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The Effect of Adding Organic Matter on the Efficiency of Salts Leaching in the Soil Affected by Salinity

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Abstract. A field experiment was implemented at the Agricultural Research Station / college of Agriculture / Basra University, Karma Ali, during the year 2021 to study the effect of adding organic matter in the efficiency of salts leaching in the soil affected by salinity using three types of organic residuses (cows , rice, and miaze) and two levels From the addition (2 % and 4 %), where the leaching process took in five stages, and laboratory measurements were performed in soil models taken for two depths 0-15 cm and 15-30 cm. The land plowed and was blessed, then the residule was added to mix to the soil with the surface layer. Soil measurements were taken after each stage of leaching, and the bulk density of the soil was measured after the end of the experiment, The measurements included: the electrical conducyivity of the soil solution, the concentration of dissolved sodium and dissolved chlorine in the soil solution and the bulk density. The results of the study showed that adding organic residue led to reducing electrical conductivity, the concentration of dissolved sodium, the concentration of dissolved chloride and the bulk density, and the decrease was more clear 'in cows treatment, as the fifth leaching stagewere more significant in reducing electrical conducctivity and the concentration of dissolved sodium and chloride in the soil solution and the bulk density of the soil, The concentration also significant 4% on the concentration 2% in reducing electrical conducyivity, sodium concentration and dissolved chlorine in the soil solution and the bulk density of the soil.

Keywords. Organic residual, Soil leaching , Soil affected salts.

1. Introduction

Soils in dry and semi -dry areas suffers from the problem of accumulating salts in it to not use sufficient leaching water to remove salts added with irrigation [1]. The salinity of the soil contributes to the low growth and productivity of developing plants in those conditions, as well as, the effect on the properties of physical, chemical and hydraulic soils. The reclamation process is a fundamental solution to the problem of salt, and one of the most important ingredients for the success of the salt soil reclamation process is to determine the optimal amount of leaching water or what is called (Norm Leaching) [2]. Hence, the leaching process and the net movement of the leaching water are required to remove the salts to prevent them from concentrating in the root zone to the appropriate level for the plants' tolerance to ensure that it does not affect their growth and productivity. The concept of leaching the soil from salts and improving its physical and chemical properties depends on several factors, including the method of leaching, salinity, the amount of water added during the leaching process and the time period for leaching, as well as the properties of the soil and other factors. [3], the superiority of the intermittent leaching method in basins compared to continuous leaching in dissolving the salts present in the surface layer and their transfer with the movement of water to the depths and from there to the drainage places of puncture, as [4], indicated that the increase in leaching periods with salinity of leaching water Low in the intermittent leaching method showed greater efficiency in the use of less water, in addition to that increasing the leaching periods may increase the speed of leaching salts from the soil unsaturated. [5], explained that the leaching process includes two stages: dissolving the salts and then removing them, as the dissolution process takes place during the entry of water into the soil pores, while the displacement takes place when the leaching water is drained after the soil is saturated. [6], indicated that the efficiency of leaching It increases with the increase in the leaching periods in the intermittent leaching method due to the increase in the solubility of salts from the soil, as drying the surface layer during the rest period between irrigations improves the entry and movement of water added in the subsequent irrigation, which contributes to the melting and movement of salts in the subsequent irrigation. Chemical methods can be used in the reclamation of saline soil by adding organic matter [7], or solid reformers [8], as well as using physical methods such as leaching with water to transfer excess and soluble salts from horizons or The upper layers to the depths of the lower soil or outside the root zone [9]. [10], indicated through the results of the experiments conducted in the Khalis project in Iraq that the efficiency of leaching increased as the area of the leaching basin became smaller. to 3 ds m^{-1}, and it was preferred not to use high leaching rates when leaching saline soils in order to avoid the appearance of negative effects on the properties of the soil as a result of leaching and to avoid added in water and raise ground water levels.

