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Effects of two organic amendments on EC, SAR and soluble ions concentration in a saline-sodic soil

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Abstract

The effects of a municipal solid waste compost and cow manure on chemical properties of a saline-sodic soil during 150 days incubation and leaching were studied. Two amendments were added to the soil at the rates of 1%, 3% and 5% by weight and incubated for 1 month. Leaching experiments then were conducted using 1, 2, 3 and 4 pore volumes of local irrigation water in 30 days intervals. The results indicated that application of manure and compost decreased soil EC by as much as 75.03% and 65.16% and SAR by 44.22% and 38.85%, respectively after 120 days and three stages of leaching. Soluble actions concentration increased after one month incubation and decreased there after by leaching operation, until the end of the experimental period. K^+ was the only action whose concentration did not decrease considerably in soil solution. In most cases there was not a significant difference between leaching with 3 pv and 4 pv. Comparison between the various levels of both amendments showed that the efficiency of the application of 1% by weight of both amendments in improving the chemical characteristics of the soil was the same as the other levels.

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Introduction

It is estimated that 1.5 billion ha of lands, all over the world, are salt-affected (Yuan *et al*, 2010). Increasing soil salinity and sodicity are serious worldwide land degradation issues, and may be even increase rapidly in the future (Wong *et al,* 2009). The excessive salt accumulation adversely affects soil physical and chemical properties, as well as microbiological processes (Lakhdar *et al*, 2009). Plants growing in such media, generally exhibit an accumulation of Na^+ Cl^- and /or the inhibited uptake of mineral nutrients, especially Ca^{2+}, K^+, N and P (Tejada *et al*, 2006). In addition, in the arid zones with limited rainfall, intense evaporation tends to accumulate salts in the upper layer of soil profile especially when it is associated with insufficient leaching (Jalali *et al*, 2008).

Several methods have been suggested to reduce adverse effects of salinity and sodicity. Two key factors concerning sodic soil reclamation are: (1) supplying sufficient available Ca^{2+} and (2) maintaining appropriate soil permeability by providing sufficiently high electrolyte concentration in soil solution (Li and Keren, 2009). Using of chemical amendments as source of Ca^{2+} which tend to replace exchangeable Na^+, as well as irrigation with water rich in divalent cations, are the traditional methods for sodic soil reclamation (Tejada *et al*, 2006). Due to the cost associated with the addition of extraneous chemicals and environmental pollution concerns, it is of interest to identify options for sodic soil reclamation that use less expensive natural calcium sources such as $CaCO_3$ (Li and Keren, 2008), but low solubility is the main obstacle for its application in sodic soil reclamation. The dissolution rate of $CaCO_3$ depends on pH value, CO_2 partial pressure and its hydrolysis reaction in soil solution (Li and Keren, 2009). Organic matter content, temperature and moisture content in soil affect CO_2 production (li and Keren, 2009). Phytoreclamation (or bioremediation) is a common method to facilitate the dissolution of native $CaCO_3$ and subsequent sodic soil reclamation (Qadir and Oster, 2002).

Using of organic conditioners became common practice in salt-affected area especially sodic soils during the last decades (Melero *et al*, 2007). Incubation of sodic soil with organic conditioners through dissolution of native $CaCO_3$ may release considerable Ca^{2+} and raise electrolyte concentration for moderate sodic soil reclamation. For sodic or saline –sodic soils, the addition of organic matter can accelerate leaching of Na^+, decrease the ESP and the electrical conductivity (EC) and thus increase water infiltration, water-holding capacity and aggregate stability. The later is particularly important for agricultural soils deficient in OM (Walker and Bernal, 2008). It has been demonstrated that the application of cotton gin crushed compost and poultry manure at rates of 5 and 10 t ha^{-1} in a 5 years period to a saline and sodic soil, considerably decreased ESP (about 50%), compared to the unamended soil. Electrical conductivity of the soil also decreased from 9 dS m^{-1} to as low as 1dS m^{-1} after 5 years in amended treatment (Tejada *et al*, 2006). Repeated applications and/or elevated application rates of animal manures or composts having relatively high salt contents may increase soil salinity leading to structural breakdown (Smith *et al*, 2001). Walker and Bernal (2008) reported that application of olive mill waste compost and poultry manure at rates of 20 and 30 g Kg^{-1} soil, to a highly saline soil, during cultivation of two beet species, did not change significantly the soil electrical conductivity or soluble Na^+, in this study sodium absorption ratio remained low.

Most of studies about the effects of organic matter application on chemical or physical properties of salt affected soils have been done without leaching experiments. Therefore this study was conducted to evaluate the effects of municipal solid waste compost and cow manure application, at three different doses to a saline-sodic soil, on soil chemical properties, during a 5-month incubation-leaching period.

Materials and methods

Soil samples

Selected soil samples (top 30 cm) were collected from a barley field (4204701.66, 587828.64 and

4204728.48, 587850.75, in UTM system) located at southwest of Tabriz, Iran. They were air dried (20-30°C for 7d) and sieved through a 2-mm mesh. The measured soil properties were: texture (hydrometer method, described by Gee and Bauder, 1986), FC moisture content (by pressure plate method at 33Kpa, described by Klute, 1986), pH of saturated soil paste (Mclean.1982), EC of saturated extract (Rhoades, 1996), organic carbon (Walkley and Black's method, described by Nelson and Sommers, 1986), equivalent calcium carbonate (titration method described by Richards, 1945), available K^+ (by ammonium acetate method described by Knudsen *et al.*, 1982), soluble $Ca^{2+}$and Mg^{2+} (titration method described by Rhoades, 1982), soluble Na^+ (extraction with water and flame photometry, Rhoades, 1982) and Cl^- (titration method described by Rhoades, 1982). The soil was a clay loam (fine-loamy, mixed, super active, mesic Typic Calcixerept). The properties of the examined soil, called hereafter "initial soil", are shown in Table 1.

Organic amendments

The organic amendments were municipal solid waste compost (C) and cow manure (M). The pH and EC (1:2.5), organic carbon concentration, total K^+ and total Na^+ by flame photometry and total Ca^{2+} and Mg^{2+} by atomic absorption were determined (Gupta, 1999). The general properties of the organic matters are shown in Table 1. Sheep and cow industry in Iran, especially in Azerbaijan, produces large amounts of manure that may be used to enhance soil fertility. Municipal solid waste compost is the product of a compost factory in Tabriz. The 1-3% is usually the agronomic rate of organic matter application in the studied area and, therefore 1, 3 and 5% (by weight) of these conditioners were applied.

