https://doi.org/10.33261/jaaru.2021.28.3.003 *Association of Arab Universities Journal of Engineering Sciences (2021)28(3):29-36*

Association of Arab Universities Journal of Engineering Sciences
مجلة اتحاد الجامعات العربية للدراسات والبحوث الهندسية

Effectiveness of Magnetized Water in Leaching Clay Loam Soils

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Published online: 30 September 2021

Abstract— Many studies indicated that some of raw water properties can be improved as it passes through magnetic field. This improvement was proved to have useful applications in many fields. Such improvement can be useful in increasing the efficiency of leaching salty soils. In this paper, an experimental test rig was designed and constructed to investigate the effects of using treated water by magnetized field to leach salt affected clay loam soil. The experiments were designed so that the used water to be treated with five different magnetic intensities and five different exposure times to the magnetic field. Three consecutive leaching processes were applied to leach the soil. Drained water from the soil samples was tested for EC and pH, K+, Na+, Mg+2, Ca+2, Cl-, HCO3-, and SO4-2. The results were compared to that achieved by leaching the soil when using untreated water. The results showed that the leaching efficiency can be increased when using magnetized water and as the magnetic intensity and the time of exposure are increased, more salts were leached out of the soil. The maximum obtained increase in the EC value of the drained water, which represent a general indicator for all anions and cations that were leached, was 58.0% compared to that when untreated water is used in the leaching process.

Keywords—Magnetization Effect, Soil Salinity, Salt Affected Soil, Magnetic Intensity.

1. Introduction

Over the few past decades, many studies and researches proved that the uses of water in leaching of soils can be more efficient when it is treated by a magnetic field. Hassan, et al. [9] studied the effects of exposure to magnetic field on water properties under different intensities of magnetic field. They found significant increase in dissolved oxygen, pH, and significant decrease in ammonium level, specific conductivity, total dissolved solids, oxygen reduction potential, and chlorides. Raheem and Azzubaidi [6] showed that the efficiency of magnetized water in removing salts from the soil is more than the untreated water in leaching of salt affected silty loam soil. They noticed that as the magnetic intensity and the time of exposure are increased, the more salts were leached out of the soil. They obtained a maximum increase in the value of EC of the drained water of 73.8% compared to that when using untreated water. Yasser [3] showed that magnetically treated water is more than three times salts out of soils. Kadhim [8] mentioned that when treating water with magnetized filed makes it possible to provide a minimal quantity of water in reclamation of additional areas of saline soils or in irrigation so this new technology is important especially in conditions of water scarcity. Abid [5] indicated that magnetically treated water showed a good ability to remove negative effect of the exchangeable sodium on the structural properties of soil, reducing the irrigation intervals and showed significant effect on decreasing the crust hardness of the soil surface,. Mohammed and Ebead [1] noticed that magnetized water helps to dissolve salts in a high rate compared to non-magnetized water. Mohammed [2] showed that by increasing the magnetization of irrigation water, the electrical conductivity and available phosphorus increase and reduce soil pH. Al-Hadidi [7] mentioned that magnetizing water directly before application gave better results than the use of water magnetized for 12hr, but both gave a good result in terms of reducing the time needed for the solubility process. Hindal [4] noticed an increase in the

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accumulated infiltration depth and the hydraulic conductivity when using magnetized water.

This study is a continuation to studies for more understanding the effects of magnetized water on the leaching of salt affected soils.

A laboratory test rig was prepared for this purpose. It consists of a constant head raw water supply reservoir, a magnetization device in which the intensity could be changed, columns of soil, and water tanks to collect water drained out of the soil columns. Water was treated under five different magnetic intensities and five different time of exposure to magnet, represented by the flow velocity of the water flow passing through a tube within the magnetization device. Drained water samples were tested for EC, pH, K, Na, Mg, Ca, HCO_3, Cl, and SO_4. EC is a general indicator for all of cations and anions that exist in water. Other tested parameters are the most important parameters related to leaching of soils.