In the study of [11], on the methods of leaching salts in the soil, it was shown that the intermittent leaching method works to expel salts from the soil in batches with the appearance of high salt concentrations at the bottom and low salt concentrations at the surface, in addition to the fact that the amount of water required for leaching is less by one third than it requires Other leaching methods. The addition of organic matter is one of the effective strategies in reducing the damage of salinity of irrigation water and increasing plant tolerance. It improves the distribution of soil pores, which in turn increases water holding capacity and aeration and improves the secretions of roots such as organic acids that regulate soil pH and reduce the harmful effect of salts in the soil solution. [12], as well as organic matter has a role in the speed of sodium ion leaching and reducing the ratio of mutual sodium and electrical conductivity [13], as well as working on the nutritional balance in the soil that is disturbed by the presence of an excess of certain ions at the expense of necessary nutrients and improving Aeration conditions and the movement of oxygen to the soil organisms, thus increasing the vital activity and the readiness of the nutrients [14]. [15], indicated that the addition of organic residues to the soil has a role in improving the physical properties of soil related to permeability, porosity, air and water movement in the soil. Also, the organic materials added to the soil from different sources play an important role in the soil, as these materials directly affect the improvement of soil construction and increase the stability of its gatherings through their work in collecting soil particles according to a clear structural system due to the products of its decomposition, and also leads to an increase in the ability of the soil to retain water and maintain On the surface of the soil from erosion and erosion by forming aggregates through the adhesion of soil particles to each other as it acts as a binding material and thus the difficulty of its fragmentation and erosion, whether by water or wind [16].

2. Materials and Methods

The site for conducting this study was chosen in one of the fields of the Agricultural Research Station in the area of Karma Ali / College of Agriculture during the year 2021 to study the effect of adding organic matter on the efficiency of salt leaching in salinity affected soil. Soil samples were taken randomly from different locations in the study area before added treatments at the layers (0-15) cm and (15-30) cm to form a composite sample, then air dried, crushed and sifted through a sieve with a diameter of 2 mm, and chemical and physical analyzes were conducted on it according to the followed methods In [17,18], which are listed in Table No. (1).

Table 1. Some primary physical and chemical properties of the studied soil.

Parameters	Depth (cm)		Unit
	0-15	15-30	
PH	8.05	8.12	-------
ECe.	5.60	6.11	ds m^{-1}
CEC	13.98	13.88	Cmol $^{+}$ gm^{-1}
available N	4.20	4.22	mg kg^{-1}
available P	11.02	11.01	
available K	115.16	114.88	
Total N	0.35	0.41	gm kg^{-1}
Organic Carbon	2.30	2.32	
Organic meatal	3.97	3.80	
Ca	9.4	9.5	mmol l^{-1}
Mg^{++}	7.75	7.77	
Na^{+}	36.5	36.1	
K^{+}	1.65	1.62	
HCO_3^{-}	5.44	5.42	
CO_3^{--}	0.00	0.00	
Cl^{-}	34.45	34.41	
SO_4^{--}	13.33	13.30	
Partical Density	2.65	2.64	Mg gm^{-3}
Bulk Density	1.26	1.25	
Porosity	36	35	%
Sand	112	110	gm kg^{-1}
Silt	433	434	
Clay	455	456	
texture	Silty Cly	Silty Cly	

Rice straw residues were collected from rice farms and maize residues from a miaze mill, washed, dried and it sieved from a 1 mm sieve. As for cow residues, they were collected from animal fields near to the study area, in sufficient quantities, and foreign materials were removed from them and mixed well.

The study was carried out by four factors:

- The type of organic residues , including (cow , rice straw, and yellow miaze)
- Addition rate (2% and 4%)
- Soil depth (0-15 cm) and (15-30 cm)
- Leaching stages (five stages using the intermittent leaching method with a rest period of five days between leaching and another, and an addition rate of 50% over the field capacity) [19].

The land was plowed orthogonally, then smoothed, leveled and divided into boards with a board area (1×1 meter) and three replications. The leaching process was carried out according to the previous treatments with the adoption of measuring the amount of change in the level of soil salinity, drainage water and the concentration of dissolved elements after each leaching stage and from depths (0-15, 15-30) cm using an Auger. The process of taking soil samples was carried out in one specific direction from each row.

The amount of water needed for leaching was determined based on the weight of the soil before each leaching and according to the following equation [20]:

$$d = (Pv/100) \times D = (w\,f.c. - wi.w.) \times Pb \times D \quad (1)$$

$$V = d \times A \quad (2)$$

Wich : d= leaching water depth (cm).

w f.c. = weight percentage of moisture at field capacity (%).
wi.w. = Weight percentage of moisture before the next leaching (%).
Pb = bulk density of soil (gm cm^{-3}) Pv, = volumetric moisture (%).
D = soil depth (cm).
V = volume of added leaching water (cm^3).
A = row area (cm^2).
Then the result of equation (2) is multiplied by the percentage increase over the field capacity (50%) and added to the total amount of water, so that the amount of water added for each stage amounted to 5613 liters for the study soil.
The electrical conductivity of the soil extracts and the dissolved sodium and chloride ions in soil extract (soil : water) (1:1) and to the previously shown depths were estimated after each stage during the leaching experiment, while the bulk density of the soil was measured after the end of the leaching experiment.