Leaching columns

The leaching columns consisted of PVC tubes, with 50cm length and 15 cm diameter. Organic fertilizers (<1mm) were thoroughly mixed with the air dried soil and were packed into the columns to a height of 30cm by tapping to achieve uniform bulk density of 1.36 g cm^{-3}. Then columns were incubated for one month at field capacity moisture and room temperature (25±5°C). A filter paper was placed on the soil surface to minimize soil disturbance due to adding of leaching water. A layer of gravel (mean diameter equal to 0.5 cm) was placed at the bottom of the columns and it was covered with a nylon mesh. The bottom of each column was inserted into a plastic funnel to facilitate free drainage of leachate from the columns.

Leaching experiments

The columns were leached with the water normally used for irrigation in the studied area. Some properties of leaching water are shown in Table 2.

For each of six organic treatments (2 amendments and 3 rates), five leaching programs were applied consisted of L_0, L_1, L_2, L_3 and L_4. The symbols used for the organic treatments and for soil columns leaching programs are depicted by Table 3.

The incubation period ranged from one month in L_0 program to 5 month under L_4 program. Leaching the columns with each pv, were completed in 13-20 days period, but the successive steps of leaching were started after 30 days. Qualitative field studies have shown that intermittent leaching is more efficient (in term of water usage and solute leaching) than continuous leaching (Cote *et al*, 2000; Mc Lay *et al*, 1991). During the leaching, water level was maintained at approximately 2cm above the soil surface and the columns were allowed to drain freely. In the intervals between successive leaching steps, soil columns were kept undisturbed in room temperature and for minimizing the evaporation, the top of the columns were covered with a plastic sheet. After each step, the soil in the columns were air dried and passed through a 2-mm mesh sieve and chemical properties including EC, pH, OC and soluble ions concentration (Cl^-, Ca^{2+}, Mg^{2+} , K^+ and Na^+) were determined, and SAR were calculated separately for each layers of the columns (0-10, 10-20 and 20-30 cm) (Page *et al,* 1992 a, b).

Experimental layout and statistical analysis

The experimental layout was a factorial split design with 30 treatments (2 organic amendments, 3 rates of application, 5 leaching programs) and three replicates per treatment. The factors were 1) type of organic amendments: a) M and b) C, 2) rate of application: a) M_1 and C_1 b) M_2 and C_2 and c) M_3 and C_3 and 3) leaching program: a) L_0, b) L_1, c) L_2, d) L_3 and e) L_4. Overally there were 90 experimental columns and soil properties were measured at three layers (0-10, 10-20 and 20-30 cm) in each column. Analysis of variance (ANOVA) was performed using SPSS software and the differences between the means were determined using Duncan's test.

Results and discussion

EC

Effects of the amendments on EC at three layers of the soil columns during leaching experiments are shown in Fig. 1. At the end of the remediation operation by each kind of amendments, EC decreased remarkably. The initial EC of the soil was 15 dS m^{-1} (Table 1). Application of both amendments decreased EC to about 5 dS m^{-1} after five months of incubation with four intermittent leaching stages. In most cases there was no significant difference between leaching with three and four pore volumes for both amendments. In all depths, during five months of incubation and leaching operation, manure was more effective than compost in reducing EC. It could be caused by higher EC of the compost in comparing to the manure. After the third leaching stage (L_3), compost and manure reduced EC by 61% and 72.93% in the 0-10 cm depth, 68.8% and 77.4% in 10-20 cm depth and 65.85% and 74.76% in 20-30 cm depth, respectively, with respect to the initial soil. Smith *et al*, (2001) reported that application of organic materials without leaching in a salt affected soil led to increase in soil salinity. Walker and Bernal, (2008) studied the effects of olive mill waste compost and poultry manure on the availability of nitrogen, phosphorus and potassium in a highly saline soil and reported that the addition of these materials to the soil and cultivation of two types of beet, did not cause any change in EC.

Table 1. Properties of the selected soil, and organic amendments.

Property	Unit	Soil	Cow manure	Compost
Sand	%	26	-	-
Silt	%	38	-	-
Clay	%	36	-	-
Texture	-	clay loam	-	-
pH	-	7.8	8.45	7.61
EC	dSm^{-1}	15	16.7	19.6
O.C	%	0.99	17.6	15.5
$CaCO_3$	%	16.75	-	-
Available- K^+	$mgkg^{-1}$	853	-	-
Total – K^+	%	-	2.15	7.84
Soluble –Ca^{2+}	$meql^{-1}$	18	-	-
Total – Ca^{2+}	%	-	3.6	5.4
Soluble–Mg^{2+}	$meql^{-1}$	14	-	-
Total –Mg^{2+}	%	-	2.1	2.4
Soluble –Na^+	$meql^{-1}$	115	-	-
Total –Na^+	%	-	0.05	0.06
Cl^-	$meql^{-1}$	110	-	-
SAR	-	20.35	-	-
FC moisture content	%	26.9	-	-

Fig. 2 shows the effects of three application rates of amendments on EC during incubation and leaching operation. The EC of the M_1 treatments in the most months, especially on the third (L_2) and fourth (L_3) months of experimental period, was less than other levels (Fig. 2a). Also in the last two months of remediation operation, the lower EC of the C_1 treatment was obvious in comparison to others (Fig 2b). Significant decrease in EC by applying 1% by weight municipal compost during 120 days of incubation and leaching with a volume of water equal to 30% of water holding capacity in a saline soil has been also reported by Elsharawy *et al*, (2008). Hao and Chang, (2003) reported that the application of 120 and 180 Mg $ha^{-1}y^{-1}$ of a cow manure with irrigating water, increased soil salinity in comparison to application of 60 Mg $ha^{-1}y^{-1}$.

Table 2. Some characteristics of leaching water.

Parameter	Unit	Leaching water
pH	-	8.1
EC	μScm^{-1}	410
Na^+	$meql^{-1}$	0.25
K^+	$meql^{-1}$	0.064
Ca^{2+}	$meql^{-1}$	2.40
Mg^{2+}	$meql^{-1}$	1.60
Cl^-	$meql^{-1}$	1.20
HCO_3^-	$meql^{-1}$	2
SAR	-	0.177

Table 3. The symbols used for the organic treatment sand for soil columns leaching programs.

Symbol(s)	Description
C_1, C_2, C_3 by weight	Compost applied at three rates of 1, 3 and 5% by weight.
M_1, M_2, M_3 by weight.	Manure applied at three rates of 1, 3 and 5%
L_0	No leaching, just one month incubation
L_1, L_2, L_3,L_4	One month incubation and Leaching with 1, 2, 3 and 4 pv of irrigation water with 30 days intervals.