2. Details of the Test Rig

Figure. 1 shows a schematic diagram of the test rig that was designed and constructed to investigate the effects of magnetized water on leaching of salt affected soil.

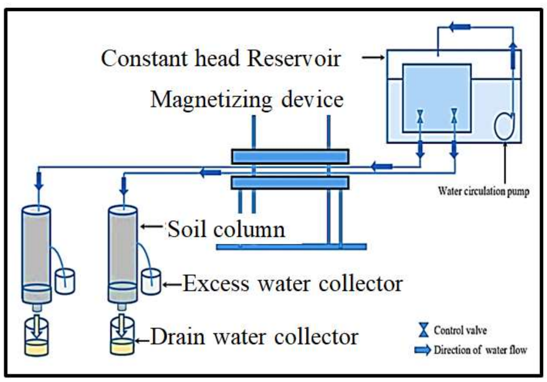

Figure 1: Schematic diagram of the test rig.

The rig consists of a constant head reservoir, two soil columns, a collector reservoir, and magnetizing device. The constant head reservoir supplies water flow to a magnetization device. Flow of water from the reservoir is controlled by using two valves. The water flow to the magnetization system through two rubber tubes of 0.5*cm* in diameter. Each end of the tubes is directed to a soil column. Soil sample to be leached is placed inside a 10*cm* in diameter plastic pipe of a length of 40*cm*. A filter paper is fixed at the bottom of plastic pipe closed by using a filter paper, which is fixed by using a reducer of 10 to 3*cm* at the bottom of the pipe. The filter allows drain water to flow and prevent the soil particles to be washed out. Excess water above a certain depth over the soil surface is drained out by using a 0.5*cm* in diameter rubber tube. Water drained from the soil columns is collected by using 1000cm^3 beakers, as a collector reservoir.

The variable intensity water magnetizing device, **Figure 2**, was produced by the Water Research Center of the Directorate of Environment and Water of the Ministry of Higher Education and Scientific Research, and Science and Technology. The device provides intensities that can be varied from 500 to 9000*gauss*. It consists of two 44*cm* long parallel steel plates used to fix the magnets. The plate on 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.

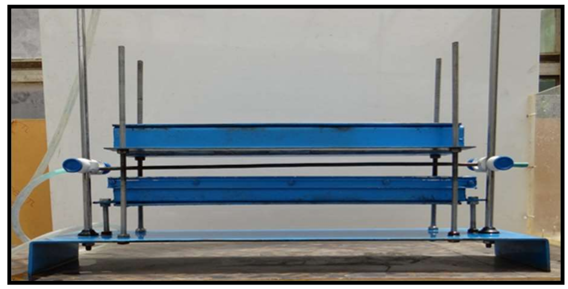

Figure 2: The variable intensity magnetizing device.

2.1 *Used soils and water*

Raw water of Tigris River was used for leaching the soil. Soil samples used in the experiments was brought from a location known to have a highly saline soil. The soil was air dried at a room temperature, disaggregation with plastic hammer. The soil was sieved by using a 2*mm* sieve and then was stored in sealed plastic containers at ambient temperature to maintain same moisture content throughout the period of the laboratory work. The soil is a clay loam texture having 28% sand, 35% silt, and 37% clay. Results of some of 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 carried out on the water and soil.

Parameter	Water	Soil
EC, *dS/m*	1.12	19.70
pH	7.00	7.22
TDS, *ppm*	717	12614
K, *meq/l*	0.45	1.50
Na, *meq/l*	11.20	35.82
Ca *meq/l*	14.60	88.11
Mg *meq/l*	9.67	61.50
HCO_3, *meq/l*	2.00	8.71
SO_4 *meq/l*	5.04	13.08
Cl *meq/l*	8.76	176.12

2.2 *Procedure to conduct each experiment*

Soil sample is weight so that all experiments have a common soil weight of 2000g. 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.