3. Results and Discussion

The effect of leaching and the level of organic residues and its sources on:-

3.1. Electrical Conductivity of Soil Extract

Table 2 shows that there is a significant effect of organic residues on the electrical conductivity values of the soil filter. The lowest electrical conductivity value was for the cow manure treatment, which amounted to 3.56 dsm^{-1} compared to the control treatment (4.28 dsm^{-1}), while there was no significant difference. between rice and miaze treatments (3.64 3.76 dsm^{-1}), respectively. This result is consistent with the findings of [14,21], who indicated that the addition of organic residues to saline soils improved the conditions for leaching salts and sodium due to reducing the bulk density of the soil, increasing the porosity and improving the construction. The addition of these residues has different effects in leaching the NaCl salt, reducing the proportion of exchanged sodium (ESP), the electrical conductivity and increasing the water tip [22], found a decrease in the salinity of the original soil to more than 50% when using organic residues. Execution of the experiment increases the chance of leaching salts under the surface layer, especially when the texture is medium to the field soil and there is an efficient puncture system in the study area.

The results also indicate that there is a significant effect of the leaching stages on the electrical conductivity of the soil extracts, as it is noted from the table that increasing intermittent soil leaching reduced the electrical conductivity rate of the soil, which amounted to 4.56, 3.99, 3.61, 3.36 and 3.21 dsm^{-1} for the leaching stages.

The first, second, third, fourth and fifth respectively. This may come due to the availability of additional quantities of water as a result of the repeated leaching stages added and the increase in soil moisture that contributed to improving the leaching and movement of salts, in addition to the possibility of leaching sodium salts that would affect the properties of the soil and reduce its permeability. [23], indicated that there is a positive correlation between the efficiency of salt leaching and the increase in the amount of leaching water, and the study indicated that the greatest efficiency of salt leaching was recorded for the 6-day rest period treatment, while the lowest efficiency was recorded for the 30-day treatment. The results also showed in Table 2 for the statistical analysis the significant effect of the interaction between the type of residues and the leaching stages on the electrical conductivity values in the soil solution, and the fifth leaching stage of cow gave the lowest value for the electrical conductivity in the soil solution (3.15 ds m^{-1}) and the highest value was at the leaching stage The first is the comparison treatment (5.58 ds m^{-1}). These results are consistent with what was indicated by [24,25], that the ability of organic residues to reduce soil salinity depends on the type of these residues. Adding it from the organic source of salts may reduce its efficiency in reducing soil salinity.

The results of Table 2 show the case of the interaction between the type of organic residues and its added levels in the electrical conductivity values of soil solution, which recorded a significant effect on the electrical conductivity of soil leachate. The highest value was recorded when miaze were treated with an addition level of 4% (3.98 dsm^{-1}). To confirm the efficiency of high levels of organic residues in reducing soil salinity, and this indicates the positive role of the presence of plant residues in soil in increasing granulation and the formation of agglomerations [26].

While the level of added residues, the binary interaction between the residue level and the leaching stage, and the triple interaction between the type, level and leaching stages of the residues had no significant effect on the electrical conductivity values of the soil solution (Table 2).

Table 2. Effect of leaching and the level of organic residues and their sources on the electrical conductivity of the soil solution.

Type of residue	**Addition rate (%)**	**Leaching stage**					**Type * Addition rate**
		1 st	**2 nd**	**3 rd**	**4 th**	**5 th**	
Cows	%4	4.04	3.36	3.15	3.06	2.99	3.32
	%2	4.49	4.1	3.66	3.44	3.30	3.80
Rice	%4	4.34	3.82	3.41	3.33	3.15	3.61
	%2	4.23	3.95	3.74	3.32	3.20	3.69
Miaze	%4	5.21	4.34	3.81	3.32	3.22	3.98
	%2	4.04	3.79	3.44	3.27	3.16	3.54
Control		5.58	4.56	4.06	3.75	3.47	4.28
Leaching stage		4.56	3.99	3.61	3.36	3.21	Type of residue
Type of residue * Leaching stage	Cows	4.26	3.73	3.40	3.25	3.15	3.56
	Rice	4.28	3.88	3.57	3.32	3.17	3.64
	Miaze	4.62	4.06	3.62	3.29	3.19	3.76
	Control	5.58	4.56	4.06	3.74	3.47	4.28
							Addition rate (%)
Addition rate * Leaching stage	%4	4.53	3.84	3.46	3.24	3.12	3.64
	%2	4.25	3.95	3.61	3.34	3.22	3.67

RLSD$_{0.05}$						
Type of residue	Addition rate	Leaching stage	Type of residue * Leaching stage	Addition rate * Leaching stage	Type of residue * Addition rate	Type of residue * Addition rate * Leaching stage
0.31	N .S.	0.33	0.91	N. S.	0.46	N .S.