Soluble cations

Soluble Na^+

The application of each amendments along with leaching could significantly decrease the sodium concentration of soil solution in all depths (Fig. 3). One month after incubation it was significantly higher than sodium concentration in initial soil (115 meq l^{-1}) in the presence of each amendment, which indicating a large amount of sodium is released due to the application of organic fertilizers. It seems that in all depths, manure was more effective than compost in decreasing soil soluble sodium. During incubation and leaching period, releasing more sodium from compost in comparing to manure was related to more sodium existed in compost (0.06%) rather than manure (0.05%). The difference between two amendments in the amount of soluble sodium at the fourth and fifth months of incubation-leaching period was not significant in most cases.

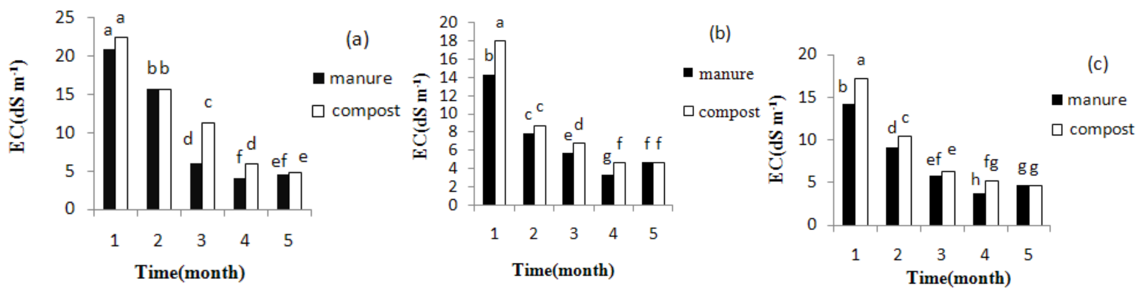

Fig. 1. EC changes at three layers, (a) 0-10 cm, (b) 10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic

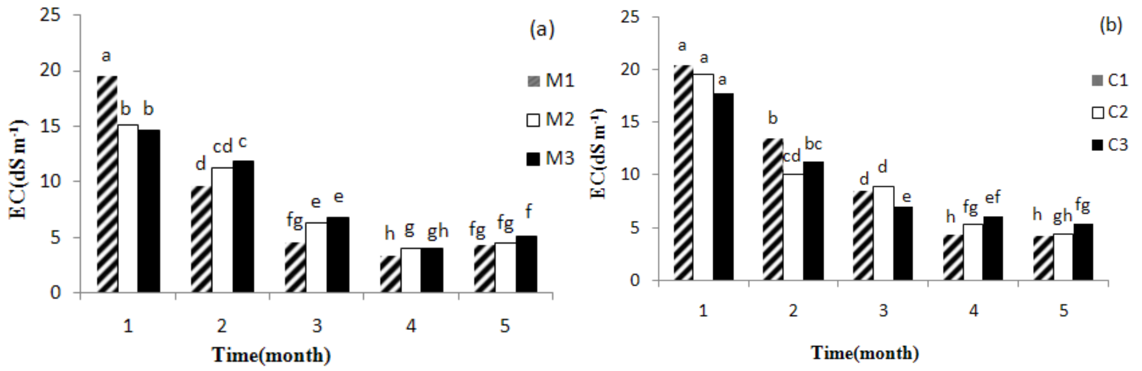

Fig. 2. EC for three rates of (a) manure and (b) compost during 5-months incubation- leaching period.

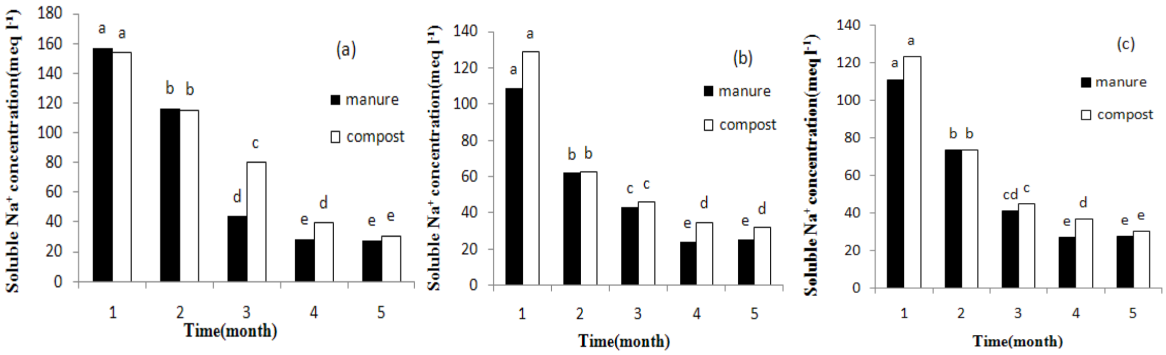

Fig. 3. Soluble Na^+ concentration changes at three layers, (a) 0-10 cm, (b) 10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments.

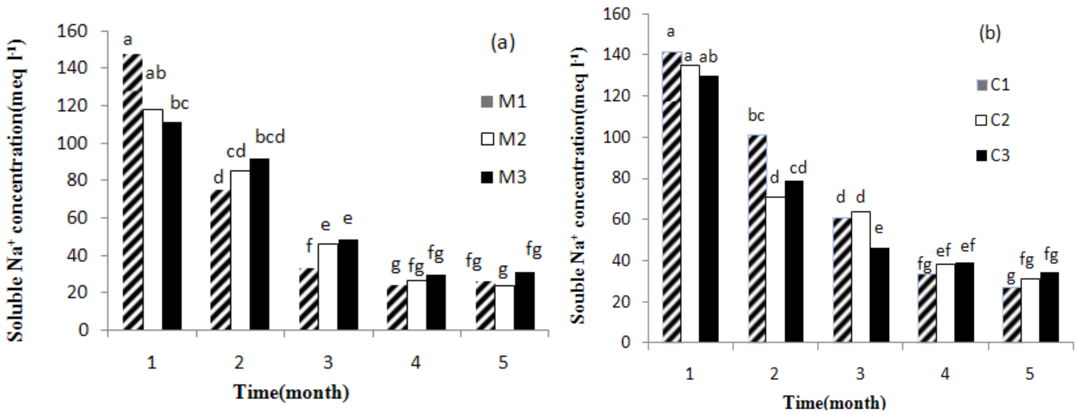

Fig. 4. Soluble Na^+ concentration at three rates of (a) manure and (b) compost during 5- month's incubation-leaching period.

The effects of three levels of two amendments at different months of incubation and leaching on the concentration of soil soluble sodium are shown in Fig. 4. As it is obvious, efficiency of M_1 and C_1 treatments in decreasing soil soluble sodium in the last months of remediation operation was the same as other levels.