Five different magnetic intensities were used to treat water, 1000, 3000, 5000, 7000, and 9000gauss. By using a Gauss meter, the required magnate intensity reading is achieved by changing the spacing between the two plates of magnetization device. Five different time 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 2.0*m/s*. Water flow is controlled to the desired discharge by the valves at the outlets of the constant head reservoir.

The treated water is applied to leach each soil column in three consecutive leaching processes. These consecutive leaching processes were coded as L_1, L_2, and L_3. Each leaching process is ended just when the collected drained water from the soil samples reaches 300*ml*, then 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 900*ml*.

2.3 *Design of the experimental runs*

To investigate the effects magnetized water on 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 levels magnetic intensities were used to treat water, these are 1000, 3000, 5000, 7000, and 9000*gauss*. 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 2.0*cm/s*. A full combination of these two variables were used to treat water used in the leaching of soils. With five level of each variable then there will be a twenty-five-different combination. During each experiment, a water sample from each of the three 300*ml* drained water is collected to be tested for EC and pH, K, Na, Mg, Ca, HCO_3, Cl, and SO_4.

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 the general experiment code is $M_xV_yL_z$. The letters refer to magnate intensity, water flow velocity, and leaching process, respectively. The extension number is an indicator to values of the magnetic intensity, the value of water flow velocity, and the sequence of the leaching process. So that M_1, M_3, M_5, M_7, and M_9 refer to the magnetic intensities that were used, that is 1000, 3000, 5000, 7000, and 9000*gauss*, respectively. V_1, V_2, V_3, V_4, V_5 are the flow velocities of 0.4, 0.6, 1.0, 1.4, 2.0*cm/s*, respectively. L_1, L_2, and L_3 refer to the first, second, and third leaching process carried out on each soil sample, respectively. Now, $M_5V_2L_3$ refers to the third leaching experiment that was carried out under magnetic intensity of 5000*gauss* and water flow velocity of 0.6*cm/s*.

3. Results and analysis

Figure 3 to **Figure 11** show the variation of EC, pH, K, Na, Mg, Ca, HCO_3, Cl, and SO_4 of drained water during leaching of the soil of clay loam texture. The value of EC of the drained water was 79.5, 38.7, and 9.8*dS/m* collected during L_1, L_2 and L_3 leaching processes, respectively. The value of pH during the first leaching process, L_1, was 7.22 and it was reduced to 7.02 and 6.92 during L_2 and L_3, respectively. The concentrations of K, Na, Mg, Ca, HCO_3, Cl, and SO_4 during L_1 were 1.5, 70.3, 210.3, 240.6, 6.7, 39.3 and 495.7*meq/l*, 1.1, 30.8, 114.2, 109.8, 3.9, 27.7 and 233.5*meq/l* during L_2, and 0.5, 22.3, 32.9, 24.5, 2.1, 15.5 and 64.8*meq/l* during L_3, respectively.

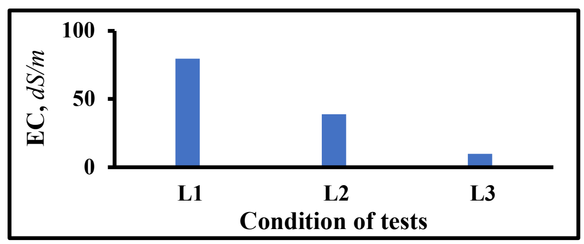

Figure 3: Variation of EC.

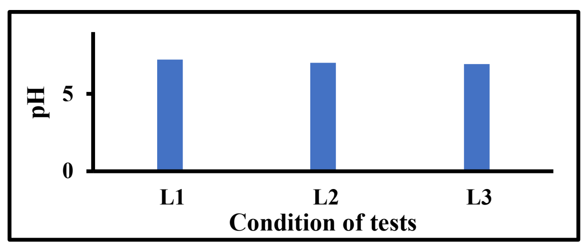

Figure 4: Variation of pH.