Figure 1 shows that there is a significant effect of the interaction between the treatments of the leaching stages and the depth of the soil on the electrical conductivity values of the soil solution. The lowest value was recorded for the treatment of the fifth leaching stage at a depth of 0-15 cm, which amounted to 3.21 ds m^{-1}, and the highest value(5.04 ds m^{-1}) was for the treatment of the first leaching stage and for a depth of 15-30 cm. This indicates the reduction of salts at a depth of 0-15 cm from the soil due to the possibility of availability of time and the sufficient amount of leaching water in the movement of the salts and their leaching to other depths of the soil. The reason for this rise at a depth of 15-30 cm as a result of the initial leaching treatments is due to allowing large amounts of water to flow into the surface layer of the soil and thus leaching more salts from the upper layers of the soil, as during the surface depths the water flows faster through the pores While the movement of water in the small pores of soil particles is much less, which is concentrated in the depths far from the surface of the soil, and then the salts within the aggregates are removed more slowly at the depths far from the surface [27].

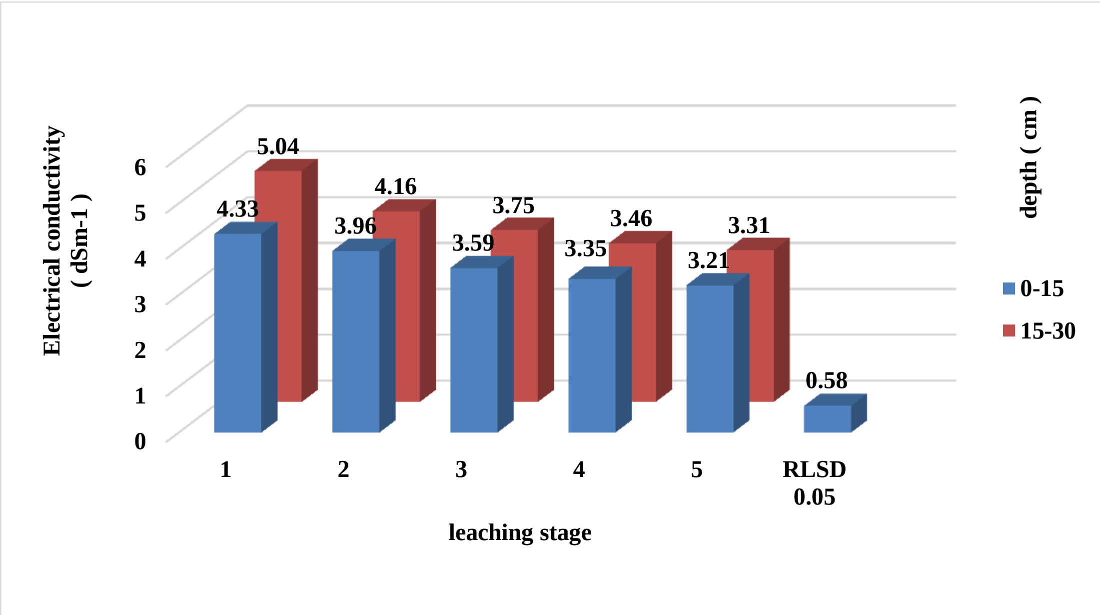

Figure 1. The effect of the interaction between the leaching stages and the depth of the soil on the electrical conductivity values of soil solution (dSm^{-1}).

3.2. The Concentration of Dissolved Sodium in the Soil Solution

The results of Table 3 show that the type of organic residues, its level, leaching stages, and the interaction between them had a significant effect on the concentration of dissolved sodium in the soil solution.

Table 3 shows a significant effect of organic residues on the concentration of dissolved sodium in the soil solution. The lowest value was 27 mmol l^{-1} for the treatment of cow manure compared to the control treatment (27.1 mmol l^{-1}), while the highest values were recorded for the treatment of miaze , which It reached 30.15 mmol l^{-1}. The reason may be due to the fact that the type of organic residues has a role in reducing the bulk density and improving the leaching conditions [28].