Soluble K^+

In none of the depths, there was no significant difference between two amendments regarding their effects on soluble potassium concentration in most months, especially in the last months (Fig. 5). Also soil soluble potassium in compost-amended soil did not changed from first month of incubation until the end of fourth month, but increasing was obvious in manure amended soil, especially at the second and third depths, during three months of incubation and leaching period. Manure due to the higher potassium (2.15%) than compost (1.84%) could increase K^+ concentration during three months, and maximum releasing of potassium from manure was happened in the third month of incubation. While compost decomposition and K^+ releasing increased after the third month of incubation. Hassan *et al.*, (1998) have also reported less decomposition rate of compost in comparing to manure because of passing the primary phases of decomposition during compost formation. Also it was observed that the concentration of soluble. potassium in most time of leaching in 10-20 and 20-30 cm layers was more than 0-10 cm layer which was caused by more leaching of K^+ from the top layers. Although leaching removed some soluble potassium from soil, both amendments due to their high potassium contents, kept the concentration of soluble potassium in a fairly fixed range. But further leaching from third stage to fourth one, caused soluble potassium to decrease significantly. Increasing in K^+ concentration due to organic materials application in salt affected soils has been reported by various studies (Walker and Bermal, 2008; Tyson and Cabrera, 1993).

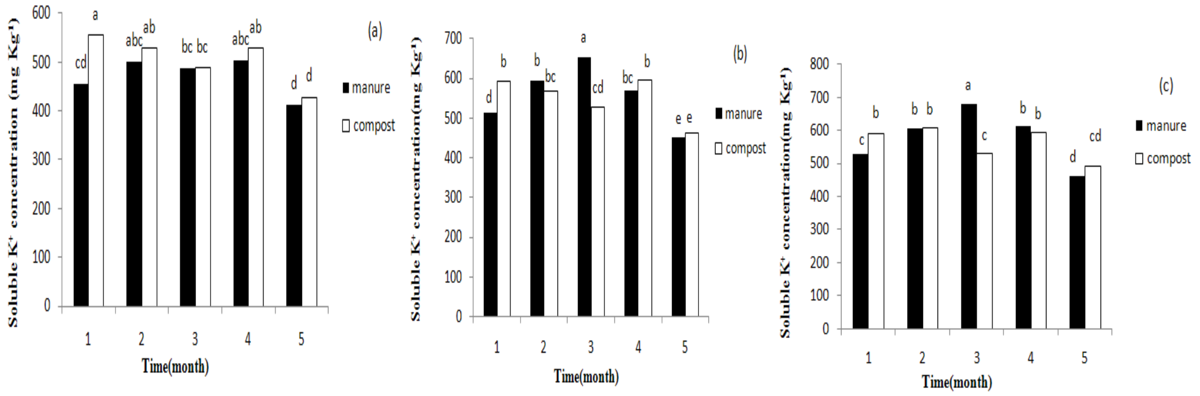

Fig. 5. Soluble K^+ concentration changes at three layers, (a) 0-10 cm, (b) 10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments.

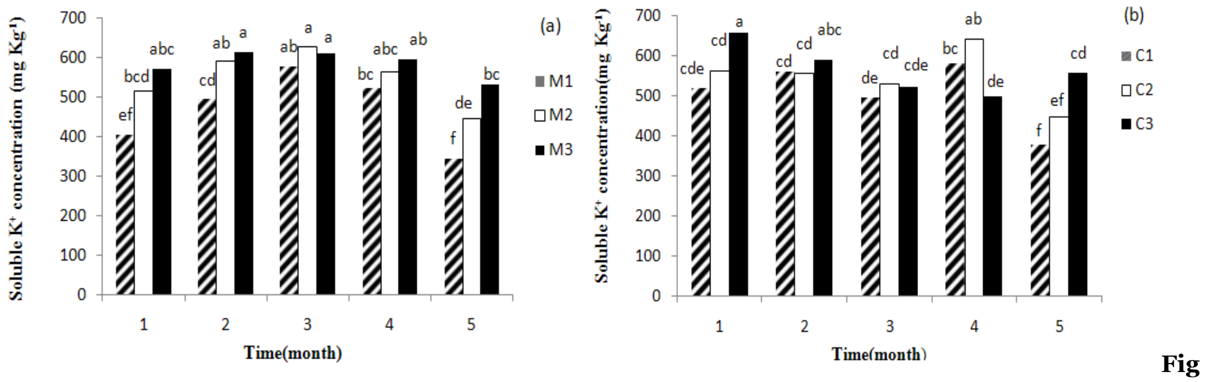

Fig. 6. Soluble K^+ concentration at three rates of (a) manure and (b) compost during 5-months incubation-leaching period.

The largest K^+ release from manure at all levels, happened at the third month of incubation and then leaching caused the soil soluble potassium to decrease significantly (Fig. 6 a). In compost treatments, C_1 and C_2 levels on the fourth month and C_3 level on the first month of incubation produced the highest amount of potassium in soil (Fig. 6b). High concentration of potassium in soil can raise salinity (Hao and Charg, 2003; Areinzo *et al*, 2009). After fourth months of incubation, there was no salinity problem in soil (Fig. 1), but concentration of soluble potassium was high at the end of the experiments as the concentration of soil available potassium (the data aren't shown). So the level of 1% by weight of both amendments is preferred to other two levels, because they left the least amount of soluble potassium in soil.

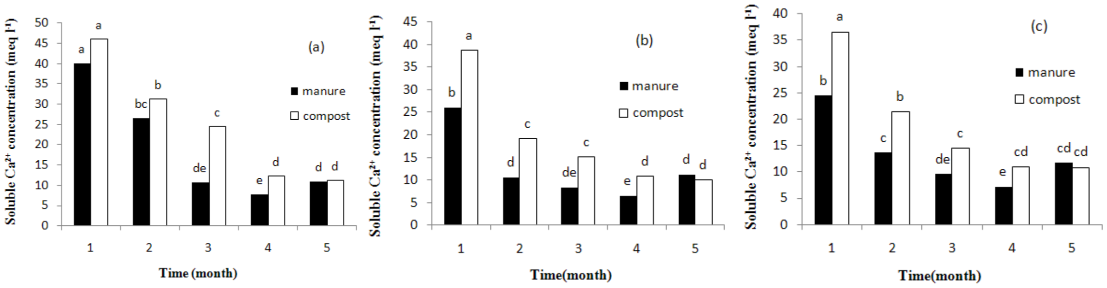

Fig. 7. Soluble Ca^{2+} concentration changes at three layers, (a) 0-10 cm,(b)10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments**.**