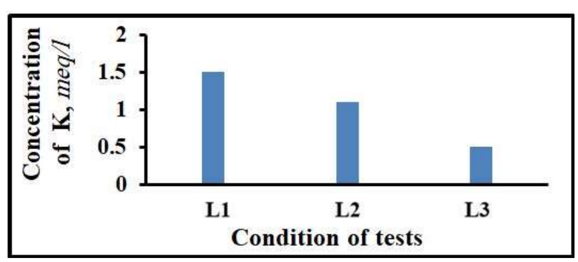

Figure 5: Variation of K.

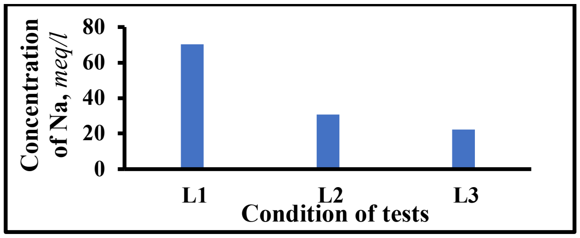

Figure 6: Variation of Na.

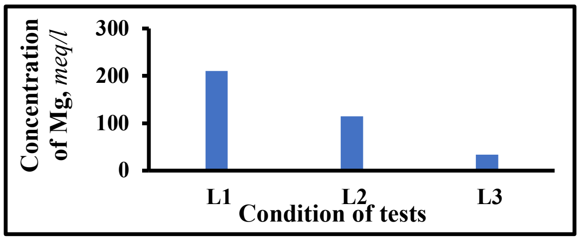

Figure 7: Variation of Mg.

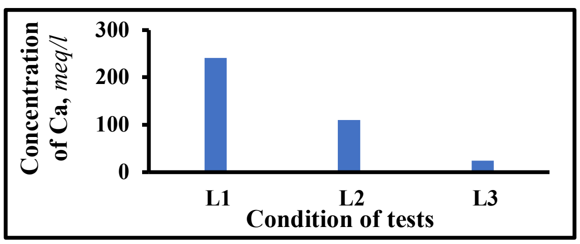

Figure 8: Variation of Ca.

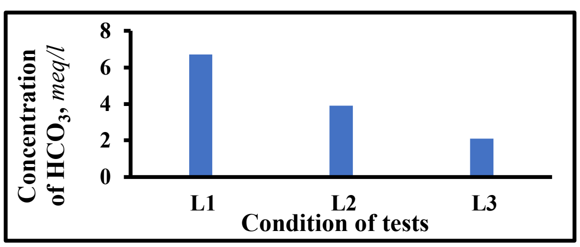

Figure 9: Variation of HCO_3.

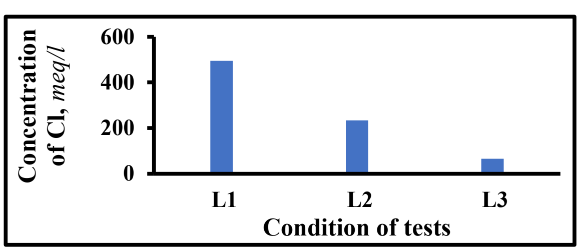

Figure 10: Variation of Cl.

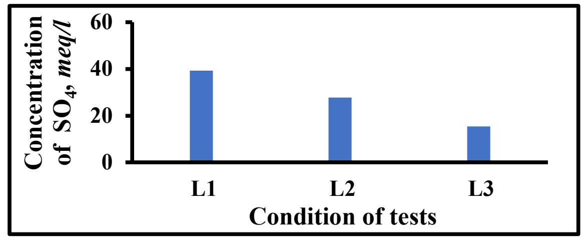

Figure 11: Variation of SO_4.