The results of Table 3 show that there is a significant effect of the level of residues on the concentration of dissolved sodium in the soil solution. It is noted from the table that the 4% level gave the lowest average dissolved sodium concentration amounted to 27.43 mmol l^{-1}, while the highest value of the dissolved sodium concentration reached at The level is 2%, at a rate of (29.03 mmol l^{-1}). This confirms the efficiency of high levels of organic residues in reducing the dissolved sodium concentration in the soil solution [29].

Increasing the leaching stages led to a significant decrease in the concentration of dissolved sodium in the soil solution, as its rates reached 55.31, 46.06, 13.5, 12.94 and 11.94 mmol l^{-1} for the five stages, respectively, with a decrease of 16.72, 75.59, 76.60 and 78.41 %, respectively. It is also noted from the results that the values of dissolved sodium concentrations in the soil solution are lower at the end of the experiment (the fifth leaching stage) compared to the first leaching stage, which may be attributed to the fact that the intermittent leaching process is sufficient to leached the salts and prevent their accumulation at the end of the leaching, in addition to the low water conductivity rate of the soil in a way It increases with time, then slows down until the end of the leaching process [30].

The results of Table 3 showed the case of the interaction between the type of organic residues and its added levels in the values of dissolved sodium in the soil solution, which recorded a significant effect on the average concentration of dissolved sodium in the soil solution, and the lowest value was for the treatment of cow manure with an addition level of 4% (25.5 mmol l^{-1}), and the highest value was recorded for the treatment of miaze with an addition level of 2%, which amounted to 30.9 mmol l^{-1}.

The results showed in Table 3 the significant effect of the binary interaction between the type of residues and the leaching stages in the concentration of dissolved sodium in the soil solution, and the stage of The fifth leaching of the miaze treatment had the lowest value of the dissolved sodium concentration, which amounted to 11.75 mmol l^{-1}, while the highest value was for the first leaching stage treatment of the miaze, which amounted to 61.5 mmol l^{-1} .

The interaction coefficients between the level of residue addition and the leaching stages (Table 3) showed that there were significant differences in the concentration of dissolved sodium in the soil solution. The 4% addition level treatment and the fifth leaching stage gave the lowest value for the dissolved sodium concentration in the soil solution (11.5 mmol l^{-1}), while the highest value of the dissolved sodium concentration in the soil solution was recorded for the treatment of the first leaching stage with a level of 2% for the addition, which amounted to (56.67 mmol l^{-1}).

The interaction between the type and levels of plant residues and the leaching stages had a significant effect on the values of dissolved sodium concentrations in the soil solution. Table 3 shows that the treatment of miaze with a level of 4% and the fifth leaching stage gave the lowest concentration of dissolved sodium in the soil solution, which amounted to 11 mmol l^{-1}, while the highest value was recorded for the treatment of miaze with an addition level of 2% at the first leaching stage Which amounted to 62.50 mmol l^{-1}.

Table 3. Effect of leaching and the level of organic residues and its sources on the dissolved sodium of soil solution.

Type of residue	**Addition rate (%)**	**Leaching stage**					**Type * Addition rate**
		1 st	**2 nd**	**3 rd**	**4 th**	**5 th**	
Cows	%4	48.00	44.00	12.50	11.50	11.50	25.50
	%2	57.00	47.00	13.50	12.50	12.50	28.50
Rice	%4	53.00	46.00	13.50	12.50	12.00	27.40
	%2	50.50	49.00	13.50	13.50	12.00	27.70
Miaze	%4	60.50	48.50	13.50	13.50	11.00	29.40
	%2	62.50	52.00	14.50	13.00	12.50	30.90
Control		55.50	41.00	13.50	13.50	12.00	27.10
Leaching stage		55.31	46.06	13.50	12.94	11.94	Type of residue
Type of residue * Leaching stage	Cows	52.50	45.50	13.00	12.00	12.00	27.00
	Rice	51.75	47.50	13.50	13.00	12.00	27.55
	Miaze	61.50	50.25	14.00	13.25	11.75	30.15
	Control	55.50	41.00	13.50	13.50	12.00	27.10
							Addition rate (%)
Addition rate * Leaching stage	%4	53.83	46.17	13.17	12.50	11.50	27.43
	%2	56.67	49.33	13.83	13.00	12.33	29.03
				RLSD$_{0.05}$			
Type of residue	Addition rate	Leaching stage	Type of residue * Leaching stage	Addition rate * Leaching stage	Type of residue * Addition rate	Type of residue * Addition rate * Leaching stage	
2.60	7.01	1.15	1.96	1.39	1.24	2.78	

As for the case of the interaction between the leaching stages and the depth of the soil (Fig. 2), which recorded a significant effect on the concentration of dissolved sodium in the soil solution, and it was the lowest value when treating the fifth leaching stage and for depth 0-15 and reached 11.63 mmol l^{-1}, and the highest value at The treatment of the first leaching phase and for a depth of 15-30 it reached

59.50 mmol l^{-1}. Repeated leaching has a role in increasing the movement of water to the bottom, which improves the ability of the soil to displace salts, which is reflected in a decrease in the concentration of dissolved sodium in the soil solution.