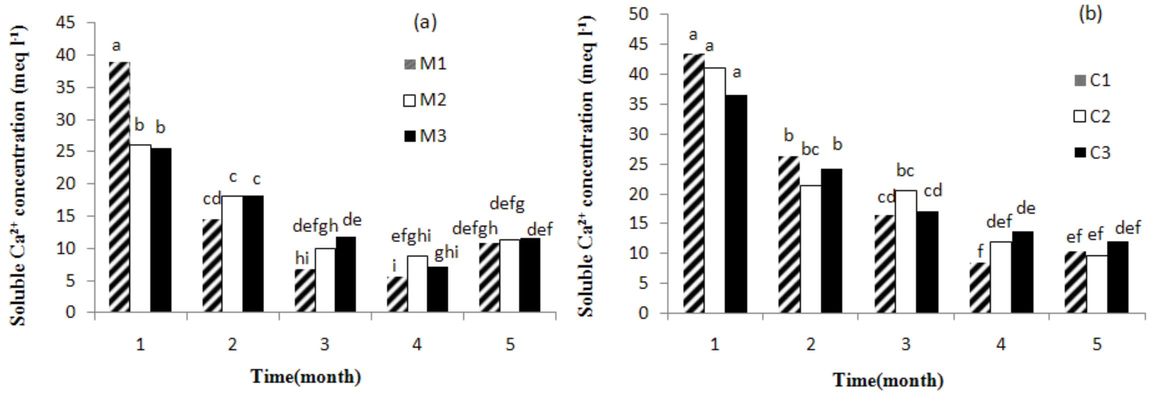

Fig. 8. Soluble Ca^{2+} concentration at three rates of (a) manure and (b) compost during 5-months incubation-leaching period.

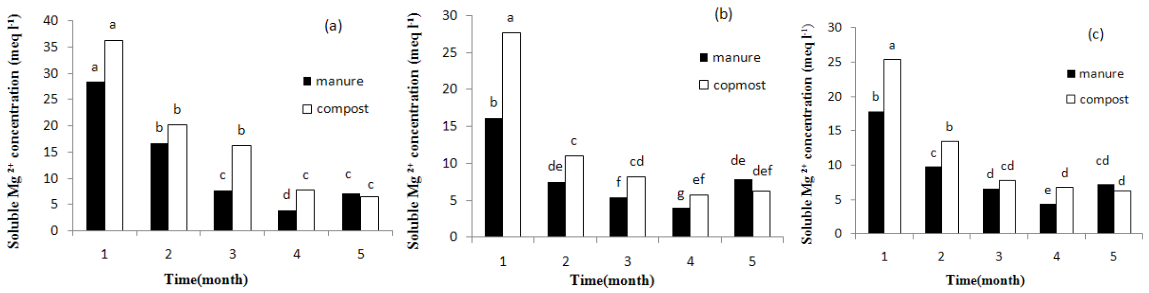

Fig. 9. Soluble Mg^{2+} concentration changes in three layers, (a) 0-10 cm,(b)10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments.

Soluble Ca^{2+}

Soil soluble calcium concentration at the first month of incubation with both amendments increased in comparison to initial soil calcium (18meq l^{-1}) and then, leaching experiments caused decreasing of soil calcium (Fig. 7). Jalali and Ranjbar (2009) also reported a remarkable increase of soil soluble calcium after one month of incubation with two types of manure in a sodic soil. Despite its less calcium, manure produced the same amount of soluble calcium as compost in soil at the last stages of remediation operation, indicating more effect of manure on dissolution of native soil calcite. Calcite dissolution in soil can keep solution calcium concentration at high level that is dependent on pressure of carbon dioxide in soil (Oster *et al*, 1996). Application of organic fertilizers released remarkable amounts of calcium to soil solution which was located on exchangeable sites or was removed from the soil during leaching experiments. Calcium due to its divalence, tends to be replaced by sodium, so the left amount of soluble calcium at the end of remediation operation, was less even than initial soluble calcium concentration.

The comparison between the different levels of the two amendments (Fig. 8) showed that the least produced soluble calcium was from M_1 and C_1 treatments. Difference between this level and the two other levels was not significant (especially in the last two months of experimental period) for both amendments.

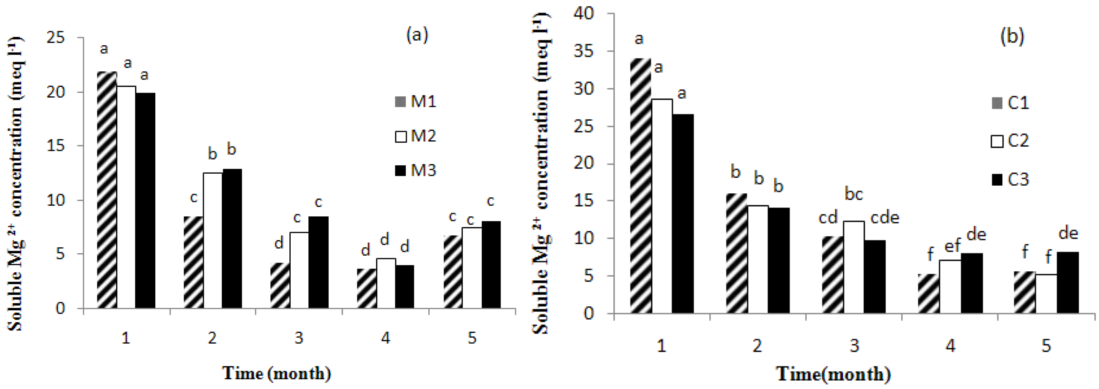

Fig. 10. Soluble Mg^{2+} concentration for three rates of (a) manure and (b) compost during 5- month's incubation-leaching period

Soluble Mg^{2+}

As shown in Fig. 9, at the first month of incubation, both amendments increased soil soluble magnesium comparing to the initial rate (14 meq l^{-1}). Decreasing of soluble magnesium with time, caused the soil soluble magnesium to be less than its initial concentration (14 meq l^{-1}), at the fourth month. The results of some studies indicate that magnesium is considered as a destructive ion in soil. Keren, (1996), stated that magnesium has adverse effects on infiltration in calcareous and non-calcareous soils. Actually, the high concentrations of magnesium in soil have a behavior similar to sodium and causes decrease in infiltration and sealing (Yuan *et al*, 2007). Undesirable effects of harmful cations such as magnesium on physical, chemical and biological characteristics of soil can be compensated through positive effects of added organic materials (Clark *et al*, 2007). Although both organic fertilizers added some magnesium into soil during decomposition, soluble magnesium concentration decreased compared to initial soil.

Comparison of three levels of both amendments (Fig.10) showed that 1% level from both amendments has left the least amount of magnesium. Although there was no significant difference between the three levels of both amendments in some months of incubation.