Figure A-12 to **Figure A-20 (Appendix A)** show the variation of EC, pH, and the concentrations of K, Na, Mg, Ca, HCO_3, Cl, and SO_4 of drained water collected during leaching of soil, clay loam texture. As a result, leaching was positively affected by the magnetized water. The maximum difference was obtained by comparing the results of $M_1V_5L_1$ and $M_9V_1L_1$ experiments.

The higher percentage of increase in the EC value was reached 39.4%. The values of pH were affected by a maximum percentage of 6.8%. The maximum percentage of increase in the concentrations of K and Na were 55.8% and 51.5%, respectively. The difference of increases in the concentrations of Mg and Ca reached at a percentage of 62.5% and 57.4%, respectively. The maximum increase in the concentrations HCO_3, and Cl as a percentage were 78.0%, and 65.4%, respectively. The concentration of SO_4 was increased as a percentage 57.5%.When comparing the results of all experiments conducted with magnetized water with that untreated water, the maximum increase in the EC value was 58.0%. The difference in the pH value was at a percentage of increase 7.3%. The concentrations of K and Na were increased by a maximum percentage of 76.7% and 83.2%, respectively. The higher increase in the concentrations of Mg and Ca were 74.0% and 70.5%, respectively. The increase in the concentrations HCO_3, and Cl as a percentage were 83.4% and 81.0%, respectively. The maximum difference of concentration SO_4 was increased by a percentage 79.0%.

4. Conclusions

Based on the results analysis of the tests on the leaching of clay loam soils, the following conclusions were achieved:

1- The magnetized water can positively affects leaching of soils.

2- The value of pH of the drained water is slightly affected by the magnetized water.

3- The magnetized water leads to increase the concentration of all other tested parameters of the drained water during leaching process compared to untreated water. This effect is increased by increasing the magnetic intensity and the exposure to the magnetic field.

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Appendix A

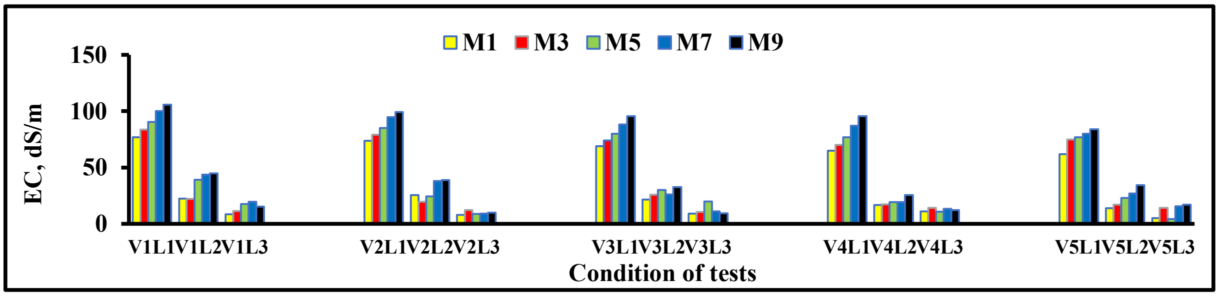

Figure A-12: Variation of EC, leaching of soil by using magnetized water.

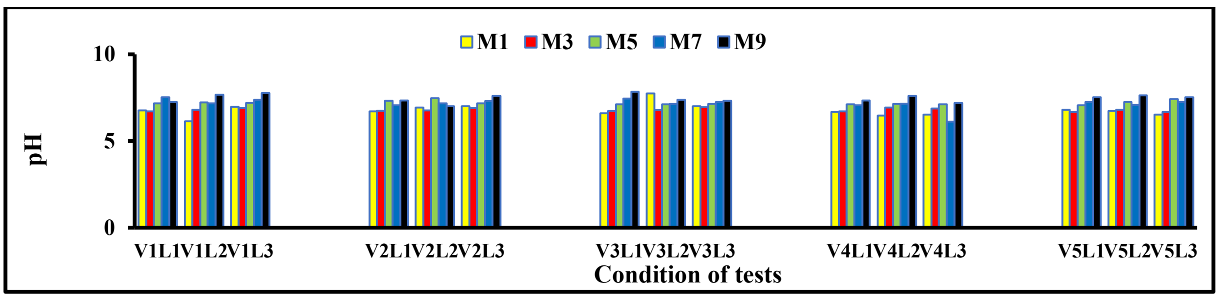

Figure A-13: Variation of pH, leaching of soil by using magnetized water.