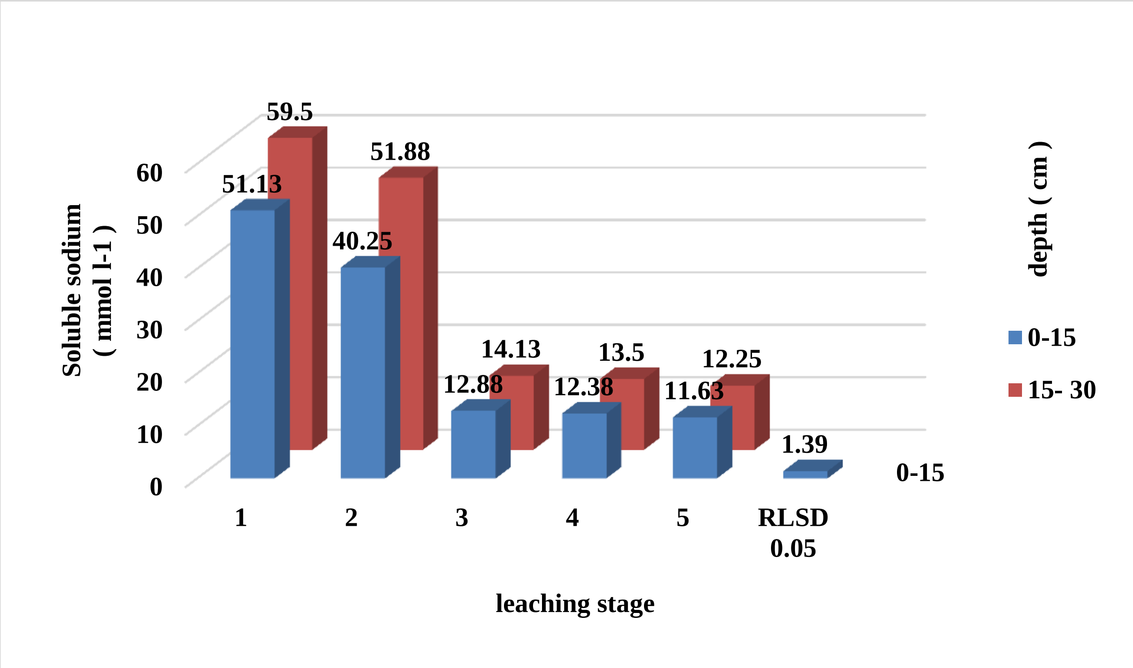

Figure 2. Effect of the interaction between leaching stages and soil depth on the concentration of dissolved sodium in the soil leachate(mmol l^{-1}).

3.3. The Concentration of Dissolved Chloride in the Soil Solution

Table 4 shows that there is a significant effect of the type of organic residues on the concentration of dissolved chloride in the soil solution. The lowest value of the dissolved chloride concentration in the soil solution when treating the soil with cow manure was 16.06 mmol l^{-1}, while the highest value of the dissolved chloride concentration in the soil solution reached 16.06 mmol l^{-1}. Soil when treated with maize residues and it reached 20.53 mmol l^{-1}. This is due to the residues containing quantities of these ions.

The results of Table 2 show that there is a significant effect of the leaching stages on the concentration of dissolved chloride in the soil solution. It is noted from the table that by increasing the intermittent soil leaching, the concentration of dissolved chloride in the soil solution decreased 27.07, 18.86, 16.69, 13.98, and 11.79 mmol l^{-1}, respectively. For the five stages of leaching. It is also noted from the results that the values of dissolved chloride concentrations in the soil solution are lower at the end of the experiment (the fifth leaching stage) compared to the first leaching stage, and therefore this is due to the fact that the intermittent leaching process is sufficient to leached the salts and prevent their accumulation at the end of the season, in addition to the unsaturated conditions allowing sufficient time for the exchanged materials to dissolve at the exchange surfaces so that they can then be removed by the water passing through the large pores and reduce the effects of water flow in the soil [31]. Where previous experiments showed that small increases in soil moisture content during leaching can lead to an increase in the efficiency of removing chloride from the soil by reducing the rate of water addition [19].