SAR

At all depths, both amendments decreased soil SAR from 20.35 to 13, which is the limit (>13) established to define saline–sodic soils (Soil Science Society of America, 1997) (Fig.11). There was not a significant difference between the leaching with three and four pore volumes at all depths and in both amendments. In general after four months of incubation and leaching with three pore volumes(L_3), manure and compost led to decreasing the soil SAR by 41.95% and 38.16% at the first, 46.81% and 39.54% at the second and 43.91% and 38.85% at the third depths respectively, with respect to the initial soil. Decrease of SAR in saline and sodic soils by using organic materials has also been reported by Husssain *et al*, (2001). There was no significant difference between three levels of both amendments especially at the last months of remediation operation (Fig. 12).

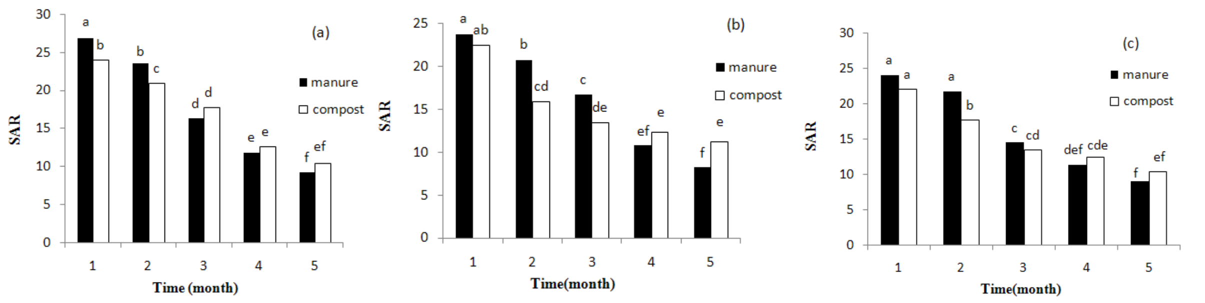

Fig. 11. SAR changes in three layers, (a) 0-10 cm,(b)10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments.

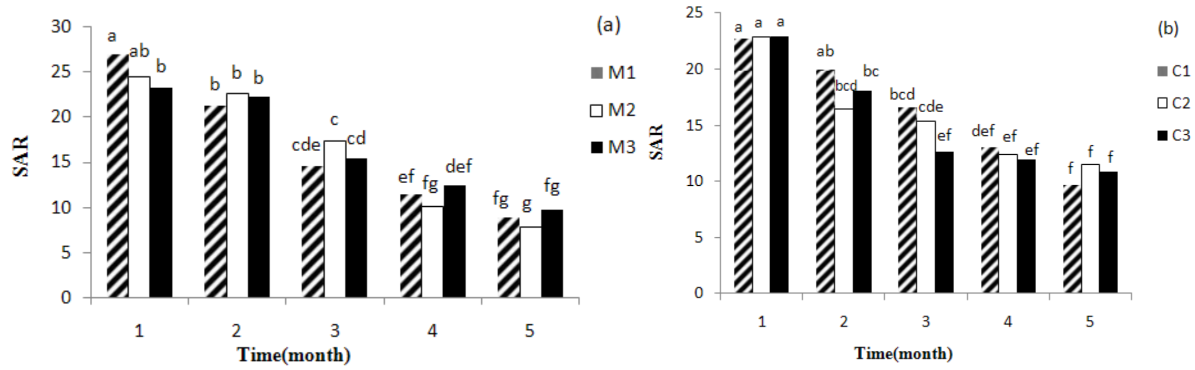

Fig. 12. SAR for three rates of (a) manure and (b)compost during 5-months incubation- leaching period.

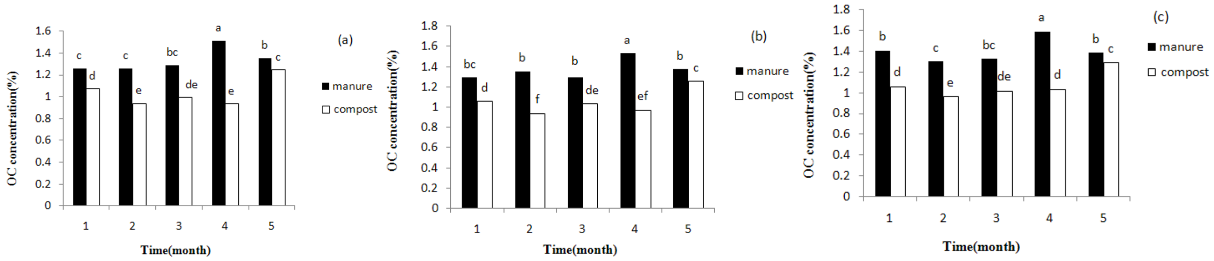

Fig. 13. OC concentration changes in three layers, (a) 0-10 cm,(b)10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments.

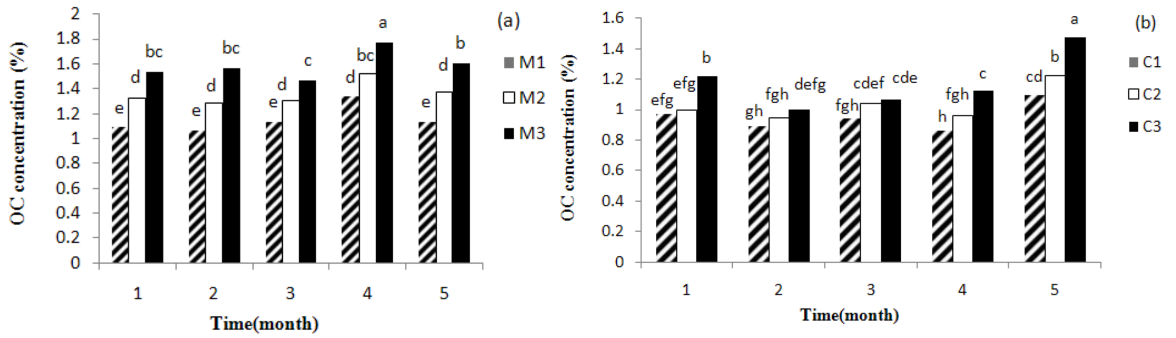

Fig. 14. OC concentration for three rates of (a) manure and (b) compost during 5-months incubation-leaching period.