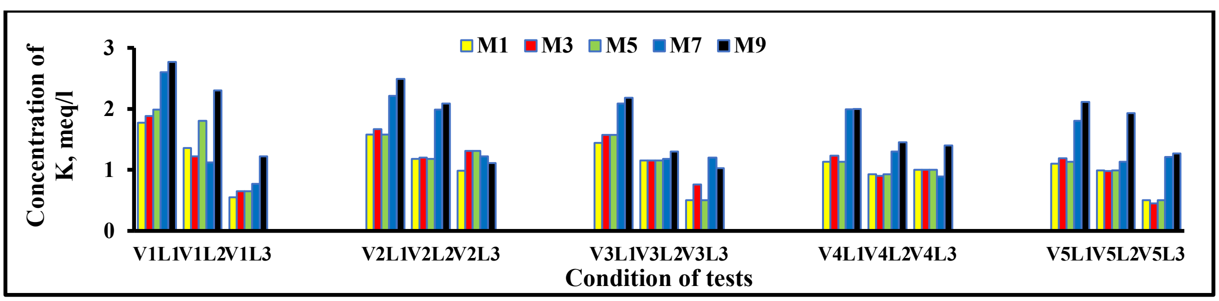

Figure A-14: Variation of K, leaching of soil by using magnetized water.

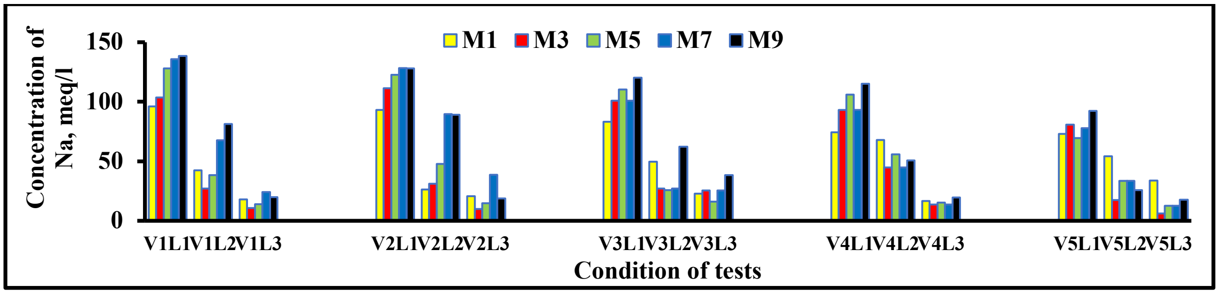

Figure A-15: Variation of Na, leaching of soil by using magnetized water.

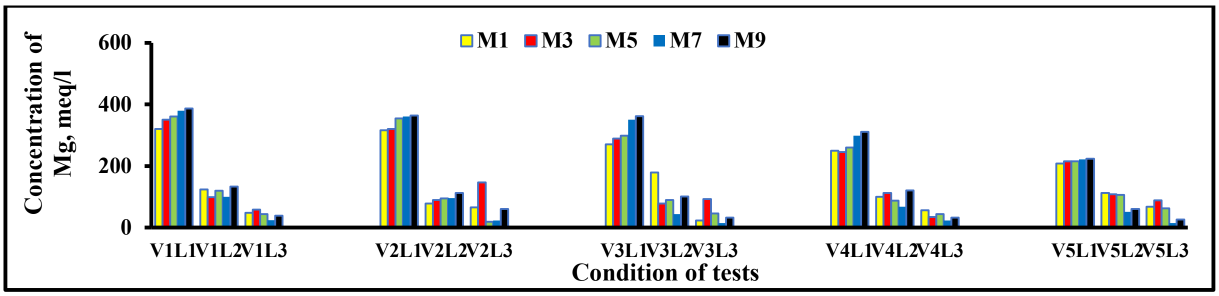

Figure A-16: Variation of Mg, leaching of soil by using magnetized water.