The results also showed in Table 3 for the statistical analysis the significant effect of the interaction between the type of residues and the leaching stages on the concentration of dissolved chloride in the soil solution. Miaze, which amounted to 34.75 mmol l^{-1}. While the level of residues, the interaction with the level of residues and the leaching stages, the interaction with the type and level of residues and the interaction with the type and level of residues and the leaching stages, had no significant effect (Table 4) on the concentration of dissolved chloride in the soil solution.

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Table 4. Effect of leaching and the level of organic residues and their sources on the dissolved chloride of soil leachate.

Type of residue	Addition rate (%)	Leaching stage					Type * Addition rate
		1 st	2 nd	3 rd	4 th	5 th	
Cows	%4	19.17	16.00	12.84	12.50	10.50	14.20
	%2	31.33	16.67	16.33	13.34	11.84	17.90
Rice	%4	21.00	17.67	17.17	12.67	12.34	16.17
	%2	21.50	21.00	19.67	15.33	11.84	17.87
Corn	%4	31.00	23.00	19.00	15.67	12.67	20.27
	%2	38.50	20.17	17.34	14.67	11.50	20.43
Control		27.00	17.50	14.50	13.67	11.84	16.90
Leaching stage		27.07	18.86	16.69	13.98	11.79	Type of residue
Type of residue * Leaching stage	Cows	25.25	16.34	14.59	12.92	11.17	16.06
	Rice	21.25	19.34	18.42	14.00	12.09	17.02
	Corn	34.75	21.59	18.17	15.17	12.09	20.35
	Control	27.00	17.50	14.50	13.67	11.84	16.90
							Addition rate (%)
Addition rate * Leaching stage	%4	23.72	18.89	16.34	13.61	11.84	16.88
	%2	30.44	19.28	17.78	14.45	11.73	18.74
RLSD$_{0.05}$							
Type of residue	Addition rate	Leaching stage	Type of residue * Leaching stage	Addition rate * Leaching stage	Type of residue * Addition rate	Type of residue * Addition rate * Leaching stage	
5.08	N. S.	4.56	14.13	N. S.	N. S.	N. S.	

As for the case of the interaction between the leaching stages and the depth of the soil (Fig. 3), which recorded a significant effect on the concentration of dissolved chloride in the soil solution, and it was the lowest value when treating the fifth leaching stage and for depth 0-15, and it reached 11.46 mmol l^{-1}, and the highest value was when treating the leaching stage The first and for a depth of 15-30 it amounted to 31.80 mmol l^{-1}. Which means that there is a process of movement and displacement of salts from the surface depth to the second depth, in which the salts accumulated with the repeated leaching process and during the study period. Also, the process of primary plowing of the soil and the addition of organic residues mixed with the soil contributed to improving some of the physical properties of the soil under study before the leaching process (The bulk density of the soil, the mean weighted diameter, the saturated water conductivity of the soil and the porosity), which increased the movement and transmission of the leaching water towards the far depths of the soil surface, and then removed the high concentrations of dissolved ions with the leaching water. These results agree with [32], who showed that increasing the amount of leaching water from 10 to 20 cm in the intermittent leaching treatment reduced the concentration of salts in the soil for depths 0-20, 0-40 and 0-100 cm by about 15.50 and 13.58 and 5.70%, respectively.