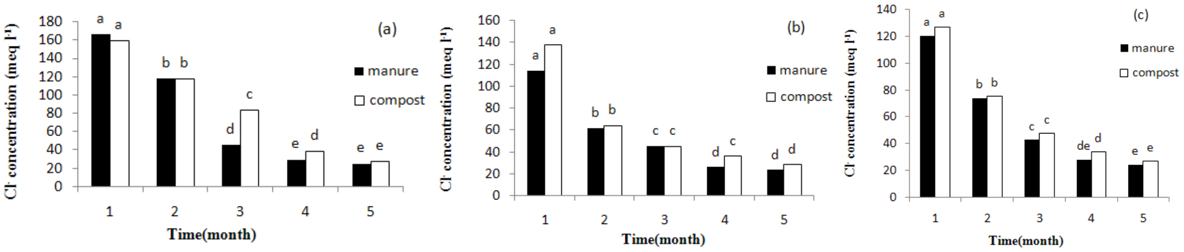

Fig. 15. Cl^- concentration changes in three layers, (a) 0-10 cm,(b)10-20 cm, (c) 20-30 cm, during 5-months incubation-leaching period for organic amendments

Organic Carbon

Fig.13 shows that adding each of organic conditioners increased soil organic carbon from the first months of incubation compared to the initial soil OC content (0.99%). The trend of OC changes in all three depths was similar to each other. Manure in all depths and in all months has led to increase in OC concentration rather than compost. Manure increased OC until fourth month of incubation-leaching period and then there was a considerable decrease in the soil OC. While compost increased OC concentration after the fourth stage of incubation-leaching period. Although manure could provide more OC to soil, it seems that its effects declined later, which is an indicator of compost superiority to the manure in term of long-term effects in soil. Madejon *et al,* (2001) and Melero *et al*, (2007) have also reported increase of OC in salt affected soils by application of organic materials. At the fourth month of remediation operation manure and compost increased the OC concentration up to 1.51-1.59% and 1.24-1.29% respectively at three different depths of soil.

The M_3 level of manure had the most positive effect on soil OC increasing (Fig.14 a). Fewer differences occurred between the compost levels, but in the last months of experimental period, the C_3 level produced the highest OC (Fig.14 b). Clark *et al.*, (2007) Studied the effect of poultry manure application on improving the characteristics of a sodic soil with initial organic carbon of 0.65% during 174 days of incubation, and concluded that the highest release of OC happened at 14-28 days, which was equal to 2.5-3.5 g kg^{-1} and then soil OC decreased in a way that after 58 days, OC retained to the initial rate and didn't change until the end of the experiments. Tejada *et al*, (2006), with comparing two levels of 14 t ha^{-1} and 28 t ha^{-1} application from two kinds of organic materials (cotton compost and poultry manure) found out that the effect of 28 t ha^{-1} level from poultry manure on the increasing of soil organic carbon was significantly more than other treatments.

Cl^-

Cl^- is one of the dominant ions in saline soils and has important role in NH_3 progression and NO_3^- uptake disturbance by plants (Gupta and Abrol, 1990), and also has antagonistic effects with some nutrients such as phosphorus (Ghoulam *et al,* 2002). Remediation operation could decrease the concentration of Cl^- in soil solution with a similar procedure in both amendments (Fig.15). The initial concentration of Cl^- in soil was 110 meq l^{-1} (Table 1) and declined below 40 meq l^{-1}after four months of incubation and leaching with three pore volumes. Jalali *et al*, (2008) studied the effect of irrigation with waste water on decreasing soil sodicity and nutrients leaching, and reported that the concentration of Cl^- declined from 61.7 to 22.2 meq l^{-1} after leaching with seven pore volumes. The effect of amendment levels on Cl^- concentration wasn't significant.

Conclusion

Results showed that the application of manure and compost decreased soil EC by 75.03% and 65.16% and soil SAR by 44.22% and 38.85% with respect to initial soil after four months of incubation and three stages of leaching, which indicated that these organic materials are efficient in saline and sodic soils remediation without need to add any chemical calcium resource. Soluble cations concentration in the first month of incubation, increased by application of each amendment and then decreased by starting leaching until the last month of experimental period. Potassium was the only cation whose concentration did not decrease considerably in soil solution. In most cases, there wasn't a significant difference between leaching with three pore volumes and four pore volumes regarding the decrease of EC and SAR, so it can be concluded that soil incubation by each kind of organic material for four months and leaching with three pore volumes is more economical. The comparison of different levels of both amendments showed that although in some cases as providing organic carbon in soil, the highest level of both amendments (C_3 and M_3) were more effective than other levels, but the efficiency of C_1 and M_1 treatments, in improving the chemical characteristics of saline and sodic soil were not less than other two levels, so are recommendable regarding economical and environmental aspects.

References

Arienzo M, Christen EW, Quale W, Kumar A. 2009. A review of the fate of potassium in the soil-plant system after land application of wastewaters. Journal of Hazardous Materials **164,** 415-422. http://dx.doi.org/10.1016/j.jhazmat.2008.08.095

Clark GJ, Dodgshun N, Sale PWG, Tang C. 2007. Changes in chemical and biological properties of a sodic clay subsoil with addition of organic amendments. Soil Biology and Biochemi **39,** 2806-2817. http://dx.doi.org/10.1016/j.soilbio.2007.06.003

Cote CM, Bristow KL, Ross PJ. 2000. Increasing the efficiency of solute leaching: Impacts of flow interruption with drainage of the preferential flow paths. Journal of Contaminated Hydrology **43,** 191-209. http://dx.doi.org/10.1016/S0169-7722(00)00087-5

Elsharawy MAO, Elbording MM, Sedeka AA. 2008. Improvement of a salt affected soil on Bahr EL-Bakar Area using certain industrial by products. Journal of Applied Sciences Research **47,** 839-846.

Gee GW, Bauder JW. 1986. Particle Size Analysis pp. 383-411 inPage *et al.* (Ed) Methods of Soil Analysis, Part 1, Physical and Mineralogical Methods, Agronomy Monograph No 9 (2nd Edition). American Society of Agronomy, Madison.

Ghoulam C, Foursy A, Fares K. 2002. Effects of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. Environmental and Experim **47,** 39–50. http://dx.doi.org/10.1016/S0098-8472(01)00109-5

Gupta PK. 1999. Soil, plant, water and fertilizer analysis. Agrobios pub. Bikaner, India.

Gupta RK, Abrol IP. 1990. Salt affected soils: Their reclamation and management for crop production. Advances in Soil Science **11,** 223-288. http://dx.doi.org/10.1007/978-1-4612-3322-0

Hao X, Chang C. 2003. Does long-term heavy cattle manure application increase salinity of a clay loam soil in semi-arid southern Alberta? Agriculture, ecosystems & environment **94,** 89-103. http://dx.doi.org/10.1016/S0167-8809(02)00008-7

Hassen A, Jedidi N, Cherif M, Hiri MA, Boudabous A, Cleemput OV, Van Cleemput O. 1998. Mineralization of nitrogen in a clayey loamy soil amended with organic wastes entriched with Zn, Cu and Cd. Bioresource Technology **64(1),** 39-45.

Hussain N, Hassan G, Arshadullah M, Mujeeb F. 2001. Evaluation of amendments for the improvement of physical properties of sodic soil. International Journal of Agriculture & Biology **3(3),** 319-322.