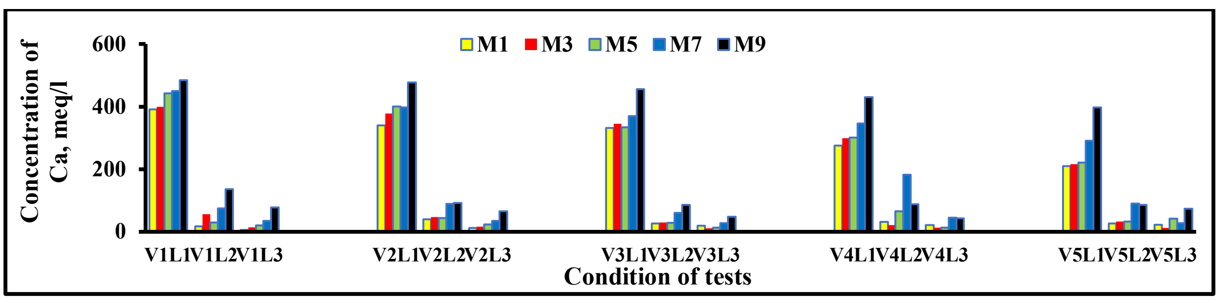

Figure A-17: Variation of Ca, leaching of soil by using magnetized water.

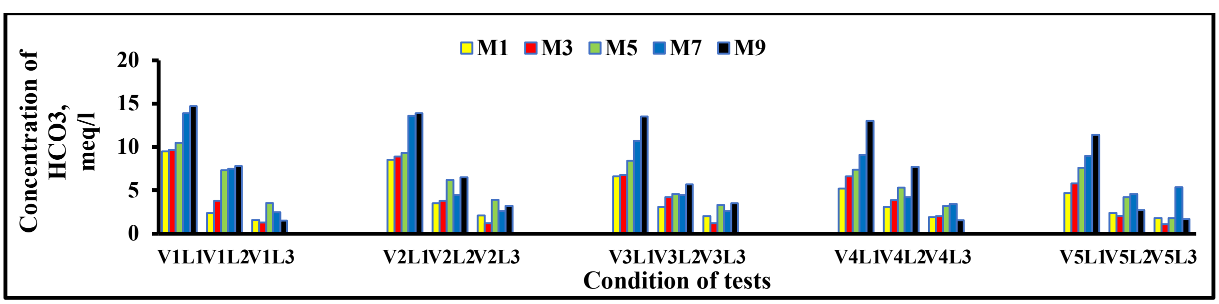

Figure A-18: Variation of HCO_3, leaching of soil by using magnetized water.

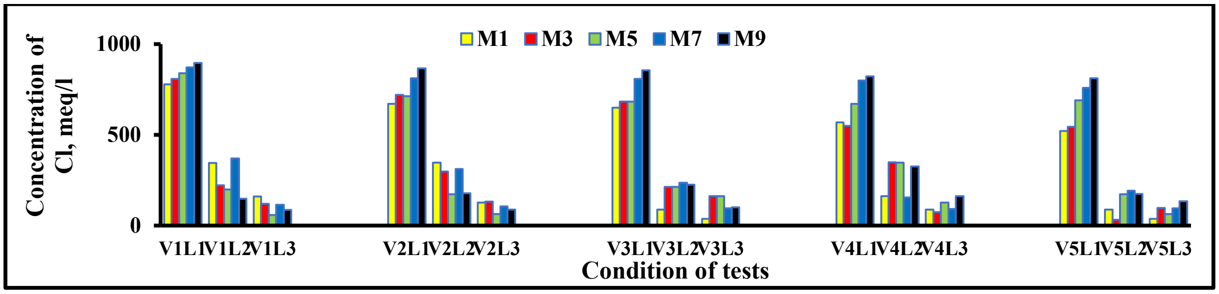

Figure A-19: Variation of Cl, leaching of soil by using magnetized water.

