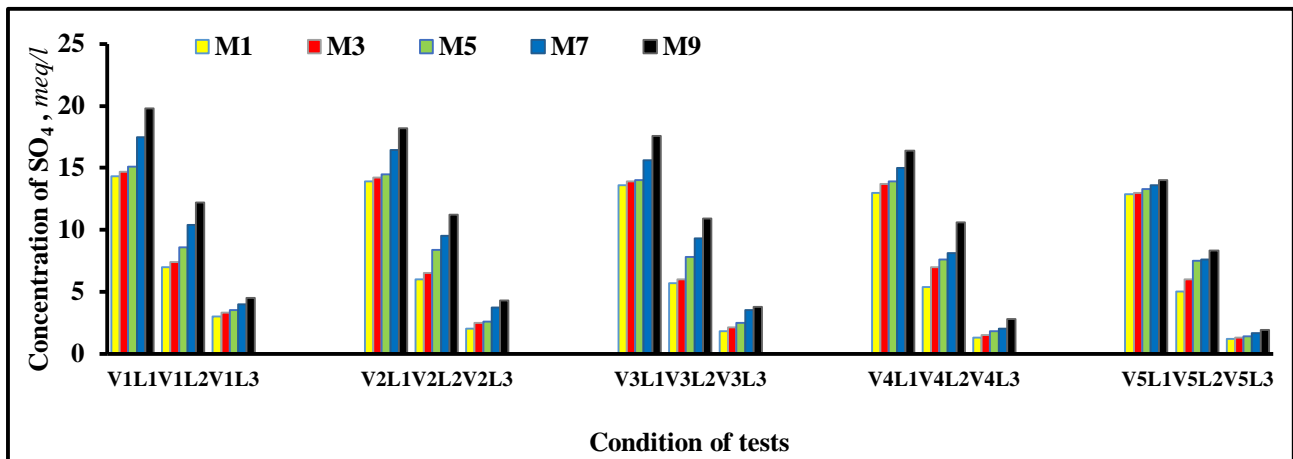


Figure 21. Variation of SO<sub>4</sub>, leaching of soil by using magnetized water.

#### 4. CONCLUSIONS

A test rig was designed and constructed to investigate the leaching of salt-affected sandy loam soil by using magnetized water. Five different magnetic intensities and five different times of exposing the flow of water to the magnetic field were used to treat the used water. It was found that magnetized water can positively affect the leaching of soils. EC values of the drained water were increased by increasing the magnetic intensity and reducing the exposure to the magnetic field. It was found that the values of the pH of the drained water are slightly affected by the magnetized water. Magnetized water increases the concentration of all tested parameters of the drained water during the leaching process compared to untreated water.

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