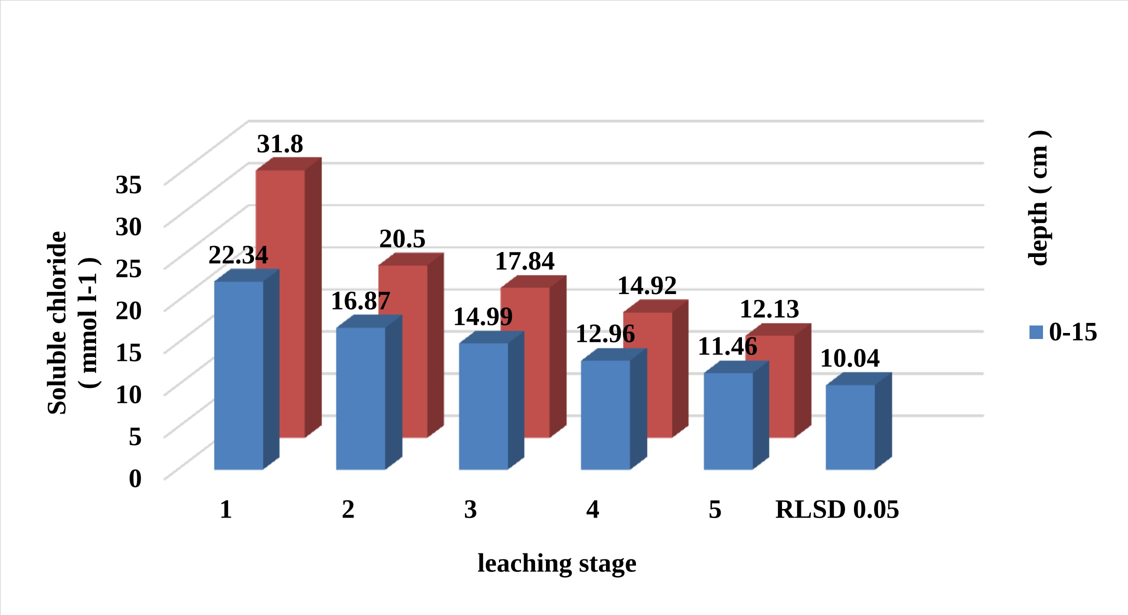

Figure 3. The effect of the interaction between the leaching stages and the depth of the soil on the concentration of dissolved chloride in the soil leachate (mmol l^{-1}).

3.4. The Bulk Density of Soils

The results in Figure 4 of the statistical analysis showed the significant effect of the interaction between the type of residues and the level of addition on the bulk density values, and the 4% level for cow residues gave the lowest value for the bulk density values and amounted to 1.56 Mgm g^{-1}, and the highest value was at the 2% level for maize , which amounted to 1.67 Mgm g^{-1}. Adding residues to the soil may have an effect on improving soil porosity and regulating the movement of water and air in it, and thus positively affects the values of the bulk density, as [33], indicated that the addition of organic matter to gypsum soil reduced the bulk density of soil from 1.50, 1.60 and 1.63 Mgm g^{-1} to 1.44, 1.50 and 1.60 Mgm g^{-1} for depths of 10 - 0 , 25 - 10 and 40 - 25 cm, respectively, which was attributed to the role played by organic matter in improving soil construction and increasing its porosity.

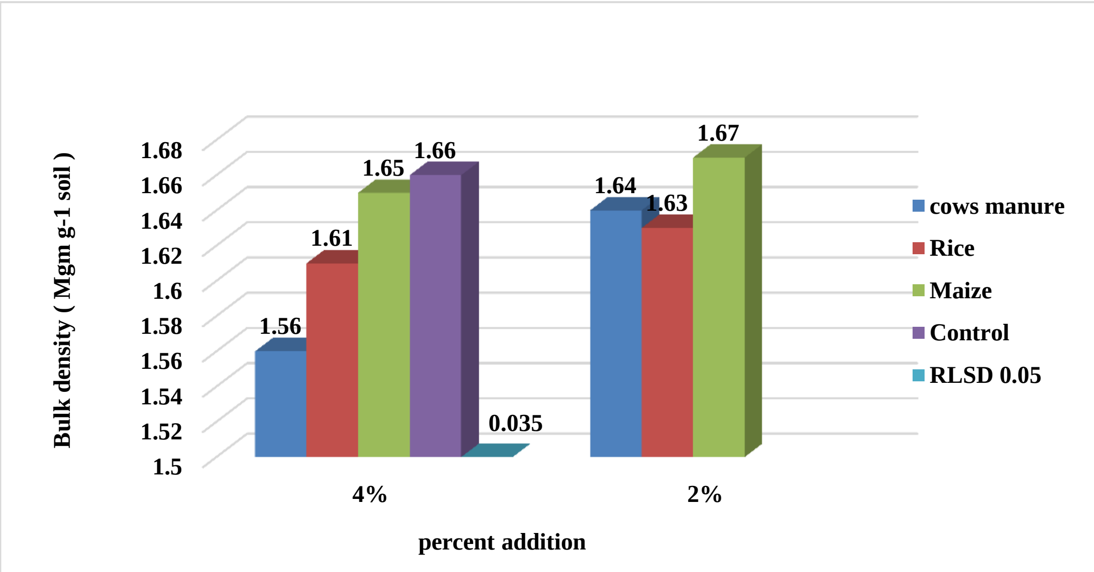

Figure 4. The effect of the interaction between the type of residues and the percentage of addition on the values of the bulk density of soil after the end of leaching (Mgm g^{-1} soil).

Conclusions

The results showed the ability of animal residues (cows) with an addition rate of 4% and during five stages of leaching in reducing the electrical conductivity of the soil solution and the soluble concentration of both sodium and chloride in the soil, as well as contributed to reducing the bulk density of the study soil.

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