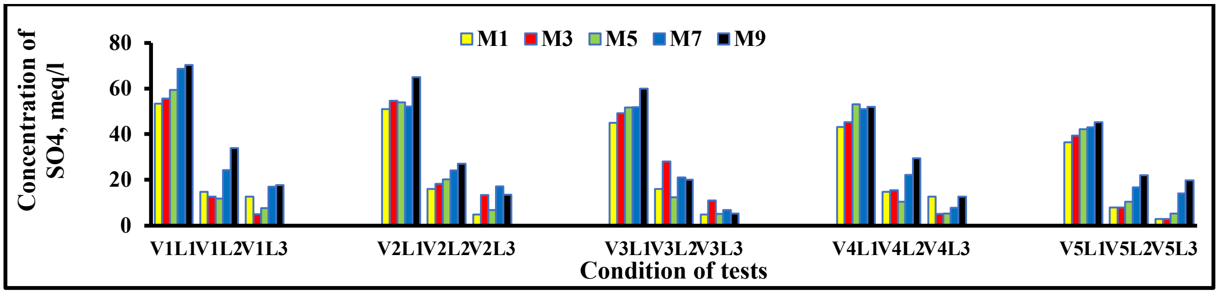

Figure A-20: Variation of SO_4, leaching of soil by using magnetized water.

اثار استخدام الماء الممغنط في غسل الترب الطينية المزيجية

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نشر في : 30 ايلول 2021

الخلاصة - أشارت العديد من الدراسات إلى امكانية تحسين بعض خصائص الماء الخام أثناء مروره عبر المجال المغناطيسي. ثبت أن هذا التحسين له تطبيقات مفيدة في العديد من المجالات. يمكن أن يكون هذا التحسين مفيدًا في زيادة كفاءة غسل التربة المالحة. في هذا البحث ، تم تصميم واعداد جهاز اختبار تجريبي للتحقق من آثار استخدام المياه المعالجة بالمجال الممغنط لغسل التربة الطينية المتأثرة بالاملاح. تم تصميم التجارب بحيث يتم معالجة المياه المستخدمة بخمس شدد مغناطيسية مختلفة وخمس أوقات تعرض مختلفة للمجال المغناطيسي. تم تطبيق ثلاث عمليات ترشيح متتالية لغسل التربة. تم اختبار المياه المترشحة من عينات التربة وقياس EC و pH و K^{+} و Na^{+} و Mg^{+2} و Ca^{+2} و Cl^{-} و $HCO3^{-}$ و $SO4^{-2}$.تمت مقارنة النتائج مع تلك التي تم الحصول عليها من خلال غسل التربة باستخدام المياه غير الممغنطة. أظهرت النتائج أنه يمكن زيادة كفاءة الغسل عند استخدام الماء الممغنط ، ومع زيادة الشدة المغناطيسية ووقت التعرض ، تم ترشيح المزيد من الأملاح خارج التربة. كانت أقصى زيادة تم الحصول عليها في قيمة التوصيل الكهربائي للمياه المترشحة ، والتي تمثل مؤشرًا عامًا لجميع الأنيونات والكاتيونات التي تم ترشيحها ، 58.0٪ مقارنةً عند استخدام المياه غير الممغنطة في عملية الغسل.

الكلمات الرئيسية – تأثير المغنطة ، ملوحة التربة ، التربة المتأثرة بالملوحة ، الشدة المغناطيسية.