Jalali M, Ranjbar F. 2009 Effects of sodic water on soil sodicity and nutrient leaching in poultry and sheep manure amended soils. Geoderma **1531,** 194-204. http://dx.doi.org/10.1016/j.geoderma.2009.08.004

Jalali M, Merikhpour H, Kaledhoncar MJ, Van Derzee SEATM. 2008. Effects of wastewater irrigation on soil sodicity and nutrient leaching in calcareous soils. Agric. Water Mang **95,** 143-153.

Keren R. 1996. Reclamation of sodic-affected soils. In: Agassi, M. (Ed.), Soil Erosion, Conservation and Rehabilitation, p. 353-374. Marcel Dekker Inc, New York.

Klute A. 1986. Water retention: Laboratory methods. pp. 635–662. In Page *et al.* (ed.) Methods of Soil Analysis. Part 1. Physical and Mineralogical Methods. 2nd ed. Agron. Monogr. 9. ASA and SSSA, Madison, WI.

Knudsen D, Paterson GA, Pratt PF. 1982. Lithium, sodium and potassium, P. 225-246. In: Page *et al.* (Eds.), Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. ASA, SSSA, Madison, USA.

Lakhdar A, Rabhi M, GhnayaT, Montemurro F, Jedidi N, Abdelly C. 2009. Effectiveness of compost use in salt-affected soil. Journal of Hazardous Materials **171,** 29-37.

Li F, Keren R. 2008. Native CaCO3 mineral dissolution and its contribution to sodic calcareous soil reclamation under laboratory condition. Arid Land Research and Management **22,** 1-15. 10.1080/15324980701784225

Li FH, Keren R. 2009. Calcareous soil reclamation as affected by corn stalk application and incubation: A laboratory study. Pedosphere **19(4),** 465-475. http://dx.doi.org/10.1016/S1002-0160(09)60139-9

Madejon E, Lopez R, Murillo JM, Cabrera F. 2001. Agricultural use of three (sugarbeet) vinasse composts: effect on crop and on chemical properties of a soil of the Guadalquivir River Valley (SW Spain). Agriculture, Ecosystems & environment **84,** 55-67. http://dx.doi.org/10.1016/S0167-8809(00)00191-2

McLay CDA, Cameron KC, McLaren RG. 1991. Effects of time of application and continuity of rainfall on leaching of surface-applied nutrients. Soil, Land Care & Environmental Research **29,** 1-9. http://dx.doi.org/10.1071/SR9910001

Melero S, Madejon E, Ruiz JC, Herencia JF. 2007. Chemical and biochemical properties of a clay soil under dryland agriculture systems as affected by organic fertilization. European Journal of Agronomy **26,** 327-334.

McLean EO. 1982. Soil pH and lime requirement. pp. 199-223. In: Page *et al.* (ed.) Methods of Soil Analysis, part2. Chemical and Microbiological Properties. Agronomy Monogr. 9, 2nd ed. ASA and SSSA, Madison, WI.

Nelson DW, Sommers LE. 1986. Total carbon, organic carbon and organic matter. PP. 539-579 . In: Page *et al.* (Eds.), Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties. ASA, SSSA, Madison, USA.

Oster JD, Shainberg I, Abrol IP. 1996. Reclamation of salt- affected soil. pp. 315-352. In: Agassi, M. (Ed.), Soil Erosion, Conservation and Rehabilitation. Marcel Dekker Inc, New York.

Page AL, Miller RH, Jeeney DR. 1992a. Methods of Soil Analysis, Part 1. Physical and Mineralogical Properties. SSSA Pub., Madison. 1750 p.

Page A L, Miller RH, Jeeney DR. 1992b. Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties. SSSA Pub., Madison. 1159 p.

Qadir M, Oster JD. 2002. Vegetative bioremediation of calcareous sodic soils: history, mechanisms and evaluation. Irrigation Science **21,**91-101.

http://dx.doi.org/10.1007/s00271-001-0055-6

Richards LA. 1954. Diagnosis and improvement of saline and alkali soils. Handbook 60 USDA, US Gov. Print. Office, Washington, DC.

Rhoades JD. 1982. Soluble salts. pp. 167-178. In: Page *et al.* (ed.) Methods of Soil Analysis: Part2. Chemical and Microbiological Properties. Agronomy Monogr. 9. 2nd ed. ASA and SSSA, Madison, WI.

Rhoades JD. 1996. Salinity: Electrical conductivity and total dissolved solids. pp. 417-435. In: Bartels *et al.* (ed.) Methods of Soil Analysis: Part 3. Chemical Methods 3rd. ed. ASA and SSSA, Madison, WI. Book series no. 5.

Soil Science Society of America (Terminology Committee), 1997. Glossary of Soil Science Terms. SSSA, Madison, WI, USA.

Smith DC, Beharee V, Hughes JC. 2001. The effects of composts produced by a simple composting procedure on the yields of Swisschard (*Beta vulgaris* L. var. *flavescens*) and common bean (*Phaseolus vulgaris* L. var. *namus*). Scientia Horticulturae **91,** 393-406.

Tejada M, Garcia C, Gonzalez GL, Hernandez MT. 2006.Use of organic amendments as a strategy for saline soil remediation: Influence on the physical , chemical and biological properties of soil. Soil Biology and Biochemistry **38,** 1413-1421.

Tyson SC, Cabrera ML. 1993. Nitrogen mineralization in soils amended with composted and uncomposted poultry litter. Communications in Soil Science and Plant Analysis **24,** 2361-2374. http://dx.doi.org/10.1080/00103629309368961

Walker DJ, Bernal MP. 2008. The effects of olive mill waste compost and poultry manure on the availability and plant uptake of nutrients in a highly saline soil. Bioresource Technology **99,** 396-403. http://dx.doi.org/10.1016/j.biortech.2006.12.006

Wong VNL, Dala RC, Greene RSB. 2009. Carbon dynamics of sodic and saline soils following gypsum and organic material additions:A laboratory incubation. Applied Soil Ecology **14,** 29-40. http://dx.doi.org/10.1016/j.apsoil.2008.08.006

Yuan JF, Feng G, Ma HY, Tian CY. 2010. Effect of nitrate on root development and nitrogen uptake of *Suaeda physophora* under NaCl salinity. Pedosohere **20(4),** 536-544. http://dx.doi.org/10.1016/S1002-0160(10)60043-4

Yuan BC, Xu X, Li G, Gao ZZ, TP Gao M, Fan XW, Deng JM. 2007. Microbial biomass and activity in alkalized magnesic soils under arid conditions. Soil Biol. Bioch **39,** 3004-3013. http://dx.doi.org/10.1016/j.soilbio.2007.05.034